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Climate Change-GDP Nexus for GCC Nations: A Dynamic Approach to the Environmental Kuznets Curve Hypothesis

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of
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ABSTRACT

The Gulf Cooperation Council (GCC) countries, which include Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates, have experienced significant economic growth in recent years. However, this growth has also increased greenhouse gas emissions and other adverse environmental impacts. The study aims to investigate the causality relationship between economic growth and climate change in these countries to understand this issue. The research applied quantitative methodology, and Several econometrics tests were employed, including the Environmental Kuznets Curve (EKC) for the period (2001-2020). These methods were used to examine the impact between Carbon Dioxide Emission as the climatic indicator and GDP and various related variables, such as Import, Export, Population, Energy generation, and Electricity Consumption. The main finding of this present study is that the GCC countries indicate that the inverted U shape of the Climate-change GDP nexus and GDP positively impacts CO₂ emission for the panel according to the fixed effect model. This implies that when GDP is increased, there is a consequential increase in carbon emissions in the panel of countries, and this is attributed to the increase in the level of consumption, which in turn increases the level of production that is reliant on energy consumption.

Keywords: GCC Countries, GDP, Climate Change, Environmental Kuznets Curve.

DEDICATION

I humbly dedicate this PhD thesis to my esteemed supervisor, whose unwavering guidance, expertise, and support have been the cornerstones of my academic journey. Your invaluable insights and mentorship have shaped my research and helped me achieve this significant milestone in my career.

I would also like to express my profound appreciation to my beloved husband, who has been my unwavering support and partner in both life and academia. Thank you for pushing me to reach my full potential and for being my rock through the ups and downs of this journey.

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Chapter One:

Introduction to the Study

Chapter One

Introduction to the Study

1.1 Chapter Overview

The introduction chapter of this PhD thesis will provide an overview of the global issue of climate change and its impact on the world economy and the environment. It will highlight the vulnerability of the Gulf Cooperation Council (GCC) nations to the adverse effects of climate change due to their reliance on hydrocarbon-based economies, and the need for empirical research on the relationship between climate change and economic growth in the GCC region. The chapter will introduce the Environmental Kuznets Curve (EKC) hypothesis as a theoretical framework for examining the relationship between economic growth and environmental degradation and the aim of the study to investigate this relationship in the GCC nations. The chapter will also introduce the research questions, methodology, and significance of the research for informing policy decisions that promote a sustainable future for the GCC nations by balancing economic growth and environmental protection.

1.2 Introduction

In an era marked by rapid economic growth, industrialization, and urbanization, understanding the relationship between economic development and environmental quality has become increasingly important. With growing concerns over climate change, resource depletion, and environmental degradation, the need for sustainable

development strategies that balance economic, social, and environmental objectives is imperative. One of the most influential theories exploring this relationship is the EKC hypothesis, which postulates an inverted-U shaped relationship between economic growth and environmental degradation.

Over the past years, the negative effects of global warming on earth and, by extension, human well-being, have risen to the forefront of worldwide concern. Changes in the global economy, society, and environment began with the industrial revolution. Several economies have been heavily reliant on manufacturing ever since the Industrial Revolution in the early 19th century. Societies witnessed significant economic expansion as a result of technological and industrial advances. The growth of industry has harmed ecosystems and accelerated climate change (Maneejuk, Yamaka, & Sriboonchitta, 2021). There was prior confirmation of this as well that the worldwide demand for energy has expanded significantly over the last several decades due to the world's rapid social and economic development and rising standard of living (Al-Mulali, Weng-Wai, Sheau-Ting, & Mohammed, 2015).

Economists and environmentalists in both developed and developing countries are becoming increasingly concerned about environmental issues, which are caused by both natural causes and the effects of economic growth. Energy's function in boosting productivity, economic development, income, and employment is widely acknowledged by scientists throughout the world to be crucial to economic progress. The study of energy economics has revealed that increasing economic activity and energy usage are major contributors to environmental damage (Iorember, Goshit, & Dabwor, 2020). Greenhouse gas (GHG) emissions, which are mostly the result of human activity, have been shown to have far-reaching effects on the global climate, with knock-on effects on life and human health, economic growth, and productivity. It

is a fact that governments face a never-ending struggle between fostering economic growth and combating climate change. To illustrate, using fossil fuels to produce energy is degrading the environment and exacerbates the issue of rising CO₂ emissions. Since there is a positive correlation between economic growth and the use of fossil fuels, it stands to reason that as the economy grows, energy use and emissions of carbon dioxide do as well (Iorember, Goshit, & Dabwor, 2020).

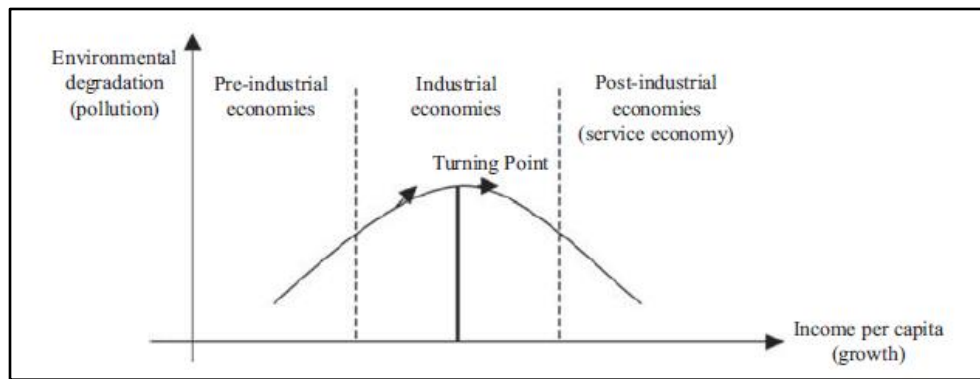
Over the past three decades, researchers have found strong evidence of a connection between energy consumption and GDP growth, as well as GDP growth and pollution. The relationship between energy consumption, economic growth, and climate change has been the topic of extensive academic research throughout the years, as carbon dioxide emissions are central to contemporary debate about environmental protection, climate change mitigation, energy security, resource use, and sustainable development (Alper & Onur, 2016).

In fact, the concept of the "Environmental Kuznets Curve" was initially proposed by Grossman and Krueger (1991), asserting that environmental conditions tend to improve following the stabilization of the economy. Increased economic activity necessitates greater consumption of natural resources, leading to higher levels of both emissions and pollution. To impose further environmental controls on emitters would be financially prohibitive. However, as time passes and people's earnings improve, they place a larger value on a clean and safe environment, and as a result, they conform to stronger environmental regulations, which in turn decreases emissions (Isabel & Lucas, 2019). When viewed in this context, it is crucial to note that Grossman and Krueger provide justification for the trend toward increased emission of various greenhouse gases with increasing economic activity at low-income levels. Yet, the

tipping point is reached at a greater income, resulting in lower emissions of greenhouse gases as the economy expands further (Ahmad, Muslija, & Satrovic, 2021).

The empirical literature on the topic of how economic growth affects environmental quality is extensive. The EKC, which suggests an inverted U-shaped connection between economic expansion and pollution, has been shown to be accurate. The EKC is a proposed relationship between environmental pollution and economic wellbeing. It claims that a decline in environmental quality is a natural consequence of economic growth. Investment in pollution abatement and clean technology improves environmental quality, which restores the ecosystem, but only if a particular economic threshold is reached (Figure 1) (Bader & Ganguli, 2019).

Figure 1: The relationship between income and environmental degradation



Source: (Bader & Ganguli, 2019)

According to the EKC theory, pollution rises in tandem with rising income in the early phases of economic growth, but then levels off once the economy develops. An upside-down U-shaped relationship can be used to illustrate this phenomenon. Thus, the

inverted U-shaped relationship among income and pollution will not occur until a critical mass of economic growth is reached, at which point technologies that improve energy efficiency and renewable energy are easily accessible (Al-Mulali, Ozturk, & Solarin, 2016). In conclusion, the Environmental Kuznets Curve hypothesis suggests that carbon dioxide emissions initially have significant environmental impacts during the early phases of economic development; however, these effects gradually diminish over time as the economy continues to grow.

The high level of environmental pollution has coincided with rapid economic growth in the GCC region. Achieving rapid economic growth without significant damage to environmental quality is the current priority of the GCC region (Alsamara, Mrabet, Saleh, & Anwar, 2018).

Since the EKC theory proposes an inverted U-shaped relationship between wealth and pollution, this study's overarching goal is to ascertain whether the pollution-fighting initiatives of the GCC have reached a successful stage or not.

Therefore, this PhD thesis aims to critically evaluate the EKC hypothesis and explore the impact of economic development on the environment by employing comprehensive econometric techniques and examining case studies from GCC countries at different stages of economic development. The study seeks to provide a nuanced understanding of the complex relationship between economic growth and environmental degradation, ultimately contributing to the formulation of effective policy recommendations for sustainable development.

1.3 Problem Statement

The integrated growth of the economy and the environment is a fundamental challenge that the globe faces. The progression of urbanization and an interlinked global economy are expected to intensify energy consumption and dependence, driven by the growth of telecommunications and mobility. As demonstrated historically, escalating energy utilization can adversely affect the environment, health, safety, quality of life, and communication systems (Baydoun & Aga, 2021).

In the ASEAN region, approximately 90% of commercial energy demands are satisfied through the combustion of fossil fuels. This has led to apprehensions that the accelerated development observed in these nations, fueled by elevated energy consumption rates, may be contributing to the emission of greenhouse gases and subsequent climate change impacts (Munir, Lean, & Smyth, 2020).

Moreover, if GDP Granger causes CO₂ emissions, it implies that economic growth contributes to CO₂ emissions, and these nations should implement policies to mitigate the harmful effects of growth, such as investment in renewable energy sources. On the other hand, if CO₂ Granger causes GDP, it signifies that environmental degradation influences GDP through factors like lost productivity, necessitating the formulation of policies that enhance environmental quality to sustain robust growth in these countries.

Economic growth is invariably reliant on energy support, with developing countries exhibiting a strong dependence on fossil fuels such as oil, coal, and natural gas. Given the considerable advancements in energy consumption observed in the relevant countries over the past several decades, the environmental concerns surrounding the greenhouse effect have garnered increased attention from both the research community and policymakers (Ahmad, Muslija, & Satrovic, 2021).

The relationship between economic development and environmental degradation remains a complex and contested issue in the field of environmental economics. The EKC hypothesis postulates an inverted-U-shaped relationship between economic growth and environmental degradation, suggesting that economic development initially leads to worsening environmental conditions, followed by improvements as a certain level of income is reached. Although this hypothesis has garnered substantial interest within scholarly and policy-making domains, its veracity and universal applicability continue to be topics of ongoing discussion.

The research problem addressed in this PhD thesis is the critical evaluation of the EKC hypothesis and the exploration of the impact of economic development on the environment across GCC nations. The study seeks to examine the key determinants of the relationship between economic growth and environmental degradation, assess the effectiveness of environmental policies and regulations, and provide policy recommendations for sustainable development.

The research problem is significant due to the ongoing global challenges of environmental degradation, climate change, and resource depletion, which call for a better understanding of the dynamics between economic development and environmental sustainability. By investigating the EKC hypothesis and its implications, this research aims to contribute to the development of more effective policies and strategies for achieving sustainable development in diverse economic and environmental contexts.

1.4 Research Questions

The following research questions guide the study's focus on investigating the complex relationship between economic growth and environmental sustainability in the GCC nations, with a specific emphasis on the Climate Change-GDP Nexus and the EKC hypothesis. The questions address the key factors that influence this relationship and provide insights into the policy implications of the research outcomes. The research questions also aim to guide the study's focus on identifying best practices for promoting sustainable economic growth in the region and informing environmental policy and sustainable development initiatives in the GCC nations.

- To what extent can the Environmental Kuznets Curve (EKC) hypothesis be validated within the GCC nations, specifically in regard to the correlation between economic growth and environmental deterioration?
- What are the unique dynamics and factors influencing the relationship between economic development and environmental sustainability in the GCC nations?
- How can the research findings be effectively translated into evidence-based policies to promote sustainable development in diverse economic and environmental contexts within the GCC nations?
- How effectively does the panel data approach capture and analyze the complex interrelationships between economic growth and environmental sustainability in the context of the GCC nations, and what insights does it provide for policy formulation?

1.5 Research Hypothesis

These research hypotheses guide the study's focus on investigating the complex relationship between economic growth and environmental sustainability in the GCC nations, with a specific emphasis on the Climate Change-GDP Nexus and the EKC hypothesis. The hypotheses test the validity of these concepts in the context of the GCC nations and provide insights into the main drivers of carbon emissions and energy consumption in the region. The hypotheses also aim to guide the study's focus on identifying best practices for promoting sustainable economic growth in the GCC nations and informing environmental policy and sustainable development initiatives in the region.

1.6 Objectives of the Study

The aim of this study is to examine the Climate Change-GDP nexus for GCC nations through a dynamic approach to the EKC hypothesis. The study seeks to investigate the existence of an inverted U-shaped relationship between environmental degradation (as measured by greenhouse gas emissions) and economic growth (as measured by Gross Domestic Product) and explore the factors that influence this relationship.

Objectives of the Study:

- To evaluate the EKC Hypothesis: Assess the validity of the Environmental Kuznets Curve (EKC) hypothesis in GCC nations, focusing on the relationship between economic growth and environmental degradation.

- To fill Regional Research Gaps: Bridge gaps in regional research by providing fresh insights into the complex interplay between economic development and environmental sustainability in the GCC context.
- To evaluate the impact of GCC nations' initiatives: Evaluate current policies on environmental degradation and their alignment with global climate agreements, aiming to provide insights and recommendations for improved environmental sustainability and economic growth.
- To inform Evidence-Based Policies: Utilize research findings to guide evidence-based policymaking for sustainable development across diverse economic and environmental contexts.

By achieving these objectives, this study aims to contribute to the existing literature on the Climate Change-GDP nexus, especially in the context of the GCC nations. It also aims to inform policymaking related to sustainable development, environmental protection, and economic growth in these nations.

1.7 Significance of the Study

The significance of this research lies in its comprehensive examination of the EKC hypothesis and its implications for the relationship between economic development and environmental quality. Given the pressing need to address the global challenges of climate change, resource depletion, and environmental degradation, a better understanding of the dynamics between economic growth and environmental sustainability is crucial for the formulation of effective policies and strategies. This research contributes to the ongoing academic debate on the EKC hypothesis, providing valuable insights into its validity, general applicability, and policy implications.

Furthermore, the inclusion of the GCC countries as a case study in this research adds an additional layer of significance. The GCC countries, characterized by their abundant hydrocarbon resources, have experienced rapid economic growth and urbanization in recent decades, with significant implications for their energy consumption and environmental footprints. These countries face unique challenges in balancing their economic development with environmental sustainability, making them an ideal context for exploring the applicability and relevance of the EKC hypothesis.

The examination of the GCC countries as a case study also holds practical significance for policymakers in the region. The insights gained from this research can help inform the development of context-specific policies and strategies that address the unique challenges faced by the GCC countries in achieving sustainable development. By identifying the key determinants of the relationship between economic growth and environmental quality in the GCC context, this research can contribute to the formulation of targeted policy interventions that promote both economic growth and environmental sustainability.

In summary, the significance of this research lies in its critical evaluation of the EKC hypothesis and its exploration of the impact of economic development on the environment, with a particular focus on the GCC countries as a case study. The findings of this research can contribute to the development of more effective policies and strategies for achieving sustainable development in diverse economic and environmental contexts, both within the GCC region and beyond.

1.8 Settings of the Study

The research settings of this study are deliberately targeted at the GCC nations, a region of strategic global importance that encompasses six nations - Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE). These countries possess vast oil and gas reserves, and their economies are heavily dependent on the exploitation of these resources. Consequently, the GCC nations are among the highest carbon emitters globally, with their fossil fuel-based energy production contributing significantly to the global greenhouse gas emissions.

The study's specific focus on the GCC nations is significant because it provides a critical context for investigating the relationship between climate change and Gross Domestic Product (GDP) within this region. The unique economic, social, and environmental challenges of the GCC countries provide a valuable opportunity to examine the interplay between economic development and environmental sustainability in a distinctive context. Moreover, this study's setting allows for an assessment of the extent to which the EKC hypothesis can be applied within the GCC nations.

The EKC hypothesis suggests that economic growth initially leads to an increase in environmental degradation, but beyond a certain threshold, further economic development can lead to a decrease in environmental pollution. The GCC nations are among the countries where the relationship between economic development and environmental sustainability is highly contested. The hypothesis has been a subject of numerous scholarly debates, and the study aims to contribute to this ongoing discourse by examining the GCC nations' case.

Moreover, the study's focus on the GCC nations is also relevant to the United Nations Sustainable Development Goals (SDGs) for Climate Change. The SDGs aim to reduce carbon emissions and mitigate the adverse impacts of climate change, and the GCC nations' strategic importance to the global energy sector implies that the region's compliance with these goals can contribute significantly to global efforts to mitigate climate change. The research settings of this study are therefore highly significant in terms of contributing to the understanding of the complex relationships between economic development, environmental sustainability, and global efforts towards climate change mitigation.

- **Research Methodology and Scholarly Contributions:**

- ✓ **Methodological Framework:**

At the heart of this thesis lies a robust philosophical foundation—a positivist philosophy. This philosophical standpoint aligns with the principles of empiricism and objectivity, akin to the natural sciences, underscoring the author's unwavering commitment to elucidating empirically demonstrable facts and cultivating generalizable insights.

The chosen methodological approach is characterized by its quantitative rigor. This approach is especially well-suited to exploring the intricate interplay between economic growth and environmental sustainability within the unique context of the GCC nations. Quantitative research equips the author to unearth empirical correlations, discern underlying trends, and derive well-substantiated conclusions.

- ✓ **Contributions to Existing Research:**

This thesis endeavor is primed to yield substantial contributions to the existing scholarly literature through several salient avenues:

- Empirical Validation of the Environmental Kuznets Curve (EKC) Hypothesis: The author's study builds upon the established yet frequently contested Environmental Kuznets Curve (EKC) hypothesis in environmental economics. By harnessing a quantitative approach, the aim is to subject this hypothesis to empirical scrutiny within the unique regional context of the GCC nations.
- Addressing Regional Research Gaps: The GCC nations present a distinctive regional milieu characterized by rapid economic advancement juxtaposed with pressing environmental concerns. This study aspires to bridge a conspicuous void in the academic discourse by centering on this specific region, offering fresh insights into the intricate dynamics between economic growth and environmental sustainability.

By incorporating this meticulous methodological framework and emphasizing the anticipated scholarly contributions, this introduction underscores the scholarly rigor and profound import of the author's research approach. Through the advancement of the comprehension of the interrelationships between economic growth and environmental sustainability, the author endeavors to shape evidence-based policymaking and propel substantial strides toward sustainable development across varied economic and environmental landscapes.

1.9 The Dissertation Structure

The dissertation structure is designed to provide a comprehensive and systematic presentation of the study's research questions, hypothesis, objectives, and outcomes. The dissertation comprises six chapters, each of which serves a specific purpose in achieving the research aims and objectives.

- Chapter one: The first chapter provides an introduction to the research topic, outlining the problem statement, research questions, hypothesis, objectives, significance, and research terminologies. This chapter provides the context for the study, and it is designed to orient the reader to the research objectives, methodology, and expected outcomes.
- Chapter two: The second chapter reviews the relevant literature on the subject matter, examining the concepts of climate change, Gross Domestic Product, the Climate Change-GDP Nexus, and the EKC hypothesis. The chapter provides an overview of previous studies in the field, highlighting the gaps in existing literature that the current study aims to address.
- Chapter three: The third chapter provides an overview of the GCC nations' economic history, environmental challenges, and sustainable development initiatives. The chapter highlights the specific challenges faced by the GCC nations in achieving sustainable development and mitigating the adverse impacts of climate change. It also demonstrates the study's relevance to the United Nations Sustainable Development Goals for Climate Change and global efforts towards climate change mitigation.
- Chapter four: The fourth chapter describes the research methodology and procedures, including research philosophy, methodology, data collection, variables, and the research model. This chapter provides a detailed explanation of the research design, data analysis, and interpretation.
- Chapter five: The fifth chapter presents the results of the study, including statistical data, tables, and graphs, and discusses the findings in light of the research questions, objectives, and hypothesis. Chapter Five will include a comparative analysis of the study's findings with those of previous research. Relevant studies on the Climate Change-GDP Nexus and the EKC hypothesis

will be reviewed, and the analysis will focus on key variables such as carbon emissions, energy consumption, and economic growth. The comparative analysis will validate the research outcomes and identify research gaps to guide future research and policymaking.

- Chapter six: The sixth and final chapter provides a conclusion and recommendations based on the study's outcomes, highlighting the key contributions to literature and their implications for future research and policymaking.

In summary, the dissertation structure is designed to provide a comprehensive and systematic presentation of the research questions, objectives, and outcomes, and it comprises six chapters that serve specific purposes in achieving the research aims and objectives.

1.10 Research Terminology

Climate change Gross domestic product (GDP); Carbon emissions; Energy consumption; Fossil fuel; Population growth; Greenhouse gas emissions; EKC hypothesis; Sustainable Development Goals; CO₂ emissions; Mitigation; Adaptation; Intergovernmental Panel on Climate Change (IPCC); Climate models; Renewable energy; Non-renewable energy; Environmental degradation; Environmental sustainability; Ecological footprint; Energy efficiency.

Chapter Two:

Literature Review and Theoretical Framework

Chapter Two

Literature Review and Theoretical Framework

2.1 Chapter Overview

Chapter 2 of the thesis provides an extensive literature review of the climate change-GDP nexus and the EKC (EKC) hypothesis. The chapter begins by introducing the concept of climate change and its impact on the environment and the economy. The chapter discusses the various causes of climate change and the adverse effects that result from the increase in CO₂ emissions. Additionally, the chapter highlights the United Nations Sustainable Development Goals for climate change and their relevance to the GCC nations.

The literature review also introduces the concept of Gross Domestic Product (GDP) and its significance in economic growth. The chapter discusses the definition of GDP and the different approaches to measuring it, including the income approach, expenditure approach, and production approach. The chapter then proceeds to examine the concept of the climate change-GDP nexus and the various theoretical perspectives that underpin it.

The literature review further discusses the EKC hypothesis and its relevance to the GCC nations. The chapter provides a definition of the EKC hypothesis and highlights the different variables that determine its shape. The chapter also examines the various models used to test the EKC hypothesis and highlights the limitations and gaps in the existing literature.

The chapter concludes with an overview of previous studies on the climate change-GDP nexus and the EKC hypothesis. The literature review examines the empirical evidence on the climate change-GDP nexus and the EKC hypothesis in different regions, highlighting the factors that influence this relationship. The chapter provides a critical analysis of the existing studies and identifies the gaps and limitations in literature.

2.2 The Concept of Climate Change

The Planet has created a new geologic phase, the Anthropocene, in which human activity is the primary cause of alterations and effects on biodiversity. The continuous development of human activities has a clear influence on the environment and might collapse the ecological system, leading to substantial climatic factors including extreme weather, storms, floods, cyclones, and flames (IPCC, 2014). The term "environmental performance" refers to a wide range of factors, including the amount of pollutants released into the environment, how much energy is used, and the effectiveness of different administrative initiatives designed to reduce the adverse effects of contaminants. (Izzaty, Astuti, & Cholimah, 2019).

Most scientists agree that climate change poses the biggest environmental danger to humanity. Greenhouse gases (GHGs) are produced on a regular basis as a result of human activities including driving, agriculture, cutting down trees, industrializing, and production. Human-caused emissions of greenhouse gases (GHGs) such carbon dioxide, methane, nitrous oxide, and ozone are responsible for greenhouse gases and the resulting environmental degradation. These gases build up in the atmosphere, trap solar heat, and lead to weather shifts (Kasem & Alawin, 2019). In addition, climate

change, exacerbated by human-caused increases in the Earth's atmospheric concentration of carbon dioxide, poses a major and urgent danger to the planet's biodiversity and the economies and cultures around them (Alvarado Perez, 2018). Sunburn and melanoma are caused by climate change in the form of hot waves, floods, and drought. They also note that climate change is a leading cause of heat stroke, drowning, and gastrointestinal illnesses. As the amount of generated GHGs continues to climb, the threat of catastrophic climate change has become more urgent (Kasem & Alawin, 2019). Human actions including chopping down trees and burning fossil fuels have led to a rise in atmospheric CO₂ levels, which in turn has caused a rise in global temperatures. Extreme weather has resulted from rising temperatures. The continued rise in temperature also causes the melting of ice in the polar areas, contributing to increasing sea levels (Emalia, Moniyana, & Asia, 2020). Both the Intergovernmental Panel on Climate Change (IPCC) and the World Meteorological Organization have come to the conclusion that human activities in the industry sectors, agriculture, and transportation are responsible for the current state of global warming (Isabel & Lucas, 2019). There can be no longer be any doubt that human activities have contributed to global warming, and international climate debates have ramped up to meet mitigation goals. Given that almost all development projects that rely on fossil fuels for energy also cause greenhouse gas emissions, which in turn affect the global ecosystem, it is reasonable to declare that the world is now responsible for more than 30 billion metric tons of CO₂ emissions annually (Alvarado Perez, 2018). The negative impact of climate change on human health has been shown by several academic and scientific articles. Mortality and disease among humans will be impacted by shifts in the world climate system, according to research by Mukhopadhyay and Forssell (2005), who cited factors such rising temperatures and increased air pollutants. About 40%-60% of cases of severe viral disease, according to research by Patz et al. (2005), may be attributed to

external factors. More than 6.34 million people annually lose their lives in developing nations owing to high levels of particle air pollution. Carbon monoxide, authors claimed, is the primary component of photochemical smoke and a highly dangerous pollutant in its own right (Kasem & Alawin, 2019).

Although oil and gas are vital to the economy, they also cause serious implications for the environment. More than 30 billion metric tons of carbon dioxide are released annually from the burning of fossil fuels across the world. According to Grossman and Krueger (1995), if there were no changes in the economy's structure or technology, the scale effect would cause pollution and other negative environmental consequences to increase in relation to the size of the economy (Alvarado Perez, 2018). Traditional forms of energy are limited in quantity and have a high environmental impact. Seventy-nine percent of greenhouse gas emissions in the United States in 2010 were caused by the combustion of fossil fuels, according to the US Scientific Advisory Panel (2018). In the last several millennia, both atmospheric CO₂ and the average world temperature have grown by around 30% and 0.3 degrees Celsius, respectively (Kasem & Alawin, 2019) While many nations have made strides toward reducing their reliance on fossil fuels and increasing their use of renewable energy, energy efficiency, and preservation, these sources still account for less than 20% of global energy consumption. As a result, climate change has become a significant issue worldwide (Al-Mulali, Weng-Wai, Sheau-Ting, & Mohammed, 2015). Among the causes for economic expansion is the industrial sector's high energy consumption, which has led to environmental inequities throughout the globe, such as a rise in global warming and climatic shifts (Halliru, Loganathan, Golam Hassan, Mardani, & Kamyab, 2020). Accordingly, there is a relationship between the exponential rise in the energy and energy market, the increasing worldwide demand for carbon emissions, and climate change concerns (Fatima, Mentel, Doğan, Hashim, & Shahzad, 2021). Burning fossil fuels emits carbon

dioxide and other greenhouse gases into the atmosphere, which are the most damaging to both individuals and the environment, as shown by a number of studies, scientists, and governments, such as the International Energy Agency. As a consequence, there has been a fundamental shift in the process that energy is generated. Nearly eighty-two percent of primary energy demand is met by fossil fuels (coal, oil, and natural gas), while only nineteen percent originates from renewable sources. This results in a dramatic increase in greenhouse gas emissions, which, without drastic environmental restrictions, would quadruple by 2050 (Ansari, Ahmad, Siddique, & Mansoor, 2020).

In order to ensure energy security, minimize carbon emissions, and sustain rapid and steady economic development, governments have developed an intense desire to investigate alternatives to oil (nuclear and renewable energy) as an alternative to conventional fossil fuels (coal, oil, and natural gas) (Alper & Onur, 2016). In addition to threatening the world's energy security, economic expansion, and development, the unpredictable price of fossil fuels and the mounting environmental pressures we're experiencing pose a significant challenge for the emerging nations. As a result, many nations are urged to limit their impact on the planet by developing plans to minimize their reliance on fossil fuels (Al-Mulali, Ozturk, & Solarin, 2016).

2.2.1 CO₂ Emissions

According to scientific consensus, manmade greenhouse gas (GHG) levels in the air (from both human activities and natural processes) are the main driver of global warming (Isabel & Lucas, 2019). It is widely accepted that carbon dioxide emissions are the primary driver of greenhouse gas emissions and, as a result, have far-reaching

worldwide consequences on environmental quality indices. Population, economic activity, lifestyle, energy usage, land - use practices, technology, and climate policy are identified as key drivers of greenhouse gas emissions in IPCC's fifth report (IPCC, 2014). From 1970 to 2010, the majority of GHG emissions came via burning fossil fuels, namely carbon dioxide. From 1950, these emissions have caused a gradual but steady rise in world average temperature, altering the climate and having repercussions on the natural and built ecosystems across all regions and seas (Isabel & Lucas, 2019). Rising greenhouse gas (GHG) levels in the air during the last century have contributed to a rise in average world temperatures (Emalia, Moniyana, & Asia, 2020). Due to the long half-life of CO₂ in the atmosphere, combating global warming requires a continuous, international effort. Since CO₂ concentrations have risen so dramatically over time, it is widely recognized as one of the most serious environmental concerns. Temperature increases coincide with rising CO₂ rates.

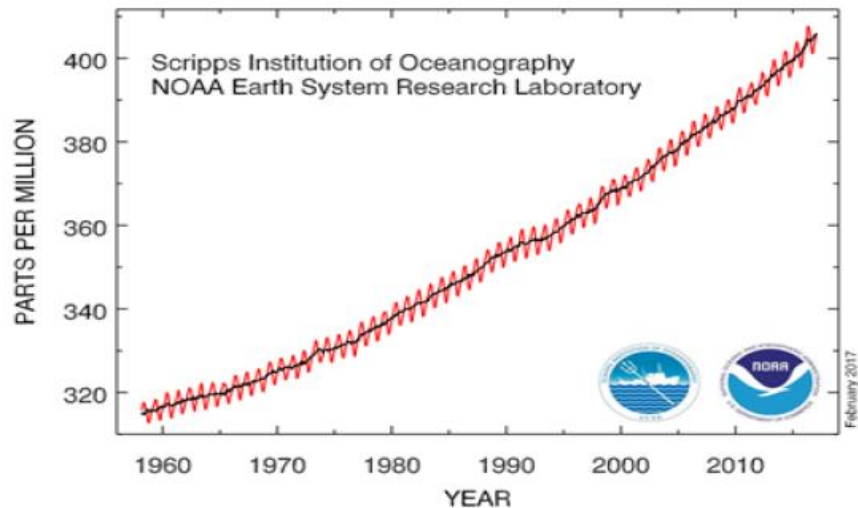
Furthermore, annual variations in CO₂ emissions have a negligible impact on total levels (IPCC, 2014) For many nations, the greenhouse effect is a top priority. This is because to the excessive amounts of greenhouse gas emissions that have been discharged into the air (Alhindawi, Nahleh, Kumar, & Shiwakoti, 2020). Majority human-caused greenhouse gas emissions (GHGs) originate from the combustion of fossil fuels, with CO₂ emissions accounting for over 60% of the greenhouse effect and thus playing a major role in driving up average global temperatures and accelerating climate change (Saboori & Sulaiman, 2013). Economic activity (generated from the use of fossil fuels), the carbon intensity of the economies, and the functioning of unexploited carbon sources and sinks on land and in the seas are the three most essential causes that determine the increase level of CO₂ emissions (Alvarado Perez, 2018). Energy consumption, particularly the burning of fossil fuels including oil, gas, and coal, is largely responsible for the rise in CO₂ emissions (Saboori, Sulaiman, & Mohd, 2012).

Carbon dioxide levels have risen rapidly during the past 70 years, with the rate of growth being around a hundred times that since the end of the last ice age. Since the industrial revolution, CO₂ levels have increased by 145% (before 1750). Constantly increasing CO₂ and greenhouse gas levels threaten to set in motion shifts to the climate system that would have never happened before, with disastrous ecological and economic consequences (Emalia, Moniyana, & Asia, 2020). Ever since beginning of the twentieth century, worldwide CO₂ emissions have been steadily rising, as indicated by Yao, Zhang, & Zhang (2019). In 2014, international carbon emissions surpassed 36 billion tons, which is 1.6 times the quantity released in 1990. In the past several decades, it has produced a marked rise in the world mean temperature, gravely endangering the well-being of humans and their health. The IPCC estimated that 40% of the original CO₂ emissions were still present in the atmosphere after five years. The remainder was sequestered in underground reservoirs and underwater aquifers. This meant that the oceans were responsible for absorbing around 30% of the world's CO₂ emissions, which ultimately resulted in acidification. Emissions would lead to significant warming and long-term changes in the climate system, some researchers concluded, with consequences including heat waves and excessive precipitation. Increased levels of carbon dioxide in the atmosphere would also lead to a rise in sea level and the extinction of many species (Isabel & Lucas, 2019). Furthermore, rising atmospheric CO₂ levels will cause a rise in world average temperatures, amplification of climate changes, and a corresponding rise in sea levels. These unintended consequences are the subject of policy-oriented studies on climate change and are referred to as the social cost of carbon (Alvarado Perez, 2018).

Prior historical research demonstrates that the atmospheric CO₂ content was around 280 ppm at the start of the industrial revolution. A peak of 360 ppm was achieved in 1994.

The current CO₂ level in the atmosphere has surpassed 400 parts per million ppm, and it is expected to keep rising (figure 2) (Isabel & Lucas, 2019).

Figure 2: Atmospheric CO₂ at Mauna Loa Observatory



Source: (Isabel & Lucas, 2019)

According to Purcel (2020) China, the United States, India, the Russian Federation, Japan, and the European Union were the most six CO₂ emitters in 2016, accounting for around 68% and 63% of total world CO₂ and total GHG emissions. Proceeding on to additional sources of CO₂ emissions, transportation is one of the industries that emits a significant quantity of CO₂. With the transportation services industry's meteoric expansion over the last four decades, rising CO₂ emissions from that industry have emerged as a pressing global problem. Approximately 30 percent of the world's carbon dioxide emissions from burning fossil fuels are caused by the transportation industry, as reported by the International Transport Forum. Roughly fifteen percent of all greenhouse gas emissions originate from the transportation industry. It was recorded

that from 1990 to 2007, worldwide CO₂ emissions rose by 45% (Alhindawi, Nahleh, Kumar, & Shiwakoti, 2020).

2.2.2 The United Nations Sustainable Development Goals for Climate Change

A worldwide collaboration for sustainable development to enhance humanity and preserve the environment was endorsed by more than 178 nations at the Earth Summit in Rio de Janeiro, Brazil in June 1992. This actionable plan is known as Agenda 21. At the Millennium Summit, held in September 2000 at UN Headquarters in New York, all participating countries accepted the Millennium Declaration. Eight Millennium Development Goals (MDGs) to end extreme poverty in the world by 2015 were drafted because of the Summit (SDGs, 2015).

By 2015, all nations and the globe's main development agencies have committed to achieving the eight Millennium Development Goals (MDGs), which range from reducing extreme poverty to stopping the spread of HIV/AIDS and delivering universal primary education. For the first time ever, people across the globe are working together to provide for the impoverished. The president of the United Nations General Assembly held a special gathering to review progress toward the MDGs on September 25th, 2013. Ban Ki-moon, the Secretary-General of the United Nations, gave a presentation to the Member States of the United Nations titled "A Life of Dignity for All," at the Special Event that was held to work toward the Millennium Development Goals. The governments of the world reaffirmed their resolve to accomplish the MDGs and scheduled a summit for September 2015 to approve a brand-new goal set that would expand on the Millennium Development Goals (MDGs, 2010).

The United Nations General Assembly started deliberating on a new development agenda for post-2015 in January 2015. In September 2015, during the UN Sustainable Development Summit, the 17 Sustainable Development Goals (SDGs) were adopted as the results of this process. Multiple historic agreements were signed in 2015, making it a watershed year for multilateralism and the formulation of international policy (SDGs, 2015):

- Sendai Framework for Disaster Risk Reduction (March 2015)
- Addis Ababa Action Agenda on Financing for Development (July 2015)
- Transforming our world: the 2030 Agenda for Sustainable Development with its 17 SDGs was adopted at the UN Sustainable Development Summit in New York in September 2015.
- Paris Agreement on Climate Change (December 2015)

Sustainable and planned growth in communities, the economy, and the environment are all proposed in the "2030 Agenda for Sustainable Development" (Wang, Wang, & Li, 2022). Although a holistic approach taking into account all three is preferable, the emphasis of this research is on the connections between the economy and the environment.

Defining sustainable development has been and will continue to be the subject of debate and study. Munasinghe (1999) stated that sustainable development is a strategy that will allow for ongoing enhancements to current day level of living with less intensity of resource consumption, preserving for upcoming generations an undisturbed or even increased base of natural resources and other commodities. Although a single, comprehensive definition of sustainable development is still unclear, the term has evolved to include not just the economic and social but also the environmental realms.

Most conventional economic strategies have prioritized increasing economic production, even if doing so came at the expense of other values. The World Commission on Environment and Development (1987) defined sustainable development in its report titled "Our Common Future" as a response to worries regarding the environmental degradation-economic growth nexus and the desire to synthesize them into a general mission of the population and the competent entities. This book explains that "sustainable development" is progress that "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Purcel, 2020).

Global warming, deforestation, and biodiversity loss are just a few of the pressing environmental challenges that have attracted a significant amount of focus since the 1992 Earth Summit in Rio de Janeiro in order to craft effective national and international sustainable development strategies (Kasem & Alawin, 2019). Contaminant levels have been dropping steadily in developed nations as a result of their tougher environmental legislation and technological advancements compared to less developed nations. Despite this, there are research and data suggesting that emerging economies also tackle and decrease pollution (Alvarado Perez, 2018). The melting of polar ice caps and an increase in the frequency of extreme weather events are just two examples of the many environmental phenomena caused by climate change, as detailed in the UN Intergovernmental Panel on Climate Change Report (AR6 Climate Change 2021: Impacts, Adaptation, and Vulnerability). In addition, by the 2080s, a 40-centimeter sea-level rise is forecast, putting an additional 75-200 million individuals at danger of coastal erosion caused by moderate climate change (Kasem & Alawin, 2019). Strengthening Resistance Risk control in response to, or in preparation for, variations in weather patterns is another aspect of adapting to climate change. The physical implications of climate change, such as the hazards to ecosystems and human life, the

costs of decarbonizing economies, and the costs of impacts on different economic sectors, have been the core concern of preventive policy (Alvarado Perez, 2018).

The goal of the world community is to keep the increase in global temperature from industrialization to only 2 degrees Celsius. The 2030 Agenda for Sustainable Development and the Paris Climate Change Agreement were both passed by the UN in 2015 to achieve this goal. Even now, the Intergovernmental Panel on Climate Change has forecast that the world's temperature might increase to 5.8 0C by 2100, indicating that it is a reality that the challenge of dealing with climate change is immense, and it is absolutely essential to develop policies to address climate change in a way to stop its damaging consequences on the environment and humankind (Halliru, Loganathan, Golam Hassan, Mardani, & Kamyab, 2020).

One such political victory was the 2015 Paris Agreement on Climate Change. However, the extent of its effects on the ecosystem are less certain. Existing Nationally Determined Contributions submitted to the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat depart the worldwide emission - reduction aims as inadequate attempts to keep the globe on path to restrict temperature rise to 1.5 °C by 2030, the purpose asserted in the Accord. Authorities need to step up their emission reduction measures if they are to achieve the targets set out in the Paris Agreement (Alvarado Perez, 2018).

Over the past few centuries, it has become clear that environmental deterioration is linked to both strong economic growth and a meteoric increase in emissions of greenhouse gases (Zmami & Ben-Salha, 2020) All facets of today's worldwide economy, both productive and otherwise, need substantial amounts of energy input. Together with a significant portion of GHG emissions, it poses a concern for both energy security and sustainable development (Ansari, Ahmad, Siddique, & Mansoor,

2020). Increases in energy use and environmental degradation as a consequence of rapid industrialization and economic expansion are obstacles to environmentally responsible and socially just sustainable development (Baydoun & Aga, 2021). In their 1972 study titled "The Limits to Growth," Meadows et al. raise similar concerns about rising populations and economies brought on by industrialization, even as natural resources decline (Purcel, 2020). Concentration in human capital and manufactured capital-intensive occupations by the developed nations perhaps help explain why environmental degradation has decreased in the former and increased in the latter. Polluting operations may be driven farther into developing countries if environmental regulations and policies in developed nations become more stringent (Alvarado Perez, 2018).

There has been a shift in society to a new stage in which communities play a central role. The city is a major economic hub. In terms of GDP, energy consumption, and greenhouse gas emissions, urban areas account for over 70%, 75%, and 72%, respectively, worldwide (Wang, Wang, & Li, 2022). Strengthening resistance managing risks in response to, or in preparation for, changes in weather patterns is another aspect of adapting to climate change. The physical implications of climate change, such as the hazards to ecosystems and human life, the expense of decarbonizing economies, and the consequences of impacts on different economic sectors, have been the core concern of mitigation policy (Alvarado Perez, 2018). There has been a significant structural change in the mix of energy sources during the last century. About 78% of the world's main energy demand is met by fossil fuels (coal, oil, and natural gas), whereas only about 19% is met by renewable sources (Ansari, Ahmad, Siddique, & Mansoor, 2020).

Long-term, economic expansion poses no harm to environmental quality and is, in fact, essential to preserving or improving ecological standards. The World Commission on Environment and Development's "Our Common Future" (1987) argued that this was crucial to achieving sustainable development (Stern, 1998). That's why, while discussing sustainable development programs, the potential of boosting economic growth and development while maintaining a sustainable use of the environment has evolved as the central concern (Zmami & Ben-Salha, 2020). While the Paris Climate Conference (CoP21, December 2015) emphasized the need of increasing the scale and scope of action, the United Nations Sustainable Development Goals (SDGs) emphasize the urgency of taking action on climate change immediately. As of the end of 2016, 195 countries, both developed and developing, have accepted the Paris Agreement and committed to achieving emission reductions by 2030 (Alvarado Perez, 2018). The Paris Climate Agreement from 2015 underlines the need of investing in education and other forms of human capital development as a strategy to combat climate change. Therefore, in order for governments to achieve their goal of a low-carbon economy, they need to invest in the people of their respective countries (Halliru, Loganathan, Golam Hassan, Mardani, & Kamyab, 2020).

There is anticipation that green technologies and cleaner energy sources might benefit from economic growth, which in turn could improve environmental quality. On the contrary aspect, more economic activity may be driven by financial growth, leading to greater energy consumption and CO₂ emissions (Baydoun & Aga, 2021). Based on (Alvarado Perez, 2018), the consequences of these externalities are being attempted to be mitigated by climate change programs in three distinct methods, which are as follows:

- a) There is a need for modifications to be made in both organizational and individual patterns of the use of technology and the development of a carbon footprint.
- b) Provide government subsidies, such as reduced tax rates, to businesses and individuals that invest in carbon-cutting technology.
- b) Assign a monetary value on the societal costs that relate to GHG emissions.

In addition, urbanization has substantial implications on both the expansion of the economy and the sustainability of the environment (Wang, Wang, & Li, 2022). Pioneering study has focused on the significance of environmental protection consciousness and its influence on certain variables at the micro and macroeconomic level (Purcel, 2020).

Removal of fossil fuel subsidies, implementation of carbon-pricing measures, increases in energy efficiency standards, creation of auctions for renewable energy with the least cost, and consideration of local factors and social reactions to climate change (including cultural values) are all necessary for making the necessary capital. The recent decade has seen widespread implementation of carbon-pricing mechanisms including cap-and-trade systems and carbon tax as successful financial tools to decrease emissions in several countries (Alvarado Perez, 2018). To increase general welfare without compromising the requirements of upcoming generations, green growth strategies are desperately required (Zmami & Ben-Salha, 2020).

By making affordable financing available for eco-friendly activities, making available environmentally friendly technologies to businesses, and rewarding those businesses that comply with environmental standards, a robust and well-developed financial sector can improve environmental quality. Financial growth may also improve environmental quality by increasing the stock of funds to be invested in energy from renewable

sources, which is predicted to lead to lower CO₂ emissions (Iorember, Goshit, & Dabwor, 2020). In addition, the transition away from fossil fuels—which are both non-renewable sources and major contributors to greenhouse gas emissions—and toward renewable energy sources helps improve environmental quality while preserving energy independence (Iorember, Goshit, & Dabwor, 2020). Power plants, factories, and cars all necessitate a significant amount of fuel when there is a strong energy need. Nonetheless, the worldwide emissions output may be reduced by enhancements in energy efficiency and reforms in the fuel mix, particularly from carbon-intensive coal to low-carbon gas or from fossil fuels to nuclear or environmentally friendly sources (Bekhet, Matar, & Yasmin, 2017). According to (Kasem & Alawin, 2019), government officials across the globe are debating how to split the responsibility for reducing greenhouse gas emissions and how much each country should contribute. Integrating renewable energy and smart conversion technologies has a significant socio-economic impact, creates jobs, and might result in substantial returns on externalities, such as beneficial health benefits. Notable instances of RES are solar, wind, and hydropower. Some Renewable energy sources (RES) have the advantages of being affordable, plentiful, and unrestricted. In addition, RES are the only viable long-term alternative to fossil fuels. In the United States, RES now provide between 15 and 20 percent of the energy needed, and it is obvious that as the technology for generating renewable energy improves and becomes more widely employed, the price gap between renewable energy and traditional energy sources will narrow. Yet, switching from fossil fuels to renewable energy sources is a time-consuming process. Developing a successful energy transition strategy requires consideration of the current relationship between energy consumption and economic development level (Yao, Zhang, & Zhang, 2019). Renewable energy and other natural resources are important components of the manufacturing system. There would be a direct correlation between the size of the

worldwide economy and environmental destruction if the mix of goods produced and the production techniques used remained unchanged. There is clear indication that economic progress causes a fundamental shift in the goods and services produced by a nation's economy. This suggests that the environmental costs of greater economic activity might well be outweighed by the positive benefits of shifting manufacturing methods and resources composition (Alvarado Perez, 2018). In 2014, fossil fuel energy amounted for more than 80% of the global energy supply, and the overall primary energy supply reached 13.7 billion tons of oil corresponding. However, renewable energy accounts for less than 20% of overall energy use. Renewable energy sources produce less or no greenhouse gas emissions as compared to traditional fuels. Replacement of fossil fuel use with renewable energy sources is an efficient strategy for lowering carbon emissions (Yao, Zhang, & Zhang, 2019). Decarbonization, or the replacement of fossil fuels with renewable energy sources, is the primary method recommended by the Intergovernmental Panel on Climate Change to preserve the health of the planet's ecosystems (Iorember, Goshit, & Dabwor, 2020).

Several analyses have shown that the costs of neglecting to curb fossil fuel use would much outweigh the expenses of implementing measures to accomplish that goal. The demand for radical action to set nations in the area on a path toward combating climate change and achieving sustainable development and green growth is, therefore, rising (Anwar, et al., 2022). Developing renewable energy sources is a priority for many nations and institutions because of the significant role they play in mitigating greenhouse gas emissions. This is illustrated by the Renewable Energy Directive of the European Union, which sets an RER goal of 27% by 2030. As of now, Bulgaria plans to reach an RER of 16% by the year 2020. By 2030, China plans to cut its carbon emissions by 65% relative to its GDP in 2005 levels. German policymakers have set a goal of reducing carbon output by 80 percent by the year 2050. In order to meet its

aspirational objective of 227 GW of renewable energy consumption by 2027, the Indian government has established some targets. The ASEAN has decided to raise the RER to 23% by the year 2025 (Yao, Zhang, & Zhang, 2019).

2.3 The Concept of Gross Domestic Product (GDP)

This section provides an overview of Gross Domestic Product (GDP), which is a widely used measure of economic performance. The chapter discusses the history of GDP, its definitions, and the different approaches to measuring it. The chapter's purpose is to provide a clear understanding of GDP and its importance in macroeconomic analysis and policymaking.

The standard measure of economic activity is gross domestic product (GDP). GDP is important because it gives information about the size of the economy and how an economy is performing. The growth rate of real GDP is often used as an indicator of the general health of the economy. In broad terms, an increase in real GDP is interpreted as a sign that the economy is doing well. When real GDP is growing strongly, employment is likely to increase as companies hire more workers for their factories and people have more money in their pockets.

GDP is measured in current prices or constant prices. Current price GDP is the total value of goods and services produced at current market prices, while constant price GDP is the total value of goods and services produced at a fixed set of prices. Constant price GDP is a better measure of economic growth because it eliminates the effects of inflation and allows for meaningful comparisons over time.

During the 1930s, Simon Kuznets recognized the information gap highlighted by the Great Depression and created a national income accounting system. By the 1940s, World War II planning needs drove the development of product and expenditure estimates, which eventually evolved into a comprehensive set of income and product accounts providing a holistic view of the economy. In the late 1950s and early 1960s, increased interest in economic growth and its sources prompted the creation of official input-output tables, capital stock estimates, and more precise and timely state and local personal income estimates. The late 1960s and 1970s saw the development of enhanced measures of prices and inflation-adjusted output to counter accelerating inflation. During the 1980s, the internationalization of trade in services led to the expansion of estimates of international trade in services in the NIPA'S, and the development of quality-adjusted price and output measures for computers. In the 1990s, more accurate measures of prices and inflation-adjusted output were introduced, and BEA created estimates of investments in computer software while incorporating updated measures of high-tech products and banking output.

2.3.1 The Definitions

Gross domestic product (GDP) is the value of the goods and services produced by the nation's economy less than the value of the goods and services used up in production. GDP is also equal to the sum of personal consumption expenditures, gross private domestic investment, net exports of goods and services, and government consumption expenditures and gross investment. GDP measures final purchases by households, business, and government by summing consumption, investment, government spending, and net exports, GDI measures total incomes earned by households by summing wages and salaries, rents, profits, interest, and other income. "Gross" signifies

that no deduction has been made for the depreciation of machinery, buildings and other capital products used in production. “Domestic” means that it is production by the resident institutional units of the country. GDP is defined as the total value of all final goods, services, and structures produced by a nation’s economy during a specified period—in other words, the total value of the economy’s output.

Gross domestic product (GDP) per capita is used to study the level of economic growth in each country (Bader & Ganguli, 2019). GDP per capita is a core indicator of economic performance and commonly used as a broad measure of average living standards or economic well-being; despite some recognized shortcomings.

2.3.2 GDP Measurement

The measurement of GDP has become more sophisticated over time, reflecting changes in the economy and new economic phenomena. For example, the inclusion of intangible assets, such as research and development, has become increasingly important in the measurement of GDP in knowledge-based economies. Additionally, the measurement of GDP has become more complex in the digital economy, where the value of online services and digital products can be difficult to quantify.

Theoretically, there are three approaches to measuring GDP:

- The production approach sums the “value added” at each stage of production, where value added is defined as total sales minus the value of intermediate inputs into the production process. For example, flour would be an intermediate input and bread the final product, or an architect’s services would be an intermediate input and the building the final product.

- The expenditure approach adds up the value of purchases made by final users—for example, the consumption of food, televisions, and medical services by households; the investments in machinery by companies; and the purchases of goods and services by the government and foreigners. GDP by summing all expenditures on goods and services by final users. Expenditures are divided into five categories: (1) consumption (expenditures by households), (2) investments (largely expenditures by businesses), (3) government spending, (4) imports, and (5) exports. Because GDP is a measure of domestic production, this approach subtracts imports from exports to arrive at net exports.
- The income approach sums the income generated by production—for example, the compensation paid to employees, rent paid to land, interest paid on capital and profit paid to the company owners. Alternatively, GDP can be calculated through the income approach by summing all income earned within the economy, including wages, rental income, interest income, and profits. Measurements of GDP produced through the expenditure approach and income approach are equivalent because the final market price of a good or service should reflect all the income earned and costs incurred throughout the production process.

In conclusion, this section has provided an overview of Gross Domestic Product, which is a measure of the economic performance of a country. The chapter discussed the history of GDP, its definitions, and the different approaches to measuring it. Additionally, the chapter examined some of the critics around GDP as a measure of economic performance.

2.4 Climate Change-GDP Nexus

Globally, one of the most difficult tasks is ensuring that economic growth and environmental protection advance in tandem. There has been a lot of research over the last few decades on the correlation between pollution and economic growth. The question of whether environmental deterioration rises inexorably with economic expansion has been at the center of several research (Anwar, et al., 2022).

In 2019, worldwide primary energy consumption rose by 1.3%. To expand economically, energy is necessary, but its production and usage are also major contributors to pollution and global warming (Baydoun & Aga, 2021). More energy is required than is currently available in order to sustainably power economic expansion. However, this dynamism results in higher CO₂ emissions, thus regulations must be developed to control energy consumption levels while simultaneously encouraging economic development. Further, in wealthy countries that tend to depend largely on fossil fuels to propel the rate of economic expansion, rising emissions and pollution are contentious issues (Alvarado Perez, 2018). All anthropogenic activities, particularly economic ones, influence the environment, as evidenced by the rise in CO₂ emissions. The costs associated with economic activity are seldom considered and are frequently left out of the bottom line altogether. This effect is known as a negative externality and may have serious consequences if it is consistently disregarded (Emalia, Moniyana, & Asia, 2020). Many scientists point to the detrimental effects of income on environmental quality. Considering that the earth's ability to absorb greenhouse gases is finite, economic activity will inevitably lead to job cuts at some point (Ahmad, Muslija, & Satrovic, 2021). By 2040, it is predicted that emissions from OECD nations would amount to around 13.8 billion metric tons of CO₂. Worldwide GDP might be cut by 5% to 20% each year due to climate change, whereas the expense of reducing

greenhouse gases would be just approximately 1% of GDP per year. Accordingly, the link between economic development and CO₂ emissions is crucial to the success of environmental policies (Alvarado Perez, 2018).

There are environmental costs associated with a growing economy due to the obvious increased demand for resources, energy production, and emissions of greenhouse gases (Zmami & Ben-Salha, 2020). Carbon dioxide greenhouse gas related emissions have been relatively stable at around (32.1) Gt for the past two years, as reported by the International Energy Agency (IEA), providing further evidence that the global economy is no longer intrinsically linked to the rate at which greenhouse gas emissions are being produced (Riti, Song, Shu, & Kamah, 2017). While past economic expansion slowed and pollution levels rose, recent years have seen a reversal of these patterns. Hence, it was assumed that affluence would inevitably bring to increased environmental degradation (Koondhar, Shahbaz, Memon, Ozturk, & Kong, 2021). Diverse academics have delved deeply into the intricate web of connections between economic expansion, energy use, and environmental degradation. These reports have looked at many countries and regions using various econometric approaches (Al-Mulali, Weng-Wai, Sheau-Ting, & Mohammed, 2015). Growing economic activity might be one of most important factors in dramatically changing environmental conditions, based on certain data (Halliru, Loganathan, Golam Hassan, Mardani, & Kamyab, 2020).

Subsequent scientific research has looked extensively at the connection between environmental deterioration and real GDP per capita. It is commonly accepted that manufacturing necessitates energy, which in turn drives both economic growth and environmental deterioration (Baydoun & Aga, 2021). Notably, emerging nations have shown remarkable development achievements during the last several decades. Yet, the

high levels of CO₂ emissions resulting from this growing achievement have degraded the natural environment. The burning of fossil fuels for electricity generation and the cutting down of forests are both regular occurrences that result in this emission, which in turn adds to the greenhouse effect (Ahmad, Muslija, & Satrovic, 2021). For a long time, there has been debate over how best to balance protecting the environment with fostering economic growth. The "Rome Club" put out the "growth limit" position in 1970, arguing that economic development is unsustainable given the state of natural resources and that we should reduce the pace of economic growth in the interest of protecting the environment (Bo, 2011). Due to the robust expansion of the world economy, total emissions in 2012 increased to 34.5 billion tons, a 1.4% rise over the previous year. Urban energy-related activities, especially in developing nations, are a key driver of the rising rate of carbon dioxide emissions (Bekhet, Matar, & Yasmin, 2017).

The emissions challenge might be managed most directly by reducing energy usage, however doing so could have unintended consequences, such as slower economic development. This is due to a strong correlation between rising GDP, energy consumption, and carbon dioxide emissions (Saboori & Sulaiman, 2013). The emissions-income correlation is a useful shorthand for describing the environmental effects as income increases (Ahmad, Muslija, & Satrovic, 2021). The consequences of financial development on economic growth are relevant to understanding the link between financial development and CO₂ emissions. Changes in the financial system will boost economic development, which will increase the need for energy, which will increase industrial production, consumer spending, and pollution (Alper & Onur, 2016).

Considerable study has been conducted over the past three decades on the correlation between energy consumption and economic development, along with the correlation between economic growth and environmental damage. Yet, the empirical data is still not convincing and cannot be used to make policy suggestions that can be implemented in different nations (Anwar, et al., 2022). There has been a resurgence in the number of scholarly works that compare factors like economic development and carbon dioxide emissions with environmental performance (Izzaty, Astuti, & Cholimah, 2019). The environmental impacts of rising economies and rising energy use vary greatly among countries and regions (Iorember, Goshit, & Dabwor, 2020). Growing performance and environmental protection are not in conflict as it may produce the finances required to solve environmental concerns. Much emphasis has been paid to the association between greenhouse gas emissions and economic growth when discussing policies to decrease emissions. In 2012, GDP growth and CO₂ emissions stopped rising, suggesting a shift away from fossil fuel-intensive activity (Alvarado Perez, 2018). It also demonstrates progress in energy efficiency and the utilization of renewable sources. Ninety percent of carbon dioxide emissions result from burning fossil fuels, making them directly tied to the quantity of energy used or expended (Bekhet, Matar, & Yasmin, 2017). Multiple variables, including increased willingness to pay for environmental preservation at higher income levels, contribute to economic development associated to decreased pollution (Alvarado Perez, 2018). In addition, the rate of environmental decline is affected differently by globalization, energy consumption, economic growth, and financial development (Baydoun & Aga, 2021). Alper & Onur (2016) claimed that financial growth safeguards environmental quality by boosting revenue and capitalization, and by making use of new technologies and adhering to environmental standards.

In recent decades, research has examined the link between anthropogenic emissions and per capita income. This is particularly true when rising countries strive to accelerate economic growth, regardless of whether it raises anthropogenic emissions. Changes in the ecology and global climate disturbances may be ascribed to this (Satrovic, Ahmad, & Muslija, 2021). With this context in mind, the 1990s have seen a surge in interest in scientific investigations of the link between economic prosperity and environmental deterioration. In 1991, Grossman and Krueger's found a connection between rising prosperity and deteriorating ecosystems. Grossman and Krueger proposed the income-degradation relationship in the environment. The first phase sees a rise in wealth and a rise in anthropogenic emissions. The second phase shows that anthropogenic emissions begin to decline after a threshold level of prosperity is reached (Satrovic, Ahmad, & Muslija, 2021). There have been scholars that have investigated this subject extensively, particularly the EKC phenomena. To rephrase, environmental deterioration increases with national income, production, and GDP per capita till the peak or threshold is reached, after which environmental degradation begins to drop (Riti, Song, Shu, & Kamah, 2017).

A substantial body of research has followed Grossman and Krueger's lead in concluding that energy use, GDP growth, and CO₂ emissions are all interconnected. To sum up, one may say that the earliest stage of economic growth will untangle environmental effects (Koondhar, Shahbaz, Memon, Ozturk, & Kong, 2021). Several research have discovered a causal loop between GDP expansion, CO₂ emissions, and energy consumption, whereas other studies have drawn one-way causal connections between GDP expansion and energy expansion and CO₂ emissions. Yet, the findings of the Granger causality test varied widely, with some studies failing to find a between the two variables at all (Al-Mulali, Weng-Wai, Sheau-Ting, & Mohammed, 2015).

The GCC member states are widely recognized for their heavy reliance on oil and gas reserves, which have been the primary engines driving their economic growth. However, the rapid economic expansion in these countries has also led to increased energy consumption and carbon emissions, contributing to the global issue of climate change. The interplay between GDP and climate change in the GCC nations has garnered significant attention from researchers, policymakers, and stakeholders. This essay delves into the causal relationship between GDP and climate change in GCC nations, drawing insights from the existing literature.

The initial study of (Al-Iriani, Energy–GDP relationship revisited: An example from GCC countries using panel causality, 2006) delves into the causal link between GDP and energy consumption across the six GCC nations, employing a panel causality method. The research identifies a robust causal connection between energy consumption and GDP in these nations, implying that energy usage significantly influences economic growth. Moreover, it reveals a one-way causal relationship from energy consumption to overall income in three countries (namely, Kuwait, Oman, and Qatar), corroborating the "growth hypothesis." Conversely, Bahrain exhibits a different causality direction aligned with the "conservation hypothesis." Saudi Arabia presents a feedback mechanism, indicating a robust causal link between energy consumption and GDP.

Another study by (Waha, et al., 2017) underscores the Middle East's vulnerability to climate change impacts. It asserts that the region faces considerable susceptibility to climate change due to its arid and semi-arid climate, water scarcity, and reliance on oil and gas resources. The study underscores the imperative of adopting a comprehensive and integrated approach to tackle climate change challenges in the region, encompassing both adaptation and mitigation strategies.

(Hossain, 2021) Explores the dynamic cointegration and causality relationships between global mean sea level and climate change. It identifies a long-term equilibrium connection between global mean sea level and climate change, suggesting that climate change significantly contributes to rising sea levels. The research also identifies a one-way causal relationship from climate change to sea level rise, underscoring the pivotal role of climate change in driving sea level elevation.

Moreover, (Coers & Sanders, 2013) reassesses the causal relationship between per capita energy consumption and GDP in GCC countries, while also considering capital and labor. The study uncovers a compelling causal nexus between energy consumption and GDP in these nations, highlighting energy consumption's pivotal role in economic growth. Additionally, it reveals varying causality directions among countries, with some demonstrating a one-way causal link from energy use to GDP, while others reveal a bidirectional causal relationship.

The (Ameyaw & Yao, 2018) study scrutinizes the influence of GDP on CO₂ emissions and provides forecasts for total CO₂ emissions in Africa through a non-assumption-driven bidirectional long short-term memory approach. It detects a positive association between GDP and CO₂ emissions in five West African countries, emphasizing the significant impact of economic growth on CO₂ emissions in these regions. The study underscores the necessity of adopting sustainable economic growth and environmental policies to mitigate the environmental consequences of economic expansion.

In addition to that, (Magazzino & Elliott, The relationship between real GDP, CO₂ emissions, and energy use in the GCC countries: A time series approach, 2016) investigates the relationship among real GDP, CO₂ emissions, and energy consumption in the six GCC countries using a time series methodology. It reveals a robust causality connection between real GDP, CO₂ emissions, and energy usage in GCC nations,

emphasizing the interconnected nature of economic growth, energy consumption, and carbon emissions. Additionally, it uncovers variations in causality directions among countries, with a one-way causal link from energy consumption to aggregate income in three countries (Kuwait, Oman, and Qatar), while the opposite causality is observed in Bahrain.

In summary, the existing literature provides compelling evidence of a robust causal connection between GDP and climate change in GCC countries. The causality direction exhibits variability among nations, with some demonstrating a unidirectional causal link from energy consumption to overall income, and others showcasing a bidirectional causal relationship. These studies underscore the importance of adopting sustainable economic growth and environmental policies to strike a balance between economic prosperity and environmental preservation, a consideration of utmost significance for policymakers and stakeholders in GCC countries.

2.5 Theoretical Framework: Environmental Kuznets Curve Hypothesis (EKC)

Essentially, EKC is the main tool for studying environmental deterioration (Halliru, Loganathan, Golam Hassan, Mardani, & Kamyab, 2020). Discussions regarding sustainable development have led to a lot of focus in the literature on the EKC hypothesis framework on the connection between economic growth, energy (fossil energy) usage, and environmental deterioration (Iorember, Goshit, & Dabwor, 2020). Per capita GDP and environmental degradation are hypothesized to have an inverse U-shaped connection, based on this theory. A rising standard of living is associated with environmental deterioration at the outset of economic growth, but this declines when

incomes rise above a specific threshold. This EKC theory is intriguing because it suggests that economically developing nations may be able to slow the rate of environmental deterioration and perhaps see improvements in environmental quality (Zmami & Ben-Salha, 2020). The EKC explores the relationships between financial status and ecosystem function (Anwar, et al., 2022).

In 1955, Simon Kuznets published his hypothesis on how income is distributed, from which this EKC connection is derived (Barbier, 1997). Economist Simon Kuznets came up with the first "Kuznets curve" (KC). In the 1940s, Kuznets found a correlation among an indicator of income disparity and economic development (Magazzino C. , The relationship between real GDP, CO2 emissions, and energy use in the GCC countries: A time series approach, 2016). To clarify his position on how GDP per capita growth relates to income disparity, Kuznets proposed the inverted U-shaped Kuznets Curve. This theory holds that income disparity rises as a country's GDP per capita rises but falls as income inequality falls (Bo, 2011). Simon Kuznets identified the inverse U-shaped correlation between income inequality and economic growth. At the outset of economic development, economies leave large imprints on their environments. Air pollution, decreasing soil productivity, increased water pollution, etc. are all visible signs of this (Koondhar, Shahbaz, Memon, Ozturk, & Kong, 2021).

The KC assumption, on which the EKC is based, states that the correlation between income and measures of inequality in the distribution of income follows an inverted U-shape (Stern, 1998). There has been a lot of research on the inverted U-shaped link between economic growth and income inequality depicted by the Kuznets Curve. The features of the nation or area under study, the data used (kind and time), and the estimating technique all contribute to yielding varying finding (Maneejuk, Yamaka, & Sriboonchitta, 2021).

The consequences of climate change on the world economy have been a topic of controversy in the economics literature ever since the 1980s. Economic growth and ecological sustainability are linked in a notion known as the EKC (or Kuznets environmental curve) (Emalia, Moniyana, & Asia, 2020), its origins date back to the early 1990s (Isabel & Lucas, 2019). Grossman and Krueger study how GDP per capita relates to several environmental factors. The results demonstrate that economic expansion does not negatively affect ecosystem health. While economic expansion often worsens the environment at first, until a certain breaking point is reached, the opposite is usually true (Emalia, Moniyana, & Asia, 2020). Research discovered no proof that environmental quality continuously declines with economic development. Instead, the study revealed that most variables they looked at showed that economic expansion causes environmental degradation at first, followed by improvement (Alvarado Perez, 2018). Grossman and Krueger suggested an inverse U correlation between income and objective measurements of environmental quality since they discovered a non-linear relationship between the two. They predicted that when GDP per capita climbed, two environmental metrics—SO₂ and smoke—would deteriorate first, but then improve as economic expansion continued (Isabel & Lucas, 2019). Sulfur dioxide and smoke levels were shown to increase steadily with national economic development at a modest level, as determined by their findings. Agras & Chapman (1999) stated that the EKC hypothesis was initially offered by Grossman and Krueger in 1992 and reaffirmed by them in 1995, with energy price being one component that has consistently been ignored in the conception of the EKC link. The link between pollution and energy costs is explained by economic theory and is vividly represented in the following data. Total worldwide CO₂ fell from 1979 to 1982, coinciding with the sharp, temporary increase in oil prices in the late 1970s and early 1980s, when crude oil peaked at \$50 per barrel. Since 1985, although nominal oil prices have remained

stable in the \$15-20 per barrel region, CO₂ emissions have steadily increased. The trend is constant across developing and developed countries. The World Bank validated these findings in 1992 and published them in a paper in 1997 (Koondhar, Shahbaz, Memon, Ozturk, & Kong, 2021). The EKC idea was given more support in the World Development Report in 1992 published by the World Bank. According to the authors, "the perspective that increased economic activity eventually harms the environment is premised on static assertions about technology, tastes, and environmental investments," and "as incomes rise, the demand for improvements in environmental quality will increase, as will the resources available for investment." Others have made even more forceful arguments, such as the following: 'there is strong evidence that, although economic expansion frequently leads to environmental deterioration in the early stages of the process, in the end, the best—and arguably the only—way to achieve a good environment in most nations is to become prosperous' (Stern, 1998). EKC has gained attention as manufacturing increases greenhouse gas emissions (Ahmad, Muslija, & Satrovic, 2021). The research literature on EKC has grown owing to the testing of many environmental indicators (both regional and international), the identification of various justifications for using the EKC connection, and the implementation of various approaches for estimating EKC. In a 1993 publication for the World Employment Programme Research Working Paper series, Panayotou coined the phrase "Environmental Kuznets Curve." Selden and Song were the first to publish using it in 1994 (Agras & Chapman, 1999).

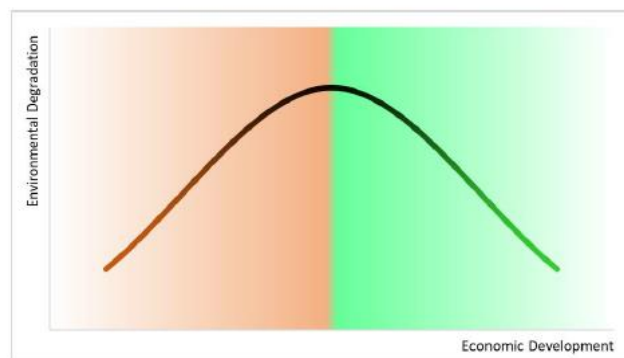
If the economy expands, carbon emissions will rise, yet will this always be the case? According to Grossman and Krueger, economic development results in both environmental degradation and improvement (Yao, Zhang, & Zhang, 2019). Anwar, et al. (2022) found that polluting emissions and other anthropogenic environmental consequences increased with GDP at lower levels of GDP but decreased at a certain

level of GDP per capita. The precise threshold varies across pollutants and economies. When people have a lot of money, they tend to care more about the environment.

(Anwar, et al., 2022) found that polluting emissions and other anthropogenic environmental consequences increased with GDP, but decreased at a certain level of GDP per capita, the rate varies across pollutants and economies. When people have a lot of money, they tend to care more about the environment (Figure 1). During the early stages of economic growth, it was noted that the excessive use of resources and the application of some manufacturing methods may lead to environmental pollution and resource depletion, however the burden on the environment begins to decrease after reaching a certain income point, and the likely result of this is public awareness and concern for environmental issues (Maneejuk, Ratchakom, Maneejuk, & Yamaka, 2020). Another explanation is that the world of the ecological Kuznets curve, pollution increases rapidly during the initial stage of industrialization as people prioritize getting a job and money over better air quality, people don't pay attention to mitigation costs, and environmental regulation is inadequate. The overexploitation of natural resources during the first phase of economic expansion is attributed to the low availability of resources and high levels of pollution in the ecosystems (Koondhar, Shahbaz, Memon, Ozturk, & Kong, 2021). As the economy grows, the scales shift and the environment is given more attention, leading industries grow cleaner, and regulatory agencies become more efficient. Others have claimed a bell-shaped relationship between pollution and economic expansion (Purcel, 2020). Ahmad, Muslija, & Satrovic (2021) clarified that the turning point is simultaneous with a drop in pollutant levels for these reasons: despair of an irreversible catastrophe drives up the desire for stricter environmental regulations; the elimination of one source of greenhouse gases leads to the elimination of another; and advances in technology allow for greater output to be achieved with less in greenhouse gas emissions. Bo (2011) presented evidence for the

income elasticity of environment demand, which states that as people's disposable income rises, they become more concerned with living a high-quality life, and so more likely to purchase environmentally friendly goods. Thus, the government will enact more stringent rules of environmental protection, ultimately leading to an improved environmental level. It has been emphasized in several studies of EKC that income elasticity of environment demand is a crucial component in reducing pollution in the environment.

Figure 3: Environmental Kuznets Curve



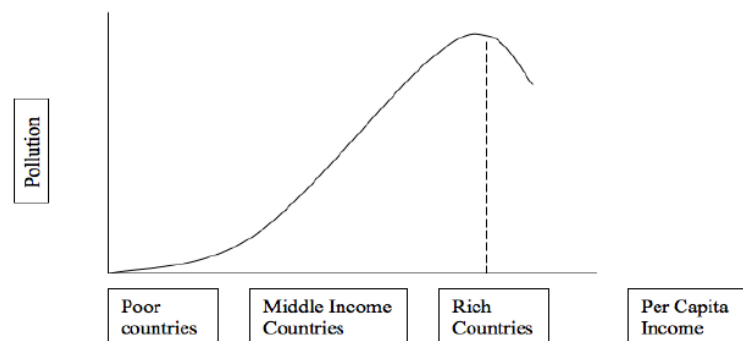
Source: (Maneejuk, Ratchakom, Maneejuk, & Yamaka, 2020)

Multiple explanatory variables in the proposed model and econometric estimating approaches may account for the wide variety of connections seen in later empirical research, including N-shaped, U-shaped, and inverted U-shaped curves (Alsamara et al., 2018). Due to its "N" form, environmental degradation is typically worsened once more after a period of restoration (Bader & Ganguli, 2019). The EKC theory represents a significant intellectual challenge. There are a variety of fundamental links that have been examined in an effort to explain why environmental degradation rises as income rises and subsequently falls again, including (Barbier, 1997): forms of environmental

deterioration and ecological processes; the relationship among desire for environmental quality and income; the consequences of underlying economic changes on the usage of the ecosystem for resource inputs and to assimilate waste.

The de-linking theory is proposed because of the widespread availability of technology and finance in developed countries. The term "de-linking" describes separating environmental effects from economic expansion. Capital-intensive economies like those in industrialized countries, the reasoning goes, have access to the funds necessary to invest in environmentally friendly technology. This results in disentanglement because once developed nations cross a certain threshold, they can afford to implement these costly but effective measures to slow the rate of environmental deterioration. While developed nations have the resources to put these innovations into practice, underdeveloped nations do not. In Figure 2, the inflection point indicates the income at which environmental deterioration becomes detached from economic development. The term for this is "threshold level" (Murthy & Gambhir, 2018).

Figure 4: A hypothetical global EKC



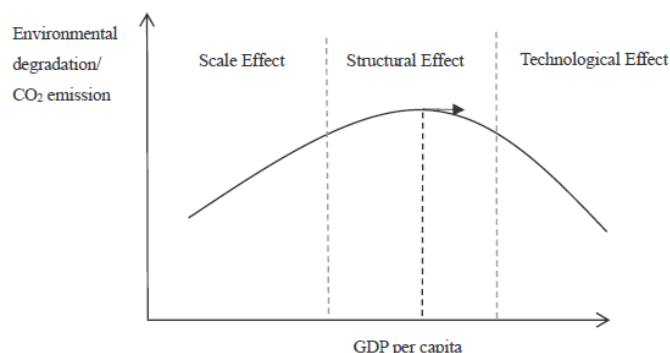
Source: (Murthy & Gambhir, 2018)

Some have contended that there are two phases to the connection between economic growth and environmental degradation. The first stage is characterized by an increase in environmental deterioration alongside rising levels of real GDP per capita. Whereas in stage two, the per capita GDP keeps rising, environmental deterioration begins to slow down once it reaches a certain point (Alsamara et al., 2018).

In contrast, other researchers refer to the ECK hypothesis to three stages. First, is the "scale effect" (energy consumption has been directly correlated with greater economic activity), second, is the "composition effect" (alterations to the economic system that promote either dirty or clean products), and last is the "technique effect" (replace harmful methods with greener ones) (Halliru, Loganathan, Golam Hassan, Mardani, & Kamyab, 2020). Grossman and Krueger break down the environmental impacts of economic expansion into three phases. It's important to first consider the scale impact which is referred to as the (scale effect). Rapid economic expansion is detrimental to ecological health because it increases resource and energy consumption and pollutant generation. Second, as the economy grows and society adapts, there will be structural effects which are called the "composition effect", which might be thought of as the impact of these shifts on the natural surroundings. The last phase is called the "technical effect". As living standards rise and technological innovation spreads, polluting older methods of production will give way to cleaner alternatives that ultimately benefit the environment (Baydoun & Aga, 2021). To this end, EKC may be seen as a curve in which the negative scale impact is most prominent at the outset, followed by the positive structural and technical effect, and finally by the structural and technical effect itself, which will ultimately outweigh the scale effect. Therefore, environmental contamination worsens at the outset, but then improves as income rises (Bo, 2011).

To sum up, economic expansion has scale, structural and technical effects on environmental pollution and carbon emission (Figure 5) (Yao, Zhang, & Zhang, 2019).

Figure 5: Environmental Kuznets Curve



Source: (Yao, Zhang, & Zhang, 2019)

Numerous articles have investigated the possibility of a connection between CO₂ and income. Much research has been conducted to test the reliability of the EKC connection, and they have shown conflicting results. Several researchers have discovered a connection between the state of the environment and economic success (Bader & Ganguli, 2019), whereas others argued that there is no solid link among them (Alsamara et al., 2018).

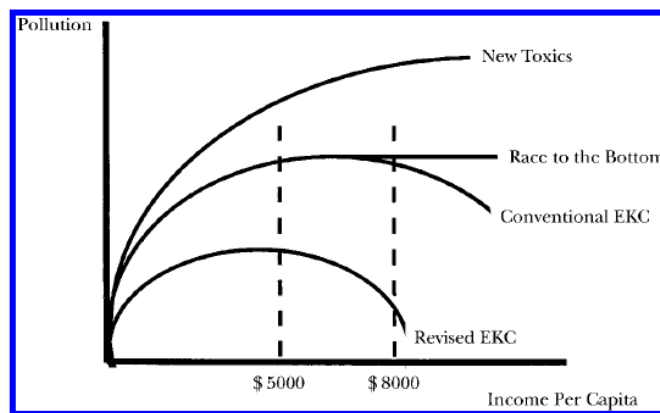
Promoters of the EKC theory claim that rates of land clearing, resource usage, and waste production per capita grow fast with expansion, although they are relatively modest at extremely low levels of economic activity (Emalia, Moniyana, & Asia, 2020). In advanced economies, environmental deterioration levels off and even declines because of fundamental shifts into information-intensive businesses and services, more implementation of environmental legislation, improved technology, and

larger financial investments in environmental protection. Consequently, the EKC connection has proximal effects, which includes shifts in education, economic model or product portfolio, innovation, and resource usage, environmental awareness, and legislation. The scale effect of increased economic activity is mitigated by several factors (Stern, 1998). The Kuznets hypothesis, which states that when nations grow, some indicators of the quality of life could at first decrease before improving, has seen renewed notice due to environmental concerns (Munasinghe, 1999). Advancements in environmental quality in high-income nations are indicative of rising public demand for such measures; this trend suggests that as economies expand, so do the needs of their residents for further focus on noneconomic components of their everyday lives. The wealthiest nations, which frequently enjoy better environmental quality, do have stronger legislative environmental regulations. This contrasts with the underdeveloped nations, several of which yet confront environmental difficulties (Alvarado Perez, 2018). The unsustainable growth of cities and their unsustainable use of natural resources has been linked to environmental destruction, according to several scientific research. Instead, other researchers have shown that encouraging urbanization slows down environmental deterioration over time, lending credence to the EKC concept (Wang, Wang, & Li, 2022).

On the other hand, the counterargument is based on research that either disprove the hypothesis or fail to detect the expected inverted U-shaped association between income and environmental deterioration (Dasgupta, Laplante, Wang, & Wheeler, 2002). Numerous critics have challenged the conventional EKC, both as a representation of what happens in the development process and as a policy prescription. Negative opponents have argued that the EKC can only be inferred from cross-sectional data, which only captures a static moment in time. Globalization, they argue, encourages a "race to the bottom" in environmental norms, such that eventually the curve will climb

to a horizontal line at maximum existing pollution levels, as shown in (Figure 6). However, some pessimists argue that the creation of new, uncontrolled, and possibly dangerous pollutants is inevitable in a nation as industrialized, even if certain toxins are decreased as money grows. In their opinion, the "new toxics" line shows that the environmental pressures out of these new pollutants likely keep growing even if other sources of pollution are eliminated. Both pessimistic philosophies have valid points, but none has provided strong evidence to support them. The traditional EKC has been criticized, but recent findings have inspired encouraging criticism. In (Figure 6), the "updated EKC" illustrates how these latest findings imply that the slope of the curve is really declining and moving to the left, as expansion creates fewer pollution in the early phases of industrialization and pollution begins reducing at lower income levels.

Figure 6: Environmental Kuznets Curve – Different Scenarios



Source: (Dasgupta, Laplante, Wang, & Wheeler, 2002)

For instance, Hsing and Smyth in 1994 used U.S. data, and they analyzed the inverted U-shaped curve of income inequality and economic progress and discovered no

statistically significant connection between the two variables. In addition, the investigations of Deininger and Squire (1996), Easterly (1999), and Dollar and Kraay (2002) provided more proof that the Kuznets curve does not occur (Maneejuk, Yamaka, & Sriboonchitta, 2021). In parallel, Halkos and Tzeremes (2009) have assessed the ecological performance of 17 OECD nations from 1980 to 2002, the study found no correlation between pollution prevention and economic growth (Bader & Ganguli, 2019).

2.5.1 Definition

The following table presents the scientific definitions of EKC as found in several scientific studies.

Table 1: Environmental Kuznets Curve Hypothesis Definition

#	Year of the study	Authors	Definition
1	2022	(Wang, Wang, & Li, 2022)	The EKC focuses on the complex interplay between environmental health and prosperity. According to the EKC theory, a rising economy leads to a fall in environmental quality, followed by a gradual improvement.

2	2022	(Anwar, et al., 2022)	The EKC theory suggests that environmental deterioration and economic development follow an inverted U-shaped interaction. To rephrase, environmental degradation rises initially as GDP per capita rises, but falls as GDP per capita rises more.
3	2021	(Koondhar, Shahbaz, Memon, Ozturk, & Kong, 2021)	According to the EKC hypothesis, a direct line may be drawn from economic growth to environmental quality decline. That is to clarify, EKC is a standard method for tracing the interconnections among economic development and environmental conservation.
4	2021	(Ahmad, Muslija, & Satrovic, 2021)	The EKC model shows a nonlinear relationship between income and human-caused pollution. The first phase finds the environment deteriorate as the economy expands. In contrast, the second phase creates conditions under which a country's economy takes measures to protect the environment properly. Thus, more economic activity

			may be viewed as both a cause and a solution to climate change.
5	2021	(Maneejuk, Yamaka, & Sriboonchitta, 2021)	According to the EKC hypothesis, there is a defining moment in the relationship between economic growth and environmental degradation. Initially, economic growth is harmful to the environment because of the rise in economic activities; however, once the economy has developed to a sufficient level, the environmental quality returns to its pre-growth levels. EKC is a spin on the Inverted-U Curve idea of how rising income disparity contributes to a rising economy.
6	2020	(Ansari, Ahmad, Siddique, & Mansoor, 2020)	There are essentially two phases to the relationship between economic growth and pollution in the environment. The environmental deterioration of a nation is reported to "follow an inverted U-shape curve, with steeper degradation occurring at the beginning of the growth stage and shallower degradation occurring once the economy has reached

			a particular threshold. The term "EKC theory" describes this occurrence.
7	2019	(Destek & Sarkodie, 2019)	As stated by the EKC theory, environmental deterioration and economic development have an inverse U-shaped connection. This correlation suggests that economic growth and development worsen environmental quality in the beginning but improve it once per capita income attains a certain level. Thus, it suggests that as civilization progresses, environmental deterioration increases at first but thereafter decreases.
8	2019	(Bader & Ganguli, 2019)	EKC illustrates the cumulative effect of pollution on economic growth. It postulates that as living standards improve, so too do emissions, reaching a peak as prosperity spreads before declining as incomes grow.
9	2018	(Alvarado Perez, 2018)	Different measures of environmental deterioration are linked to lower per capita income in the EKC. This

			hypothesis states that while environmental degradation and pollution tend to rise during the beginning phases of growth, this phenomenon overturns once a specific level of GDP per capita is attained, suggesting that high levels of economic growth are associated with improved environmental conditions.
10	2018	(Alsamara, Mrabet, Saleh, & Anwar, 2018)	In accordance with the EKC hypothesis, the correlation between per capita real GDP and environmental deterioration takes the form of a reversed U.
11	2011	(Bo, 2011)	As stated in the "World Development Report 1992" EKC is the theory that more economic activity results in more environmental degradation because individuals will dedicate more attention to environmental issues and resolve them as their income rises. This theory assumes that technological progress, consumer tastes, and environmental investment will all remain stable. To sum up, a thriving economy will cause

			environmental conditions to degrade before they recover.
12	1999	(Agras & Chapman, 1999)	According to the EKC theory, pollution levels rise during the early stages of economic development but begin to fall once a nation's per capita income reaches a certain threshold. The correlation among pollution and GDP is depicted as an inverted U-curve.
13	1997	(Barbier, 1997)	According to the EKC hypothesis, certain measures of environmental degradation or resource scarcity correlate negatively with rising standards of living. That is, when GDP per person rises, environmental damage worsens at first, then improves.
14	1997	(Cole, Rayner, & Bates, 1997)	A key tenet of the EKC theory is that rising prosperity is associated with a corresponding increase in environmental degradation. There may be a diminishing marginal shift in pollution as a function of higher per capita incomes as a result of alterations in the output mix, the

			adoption of greener industrial equipment, and increased public demand for stronger limits on emissions.
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Source: Author

2.5.2 Variables

There has been a significant uptick in the number of theoretical and empirical investigations on the EKC hypothesis and its variants throughout the years. Scientists have spent a considerable amount of time trying to figure out what factors influence the correlation between environmental deterioration and economic growth. Various scholars make arguments relying on their intuitive understanding of economics. On the contrary, other researchers construct different theories with solid assumptions and/or constraints that result in a bell-shaped relationship between pollution and economic development (Purcel, 2020). The income at the inflexion point of EKC fluctuates with respect to various pollution indicators (Bo, 2011). The EKC is influenced by or contributes to several external circumstances. Various plausible causes for the inverted U-shaped association between an economic indicator and some environmental variables are shown by the certain variables. Isabel & Lucas (2019) discovered that the most important factors in explaining the EKC, which are:

- The desire for environmental quality and income elasticity.
- The scale, technology, and compositional effects on the economy.
- Trading between countries.
- Environmental norms and regulations.

- Estimation-supporting empirical considerations.

Research studies confirmed that environmental quality immediately related to human well-being and tend to increase with rising income, yet this trend holds although if environmental concerns are externalized, at greater levels of income. Therefore, while thinking about the connection between economic growth and ecological shifts, it is crucial to use appropriate indicators (Bo, 2011).

When assessing the state of the planet, pollution measures including carbon emissions are frequently used (Wang, Wang, & Li, 2022). Greenhouse gas (CO₂, methane, nitrous oxide, as well as other gases), marine pollutant, and excrement indicators have all been used in past research to quantify environmental destruction in EKC (Emalia, Moniyana, & Asia, 2020). Total suspended particulates (TSP), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO), oxygen (O₂) regimes, fecal contamination, and heavy metals in rivers are the most researched contaminants (Isabel & Lucas, 2019). Not all indicators of environmental degradation fit the EKC hypothesis. One of the most notorious for conflicting results has been carbon dioxide (CO₂) emissions (Barbier, 1997).

Among these factors, CO₂ is the most widely employed in EKC studies conducted for a wide variety of countries and regions (Destek & Sarkodie, 2019). Based on Purcel (2020), most empirical research on environmental deterioration has relied on carbon dioxide emissions as a proxy. Researchers may have paid more attention to the effects of carbon dioxide because of its significance to climate change and the abundance of information about it. Numerous attempts to conduct research grounded on the EKC theory have incorporated CO₂ emissions as the variable representing the extent of environmental damage, as shown, for example, in the works of (Maneejuk, Ratchakom, Maneejuk, & Yamaka, 2020). Most greenhouse gas (GHG) emissions come from

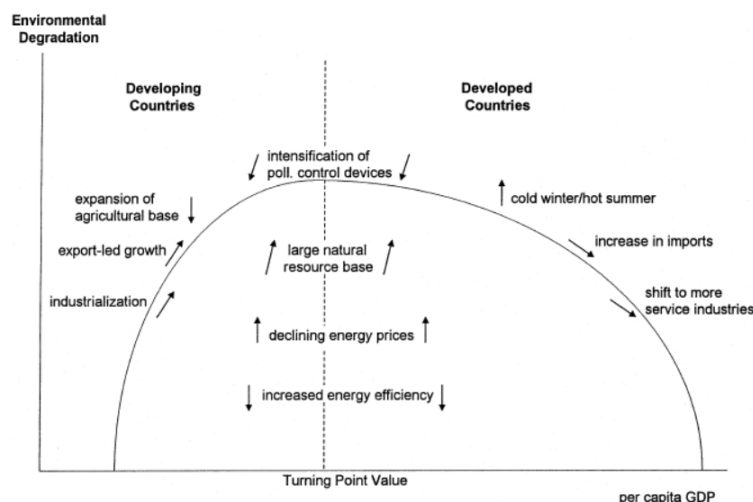
combustion processes, and they have global impacts. Between 1970 and 2010, 78% of all greenhouse gas emissions were caused by CO₂ released from burning fossil fuels, from 1950, the world's average temperature has been rising due to these emissions, causing climate change and having consequences for the natural and built ecosystems across all continents and seas (Isabel & Lucas, 2019). Various investigations have employed both CO₂ and sulfur dioxide (SO₂) emissions to test the EKC hypothesis, considering emissions of SO₂, N₂O, and CH₄, several research have corroborated the EKC concept. While using SO₂ emissions as an indicator of environmental quality, however, some have suggested that the EKC hypothesis is not consistent (Alsamara, Mrabet, Saleh, & Anwar, 2018).

Findings for SO₂ in especially, and to a lesser extent solid particle matter (SPM), validates the presence of the EKC for these pollutants, suggesting that the EKC theory is mostly true for air pollution indicators, with the possible exception of CO₂ emissions (Barbier, 1997). Nonetheless, a variety studies have employed additional indicators of environmental damage, including methane (CH₄) emissions, sulfur dioxide (SO₂) emissions, nitrous oxide (N₂O) emissions, deforestation, and the ecological footprint (which measures the total area of land and water that has been degraded) (EF) (Alsamara, Mrabet, Saleh, & Anwar, 2018). Based on Destek & Sarkodie (2019), most studies on EKC have used CO₂ emissions as a proxy for environmental deterioration, in fact, deterioration of the soil stock, forestry stock, mining stock, oil stock, and so on are among a few examples of the many forms of environmental degradation.

(Figure 7) is a visual representation of the pressure exerted on the EKC relationship. The initial EKC assessments track the rise of low-income nations as they transition from agriculturally based to industrial economies, and the fall of industrial nations as

they enter the post-industrial era characterized by a greater emphasis on services (Agras & Chapman, 1999).

Figure 7: Conflicting dynamics of the EKC curve



Source: (Agras & Chapman, 1999)

It is possible to classify the research done about the EKC connection into three distinct categories. At the most fundamental level, scientists find a correlation between environmental deterioration and real GDP and real GDP squared. Research that expands the primary correlation to incorporate energy use as an extra interaction forms the second subset. As in third category includes analyses that improve upon the EKC formula by introducing new variables (such as financial development, trade openness) (Alsamara, Mrabet, Saleh, & Anwar, 2018).

Empirical findings from these studies may vary depending on the environmental indicators chosen. Commonly used indicators include exhaust gases, wastewater, garbage, and traffic patterns, employing potential harmful gas indicators including

sulphur dioxide (SO₂), particulate matter (PM), carbon monoxide (CO), and nitrogen oxide (NO₂). Certain wastewater variables seemed to have an inverted U-shaped relationship with both income and other indicators, whereas others looked to have an N-shaped relationship with both. Some indicators, such as solid waste, energy use, and traffic flow, did not back up the EKC theory, as claimed by (Bo, 2011). Moreover, the linkage amplifies several other crucial factors of the environmental indicator, such as energy consumption and globalization, as further research supports globalization in respect of trade. Various empirical studies examine the feasibility of the EKC hypothesis and the influence of energy consumption, globalization, and trade openness for a variety of panel and single-country situations (Ansari, Ahmad, Siddique, & Mansoor, 2020).

Latest research has investigated the "energy-environment-growth nexus" in EKC paradigm, which uses ecological footprint as a measure of environmental quality (Alsamara, Mrabet, Saleh, & Anwar, 2018).

An ecological footprint may be used to calculate how much of the Earth's regenerative biological capacity is used up by human activities including resource utilization and product creation at a specific time and place, some authors stated that the ecological footprint, proposed by Wachernagel and Rees in 1996, has the capability to provide a more accurate reflection of environmental impact, where Cropland, grazing land, fishing grounds, forest land, developed land, and CO₂ emissions are all included in the total, as are the other six components that make up a person's carbon footprint (Destek & Sarkodie, 2019). Multiple academics have tried to assess the validity of the EKC hypothesis for various groups/single nations by utilizing ecological footprint as an indication of environmental deterioration. Depending on the methodology used, investigations can either corroborate or refute the EKC hypothesis of an inverted U-

shaped pattern (Ansari, Ahmad, Siddique, & Mansoor, 2020). That was also emphasized by (Alsamara, Mrabet, Saleh, & Anwar, 2018) to rather than using isolated metrics to gauge environmental effect, recent studies have begun to use more comprehensive measures, such as the ecological footprint.

Recent research has explored new environmental quality metrics to further evaluate the EKC theory with the indicators previously described. Instances include fossil fuels, nuclear power, and transportation fuels; endangered animal and bird species; the percentage of species that have been preserved as a measure of biodiversity (Isabel & Lucas, 2019). Moreover, Alvarado Perez (2018) argued that the diverse nature of pollutants including CO₂ and their potential for externalization owing to global mixing of GHGs meant that they might not be included in the political variables driving a local EKC, which include voters seeking cleaner air and better environmental conditions.

It is important to mention that human development in specifically has been credited as a key factor in the expansion of the global economy. The EKC framework allows for Human Development (HD) to be recognized as a contributor to long-term economic growth as research results point to HD dimensions as a major factor in the EKC model. Moreover, sustainability's is an essential extra lens that has to be closely examined and linked to the quality of institutions and investments to boost growth (Farhani, Mrizak, Chaibi, & Rault, 2014).

2.5.3 Model

Cross-sectional and panel data analyses are useful in analyzing the EKC hypothesis. This paper follows Dinda's (2004) suggestion of using country-specific time-series

data, since it helps understand the relationship between economic development and pollution which are specific to a country (Bader & Ganguli, 2019).

Several research, using a variety of econometric techniques and focusing on various geographical areas, have investigated the reliability of EKC (Al-Mulali, Ozturk, & Solarin, 2016). Two main kinds of proof have been the subject of empirical investigations on the EKC (Barbier, 1997):

1. Verify whether there is an 'inverted-U' correlation between per capita income and a particular environmental variable.
2. Finding the "tipping point," or the amount of per capita income at which the EKC "peaks," meaning that further changes in the indicator of environmental deterioration have no effect.

That was also approved by (Barbier, 1997), that analysis of EKC turning points can provide two important pieces of information:

1. The projected per capita income at the tipping point may be compared with the real income levels of the observable given dataset, showing if the income at the tipping point is within or beyond the recorded income range.
2. It is possible to gain insight into the accuracy of the EKC calculations by an examination of the stability of the turning point.

The Kuznets hypothesis has been studied and calculated with several different methods. Regression models such as autoregressive distributed lag model (ARDL) and the error correction model, upon which most of the empirical research are based, have a linear rigid quadratic structure (ECM). The Kuznets hypothesis has been investigated explicitly by the modification of linear regression to quadratic regression, which

permits the examination of the nonlinear connection among economic growth and income disparity.

To employ panel data to empirically evaluate the EKC model, comparable evolution paths across individuals are required, hence time-series data or panel data in which the environment has also evolved similarly is preferable (Bo, 2011). All these models have the commonality of using an estimated quadratic or log quadratic connection between environmental degradation and per capita income to validate the inverted-U shape of the EKC (Agras & Chapman, 1999).

Real per capita income (Y) as well as other variables (Z) (population density (D), trade (X), investment (Y), etc.) are examined in connection to some measure of environmental degradation (ED) as follows (Agras & Chapman, 1999):

$$\ln(ED_{it}) = a_i + y_t + \beta_1 \ln(Y_{it}) + \beta_2 \{\ln(Y_{it})\}^2 + \beta_k \ln(Z_{it}) + \epsilon_{it}$$

At which a_i is a constant country or site-specific effect, y_t is a constant temporal effect, i is an index of countries, t is an index of times, and ϵ_{it} is a stochastic error factor. Value of the tipping point is given by $Y(TP) = e^{-\beta_1/\beta_2}$, where β_1 is the income coefficient and β_2 is the income squared term coefficient. The whole model is represented by (Eq. 2):

$$\begin{aligned} \ln(ED_{it}) = & a_i + y_t + \beta_1 \ln(ED_{it_1}) + \beta_2 \ln(Y_{it}) \\ & + \beta_3 \ln(Y_{it-1}) + \beta_4 \{\ln(Y_{it})\}^2 \end{aligned}$$

$$\begin{aligned}
& +\beta_5 \{\ln(Y_{it} - 1)\}^2 + \beta_6 \ln\left(\frac{M}{GDP}\right)_{it} \\
& +\beta_7 \ln\left(\frac{M}{GDP}\right)_{it-1} + \beta_8 \ln\left(\frac{X}{GDP}\right)_{it} \\
& +\beta_9 \ln\left(\frac{X}{GDP}\right)_{it-1} + \epsilon_{it}
\end{aligned}$$

2.6 Previous Studies

(Al-Mulali, Weng-Wai, Sheau-Ting, & Mohammed, 2015) This study utilizes the ecological footprint as an indicator of environmental degradation to have a better understanding of the relationship between environmental degradation, energy consumption and GDP growth. In addition, this study investigates ninety-three countries, categorizing them by income level because the ecological footprint varies between countries based on their income levels. The study examines EKC hypothesis using the country environmental footprint as an indicator of environmental degradation. Ninety-three countries have been screened, classified by income. The consistent effects and generalized method of moment results clearly showed a reverse U-shaped relationship between the environmental footprint and GDP growth, which represents the EKC hypothesis in middle- and high-income countries but not in low- and middle-income countries. This relationship occurs only at the stage of economic development, where technologies that improve energy efficiency, energy savings and renewable energy are available, and which are inaccessible to low-income countries because of their high cost. Furthermore, energy consumption, urbanization and trade openness increase environmental damage through their positive impact on the environmental footprint of most countries across all income groups.

(Magazzino C. , 2016) This study investigates the relationship among CO₂ emissions, economic growth, and energy use in 10 Middle East countries over the period 1971–2006. The empirical strategy uses a recent panel VAR approach. Correlation analysis shows that pairwise correlation coefficients between these three variables are higher in the subgroup of four non-GCC countries than in the six GCC members. Further, the three-variable VAR estimates underline that for the six GCC countries the response of economic growth to CO₂ emissions is negative in the estimated coefficients and impulse responses. For the other four non-GCC countries, the result is the response of real GDP: neither CO₂ emissions nor energy use seems to have an impact on growth, which is determined by its own lagged values. The authors conclude that energy is a limiting factor to economic growth and, hence, shocks to energy supply will have a negative impact on economic growth. For the remaining four non-GCC countries, the authors found that forecast errors in energy use are mainly due to energy use itself. This suggests that different strategies are required for GCC and non-GCC countries to implement reform of energy sector.

(Dogan & Turkekul, 2016) This study examines the relationship between CO₂ emissions, energy consumption, real output, the square of real output, trade openness, urbanization, and financial development in the USA for the period 1960–2010. To analyse this relationship, the authors used unit root tests to find out the stationarity properties of the analysed variables, the ARDL bounds testing approach to explore the possible cointegration between the variables, and short-run and long-run estimates, Granger causality test based on VECM, to reveal the short-run and long run causal relationships between analysed variables. According to the results, the authors claim that urbanization is stationary at level and CO₂, energy consumption, real output, the square of real output, trade openness, and financial development are stationary at first differences. The Granger causality analysis presents that there is strong causal

relationship between gas emissions and real output, energy consumption, and urbanization both in the short run and long run. By putting together the results, the US government should take into account the importance of trade openness, urbanization, and financial development in controlling for the levels of GDP and pollution.

(Saboori, Al-Mulali, Bin Baba, & Mohammed, 2016) Main objective of this study is to examine the EKC hypothesis in the OPEC. This study utilized the ecological footprint as an environment indicator and GDP growth and other macroeconomic variables as economic indicators. A time series model that represents the environmental degradation is established during the period 1977- 2008. Moreover, the Autoregressive Distributed Lag (ARDL) approach and the Toda– Yamamoto–Dolado–Lütkepohl (TYDL) causality test were used. The results concluded that the EKC hypothesis is present in Algeria, Iraq, Venezuela, Nigeria, Qatar and Kuwait. Moreover, oil consumption and income represent a major source of the environmental damage by its significant effect on the ecological footprint. Labour and capital have a significant effect on the ecological footprint as well, which indicates that most of the labour and capital goes towards polluted and energy intensive industries which represent the pollution haven hypothesis (PHH). Based on the PHH, countries with lower environmental regulations produce more pollution intensive goods for consumption than countries with higher environmental regulations. As a result, developing countries increasingly specialize in pollution intensive production and would change to net exporters of pollution intensive goods, thereby deteriorating their environmental quality.

(Magazzino C. , The relationship between real GDP, CO₂ emissions, and energy use in the GCC countries: A time series approach, 2016) This study has used several time series econometric techniques to explore the relationship between real GDP, CO₂ emissions, and energy use in the six GCC countries, for 1960–2013 years. Causality

tests show for three countries (Kuwait, Oman, and Qatar) a unidirectional causal link, running from energy use to the aggregate income, giving empirical support to the “energy-led growth hypothesis”. Furthermore, the opposite direction of causality is observed for Bahrain, where “conservation hypothesis” holds. Finally, for Saudi Arabia a feedback mechanism emerges. The “neutrality hypothesis” holds only in the case of the United Arab Emirates. Cointegration results reveal that only for Saudi Arabia the hypothesis of a long-run relationship between these variables could not be rejected. Regarding the forecast error variance decomposition, the shocks in the energy use contribute more to explaining the forecast error variance in real GDP for Kuwait, Oman, Qatar, and Saudi Arabia. Meanwhile, the real GDP has a greater impact on the energy use only in Bahrain. However, given the different causal consequences of the six GCC countries, unified energy policies will not be a good formula for the entire region.

(Jamel & Maktouf, 2017) In this study, the authors empirically investigated the causal connection among GDP, CO₂ emissions, the financial sector development, and trade liberalization. The authors utilized the OLS as an econometric methodology for yearly panel data composed of 40 European economies through the period from 1985 to 2014. The main objective is to empirically inspect the four-way connection among GDP, financial sector development, trade liberalization, and CO₂ emissions by employing four models to examine the consequence of (1) CO₂, financial sector development, trade liberalization, and other explicative variables on GDP; (2) GDP, CO₂, trade liberalization (openness), and other control variables on the financial sector development; (3) financial sector development, GDP, CO₂, and other explicative variables on trade openness; and (4) trade liberalization, the financial sector development, GDP, and other explicative variables on environmental pollutants. The main empirical findings of the study is that GDP and the environmental degradations

are positively and extremely associated. The GDP per capita predicts a positive linkage with gas (CO₂) emissions. Furthermore, GDP per capita promotes the financial sector development. However, GDP can prevent trade openness. The increase in financial development can increase trade openness.

(Bekhet, Matar, & Yasmin, 2017) The study aims to investigate the relationship and causality among economic growth, financial development, CO₂ emissions, and energy consumption in one framework. To test the long-term relationship among the variables, the study employed the ARDL bounds testing approach for the period of 1980–2011. The empirical results proved the existence of a long-term equilibrium relationship among CO₂ and real GDP per capita, energy consumption, and financial development in all GCC countries except UAE. From the short-run disequilibrium among the variables is corrected in each period to return to the long-run equilibrium level. Furthermore, the study reveals that the rate of adjustment in returning to equilibrium for UAE is much faster than for the other GCC countries in absolute value. While in the long run 1% significance level in Saudi Arabia, Oman, Kuwait, and Qatar have been found, but there is no long-run relationship among these variables in the case of UAE and the result is inconclusive for Bahrain. The findings of this study have important policy implications for GCC not only in terms of environmental perspective but also offering the allocation of financial resources for future planning.

(Riti, Song, Shu, & Kamah, 2017) The main objective of this paper is to examine the EKC hypothesis in China as well as to validate or invalidate the consistency of the different estimation results, using same data, over the period 1970–2015 by employing various econometrics techniques such as auto regressive distributed lag (ARDL) approach, dynamic ordinary least squares (DOLS), fully modified ordinary least squares (FMOLS), variance decomposition and impulse responses. The results also

revealed that growth of CO₂ emissions and growth of energy consumption in China is bidirectional in the short depicting a feedback hypothesis. Since global warming is becoming more serious, investment in renewable energies and more efficient energy use are needed to minimize the CO₂ emissions. The most important finding of this study is the consistency of the estimation results from different econometric techniques and the confirmation of the validity of ECKC in China. In all the estimation results, CO₂ emission increases with increase in per capita GDP. Also increase in energy consumption increases CO₂ emission in both short run and long run. However, per capita GDP reduces CO₂ emission in the long run.

(Alsamara, Mrabet, Saleh, & Anwar, 2018) The study aims to extend the existing literature by using two alternative measures of environmental pollution: CO₂ and sulfur dioxide (SO₂) emissions. Specifically, this study examines the EKC relationship in the GCC region by using panel data over the 1980–2017 period, and electricity consumption and openness to trade as control variables. Moreover, this study uses three estimation techniques: the fully modified ordinary least squares (FMOLS) method developed, the pooled mean group (PMG) method and the dynamic common correlated effects (DCCE) estimator. Using the data commission of inquiry in 1980-2017 and two alternative indicators of environmental pollution (CO₂) and (SO₂) emissions. Results indicates evidence of a long-term, U-shaped relationship between real PER CAPITA GDP and both environmental indicators in the GCC region. Short-term analysis at the country level indicates that the EKC hypothesis applies to Bahrain, Kuwait, Qatar, Saudi Arabia, and the United Arab Emirates when using CO₂ emissions as a measure of environmental pollution. However, when CO₂ emissions are used as a measure of environmental pollution, the EKC hypothesis applies to Oman, Qatar, Saudi Arabia, and the United Arab Emirates. Results of the recently developed causality test.

(Murthy & Gambhir, 2018) The study aims to test for the different forms of EKC in the Indian context and to synthesize a model to test for the joint hypothesis of EKC and pollution sanctuary hypothesis (PHH) in the Indian context. The authors have modelled the relationship between GDP and CO₂ emissions (aggregate and per capita) with alternative model specifications to bridge the gap between conventional and modern EKC studies. FDI has a smaller influence in per capita terms, which could be gauged from the respective coefficients, in aggregate and per capita equations. This implies that PHH is not really working at the individual level. However, FDI is more significant in per capita terms, which cannot ignore this phenomenon yet numerically its impact is much smaller. The policy implication is that gains of green technologies are being wiped out by over-consumption of environmentally unfriendly goods. India may be falling into the trap that developed economies already experienced (the N-shaped EKC). In terms of PHH the policy recommendation is clear that indiscriminate introduction and encouragement of FDI that raises the level of pollution is not welcome in India.

(Bader & Ganguli, 2019) The primary objective of this paper is to explore the validity of EKC using time-series analysis for each GCC state during 1980–2012. This will be followed by studying the second objective, which aims to investigate the relationship between health and income in the GCC during the same period. GDP per capita is used to study the level of economic growth in each country. CO₂ nitrous oxide (N₂O) and methane (CH₄). The second part of this paper explores the relationship between GDPs per capita and the following health variables: life expectancy, infant mortality and child mortality in GCC countries during 1980-2012. There is evidence of a U-shaped relationship between environmental pollutants and GDP per capita in Bahrain and Saudi Arabia. The study then explores a potential relationship between health and GDP in the GCC, where high incomes were found to have improved the standard of living,

improving health standards and rising life expectancy. Adequate diversification of GCC economies from their dependence on hydrocarbons will also contribute toward enhanced environmental quality.

(Kasem & Alawin, 2019) This study explains that the energy sector in the GCC countries is the main contributor to CO₂ emissions, which is the major component of GHGs. This research explores the impact of multiple variables on CO₂ emissions, underscoring the importance and necessity of considering reform and regulations to minimize energy consumption. This research empirically examines the impact of renewable energy sources and other factors in the GCC countries in reducing CO₂ emissions, using a consistently impacted combined square slope analysis. Using pooled OLS regression analysis, this research finds that RES contribute in reducing the CO₂ emissions. The results indicate that GDP per capita, REC, and electrical power consumption have a statistically significant impact on CO₂ emissions in the GCC countries. Similar results were found by the FE model, except that GDPC gave the opposite sign. This proves this variable could possibly have different effects as explained earlier. Further studies are crucial to determine this issue. Results indicate that renewable energy consumption, per capita GDP and electricity consumption have a statistically significant impact on CO₂ emissions.

(Destek & Sarkodie, 2019) This study aims to examine the relationship between ecological footprint, economic growth, energy consumption and financial development in 11 newly industrialized countries. For this purpose, the annual period from 1977 to 2013 is investigated using the augmented mean group estimator and heterogeneous panel causality method. It is concluded that an inverted U-shaped EKC hypothesis is supported by the panel of newly industrialized countries. When the estimator results of each country were evaluated, the authors found an inverted U-shaped EKC hypothesis

valid in Mexico, Philippines, Singapore, and South Africa while a U-shaped relationship is found in China, India, South Korea, Thailand, and Turkey. In addition, increased energy consumption leads to an increase in environmental degradation in China, India, Mexico, Singapore, and Thailand. However, the negative coefficient of financial development on environmental degradation is found in China and Malaysia. Causality test results show that there is evidence of a bidirectional causality link between economic growth and ecological footprint. Finally, the authors found one-way causality running from energy consumption to ecological footprint, from ecological footprint to financial development, from economic growth to energy consumption and from economic growth to financial development.

(Magazzino & Cerulli, 2019) The aim of this study is to investigate the relationship among CO₂ emissions, GDP, and energy in the Middle East and North Africa countries over the period 1971–2013. This study presents an evaluation of the effect of economic growth, energy consumption, urbanization, and trade on environmental pollution in the MENA area. this study employs the Responsiveness Scores (RS) approach, a method providing a single-country/single-factor average partial effect. Put simpler, the RS approach allows each country to have its own regression coefficient for each factor considered, in a regression of a given outcome y on Q factors (or predictors). Experimental results indicate that GDP shows per capita energy consumption and positive energy consumption, while trade and urban dwellers are negative. Furthermore, energy consumption and urban dwellers show a moderate increase in volume, while per capita GDP has shown declining positive returns. The study recommended an appropriate environmental and energy policies to attract investment, provide energy security through diversification, spur technological innovation, and enhance stable economic growth. Policies that focus on emission reductions must focus on adjusting the industrial structure and improving energy efficiency.

(Dkhili & Dhiab, 2019) The purpose of this paper is to understand the attitude of the economic growth towards the environmental components: the level of emission of CO₂ emissions and the environmental performance in the context of the GCC countries. This relationship is studied based on the reaction of macroeconomic variables such as foreign direct investment, trade openness, and investment. The authors used the econometric approach embodied by the GMM method on a data panel composed of six GCC countries. The results prove positive unidirectional relations between economic growth and the variable economic growth and environmental performance (EPI), (FDI), (INVEST), (TRAD). Also, the results advanced a negative unidirectional relation with the variable economic growth and CO₂ emissions (CO₂E). The conclusion found for GCC countries proves a positive relationship between the variables of the study except for the variable CO₂ emissions, the results showed a negative relationship. More concretely, the more economic growth improves in countries, the more they release CO₂. This is seen clearly by encouraging foreign investment, open trade, investment. The results don't support the EKC in the GCC countries, and they can't be able to promote the validity of the CO₂ emission against the EKC framework.

(Halliru, Loganathan, Golam Hassan, Mardani, & Kamyab, 2020) This study examines the validity of the EKC hypothesis using utilised panel quantile regressions that captured unobserved individual and distributional heterogeneity to analyse the nexus between pollution, GDP, biocapacity, trade openness, financial development, and human capital in a panel of six ECOWAS countries for the period from 1970 until 2017. Experimental results revealed that the U-shaped relationship between economic growth and CO₂ emissions holds in low, medium, and high-emission countries, contrary to the reversed character-shaped EKC hypothesis U. The findings highlight the need to raise environmental awareness and promote green research and development. Based on the empirical findings of this study, the following conclusions are drawn: First, the EKC

hypothesis is not valid for the ECOWAS countries because the relationship between economic growth and carbon emissions portrays a U-shaped pattern at all quantiles. This signifies that a sustained rise in income via the expansion of economic activities undermines the state of the environment by generating more pollution. The study argued that the sustained economic activities in the region are not being pursued on the path of clean production and economic growth would not automatically clean the environment.

(Alhindawi, Nahleh, Kumar, & Shiwakoti, 2020) This paper aims to develop a multivariate linear regression and double exponential smoothing model for the projection of GHG emissions from the road transport sector in the North America region. The study used the ratio between the number of transportation vehicles (NTV) and vehicle kilometres travelled (VKT). The ratio considers the six modes of transport: light trucks, tractors, motorcycles, passenger cars, buses and single-unit trucks. Examines the relationship between transport CO₂ emissions and energy consumption in road transport and economic activity in Saudi Arabia. The authors verify EKC hypothesis for Saudi Arabia during the period 1971-2011. Traditional unit root tests, unit root tests with stop point, and distributed self-regression boundary testing (ARDL) are used for joint integration and Granger causal tests. The study found that the U reverse relationship does not exist between CO₂ emissions during transport and economic growth in Saudi Arabia. In addition, there is a two-way causal relationship between CO₂ emissions during transport and short/long-term land transport capacity consumption. However, there is only one-way causality ranging from economic growth to the transfer of CO₂ emissions and long-term land transport energy consumption.

(Zmami & Ben-Salha, 2020) This paper represents an empirical attempt to examine the potential determinants of environmental degradation in six GCC countries during the

period 1980–2017. The study examines the role of GDP and its square, energy use, urbanization, international trade, and foreign direct investments in the environmental degradation. The aim of including the square of per capita GDP in the regression is to check the validity of the EKC hypothesis in GCC countries. Results suggest the presence of an inverted-U shaped relationship between per capita GDP and per capita CO₂ emissions, and consequently the validity of the EKC hypothesis in GCC countries. Findings suggest that energy consumption and foreign direct investment have deteriorated the environment in the long run, while urbanization has a negative impact. In the short-run, only foreign direct investments reduce environmental degradation. Accordingly, the Pollution Haven Hypothesis is verified in the long run, while in the short run the Pollution Halo Hypothesis is confirmed for GCC countries. Measures that should be taken include the identification of institutional, technical, and financial obstacles to the development of renewable energy technologies in the region.

(Ansari, Ahmad, Siddique, & Mansoor, 2020) This study aims to investigate the validity of EKC for ecological footprint and to measure the relative effect of energy consumption and globalization on environmental degradation. The authors examined the nexus between economic growth, energy consumption, globalization, and ecological footprint (EF) in GCC countries namely Bahrain, Oman, Qatar, Saudi Arabia and the UAE using the data from 1991-2017. Using the J-Measuring Economy Panel curriculum that looked at issues of heterogeneity and cross-section dependence, all variables were fixed in terms of the first variation using IPS booster CT (CIPS) and the root of the Dickie Fuller CT Booster Unit (CADF) tests. There is a long-term relationship between the examined variables tested using Wester Lund's shared integration test statistics. Our empirical work rejects the existence of EKC hypothesis in the GCC countries. Moreover, consumption of energy and globalization increases the ecological footprint. From the empirical analysis, the paper highlights some key

policy implications to sustain the environmental quality and development of GCC countries.

(Ahmad, Muslija, & Satrovic, 2021) The purpose of this research is to assess the existence of the EKC theory of the U-shaped reverse correlation between real per capita GDP and CO₂ emissions per capita. Moreover, it pursues the investigation of EKC theory's relevance in the developing countries. In this regard, a panel data of selected 11 developing countries, ranging from 1992 to 2014, are compiled and analysed. In specific arrangements: (1) a long-run equilibrium association is tested by using both Pedroni and Westerlund cointegration approaches. (2) The fully modified ordinary least squares (FMOLS) is applied for long-run parameter estimations. At the same time, the pooled mean group (PMG) approach is used as an empirical counterpart for the robustness check. (3) The short-run is investigated by the Dumitrescu-Hurlin causality approach. It has shown that these countries need to design targeted strategies to reduce CO₂ emissions from economic activity and electricity generation by improving efficiency or promoting renewable energy sources. Finally, two-way causal links were observed between all important variables. The results suggest that each country targeted action plans should be implemented to ensure environmental sustainability in the developing world.

(Baydoun & Aga, 2021) This research study assessed the effect of energy consumption, economic growth, financial development, and globalization on CO₂ emissions in GCC nations by utilizing a dataset stretching between 1995 and 2018. The study used cross-sectional dependence, slope heterogeneity, Pesaran unit root, Westerlund cointegration, cross-sectionally augmented autoregressive distributed lag, and Dumitrescu and Hurlin causality approaches. The results of the cointegration test unveiled a long run association between CO₂ and the regressors, suggesting evidence of cointegration. The

outcomes of the CS-ARDL showed that economic growth and energy consumption decrease the sustainability of the environment, while globalization improves it. Moreover, the outcomes of the DH causality test demonstrated feedback causality association between GDP and CO₂ and between FD and CO₂. In addition, there is a one-way causality from energy use and globalization to CO₂ emissions in GCC economies. This research showed that there is a negative link between globalization and CO₂ emissions. Policymakers in GCC economies may also strengthen relationships with their foreign commercial partners in order to relieve poverty, create new job opportunities, and increase exports and imports. In addition, the increase in CO₂ emissions, due to economic expansion, reduces environmental sustainability.

2.7 Research Gap

The GCC nations, comprising Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates, have undergone remarkable economic growth and development over the past few decades. However, this growth has been accompanied by increasing concerns about environmental sustainability, particularly in the context of rising carbon footprint and greenhouse gas (GHG) emissions.

- Limited Understanding of the Environmental Kuznets Curve (EKC) Hypothesis in GCC Nations:

One of the central research questions in this study pertains to the validity of the Environmental Kuznets Curve (EKC) hypothesis within the GCC nations. The EKC hypothesis suggests an inverted U-shaped relationship between economic growth (proxied by Gross Domestic Product or GDP) and environmental degradation,

indicating that as economies develop, environmental degradation initially worsens but eventually improves. While the EKC has been explored extensively in global contexts, there is limited empirical evidence to confirm or refute its applicability within the unique economic and environmental dynamics of the GCC nations.

- **Complex Factors Influencing Economic-Environmental Relationships:**

Furthermore, the dynamics and factors influencing the relationship between economic development and environmental sustainability in the GCC nations remain relatively unexplored. The interplay of variables such as population growth, energy generation, electricity consumption, and trade (import and export) of goods and services, alongside GDP and carbon emissions, presents a complex web of interactions. Understanding the specific factors that drive environmental sustainability or degradation within this region is crucial for informed policymaking.

- **Policy Relevance and Translation of Research Findings:**

While academic research provides valuable insights, there is often a gap in effectively translating these findings into evidence-based policies. In the context of the GCC nations, where environmental concerns intersect with economic aspirations, bridging this gap is paramount. Identifying actionable policy recommendations based on empirical evidence becomes a pressing need to promote sustainable development while maintaining economic growth.

- **Methodological Challenges in Panel Data Analysis:**

The research objectives of this study involve analyzing panel data to capture and understand the complex interrelationships between economic growth and environmental sustainability in the GCC nations. Utilizing panel data analysis

techniques presents unique methodological challenges. These challenges include addressing issues of cross-sectional dependence, slope heterogeneity, and non-stationarity, as well as ensuring the robustness and reliability of the results obtained.

- Alignment with Global Climate Agreements:

Additionally, as global initiatives like the Paris Agreement and the United Nations Framework Convention on Climate Change (UNFCCC) aim to address climate change and GHG emissions, it is crucial to assess the extent to which GCC nations align with international commitments. Investigating whether the actions and policies implemented within these nations are effectively reducing their carbon footprint and contributing to global environmental sustainability goals is of paramount importance.

In conclusion, while substantial research has been conducted on the EKC hypothesis and environmental sustainability at a global scale, there remains a notable research gap specific to the GCC nations. This gap pertains to both the empirical validation of the EKC hypothesis within this regional context and the nuanced understanding of the multifaceted factors influencing economic-environmental relationships. Bridging this gap not only contributes to academic knowledge but also offers actionable insights for policymakers working toward sustainable development goals within the GCC nations.

2.8 Chapter Summary

In conclusion, Chapter 2 of the thesis provides a comprehensive literature review of the climate change-GDP nexus and the EKC hypothesis. The chapter introduces the concept of climate change and the adverse effects of carbon dioxide emissions on the environment and the economy. Additionally, the chapter highlights the United Nations

Sustainable Development Goals for climate change and their relevance to the GCC nations.

The literature review also examines the concept of GDP and its significance in economic growth, with a focus on the different approaches to measuring it. The chapter discusses the climate change-GDP nexus and the different theoretical perspectives that underpin it. The chapter further introduces the EKC hypothesis and provides a definition of the different variables and models used to test it.

Furthermore, the literature review examines the previous studies on the climate change-GDP nexus and the EKC hypothesis, specifically in the GCC nations. The chapter highlights the empirical evidence on the relationship between economic growth and carbon dioxide emissions in the GCC nations and identifies the gaps and limitations in the existing literature.

Overall, Chapter 2 provides a solid foundation for the subsequent chapters of the thesis. The literature review synthesizes the key concepts of climate change, GDP, and the EKC hypothesis, and provides valuable insights into the empirical evidence on the climate change-GDP nexus in the GCC nations. The review informs the research design and analysis of the study and contributes to the understanding of the complex relationship between economic growth and environmental sustainability in the GCC nations.

Chapter Three:

GCC's Overview

Chapter Three

GCC's Overview

3.1 GCC Overview

The Gulf Cooperation Council (GCC) countries, including Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE), are in a strategically important region with rich natural resources, particularly oil and gas. The GCC economy has undergone significant transformation since its inception in the 1980s. This chapter provides an overview of the GCC economy, including its origins and how it has progressed over time. The chapter will also highlight the environmental concerns that the region faces, as well as the initiatives undertaken by the GCC countries to address these concerns.

3.2 Historical Overview of the GCC Economy

The GCC countries, including Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates, are in a strategically important region with rich natural resources, particularly oil and gas. The GCC economy has undergone significant transformation since its inception in the 1980s. This section provides an overview of the GCC economy, including its origins and how it has progressed over time.

The GCC was established in 1981 to promote economic cooperation and integration among its member countries. The GCC countries recognized the potential of their strategic location and natural resources and aimed to achieve greater economic prosperity by working together.

The discovery and exploitation of vast oil and gas reserves in the region led to a period of rapid economic growth during the 1960s and 1970s, known as the oil boom. The GCC countries used their newfound wealth to invest in infrastructure, education, healthcare, and other areas of social development. They also became major players in the global oil market and used their oil revenues to diversify their economies. The oil boom transformed the GCC countries from being predominantly agrarian and pastoral societies to modern, industrialized economies. The GDP per capita of most GCC countries increased tenfold by the end of the 1970s, making them some of the richest countries in the world (Kasem & Alawin, 2019).

By 2018, Saudi Arabia, the UAE, and Kuwait are three of the world's ten largest crude oil producers, and the GCC states generate about 25% of global crude oil. GCC economies have grown over decades. Saudi Arabia and the UAE account for two-thirds of global GDP. Nationwide GDP was divided: 47% Saudi Arabia, 26% UAE, 11% Qatar, 9% Kuwait (Fatima, Mentel, Doğan, Hashim, & Shahzad, 2021).

Economic growth in the GCC states has been bolstered by a combination of factors, including relatively high oil prices, oil output policies, expansionary financial measures, and low borrowing rates. Nonetheless, provided that the effects of increased oil prices on nominal GDP are long-lasting, these gains would be "real" income rather than merely an indication of inflationary price rises (Bekhet, Matar, & Yasmin, 2017).

Besides possessing 19.8% of the global natural gas reserves, the countries in the GCC also significantly contribute to worldwide carbon emissions (Ansari, Ahmad, Siddique, & Mansoor, 2020). The GCC's low-cost hydrocarbon supplies and favorable tax regimes make it an ideal alternative for industrial and energy enterprises to manufacture high-value items including steel, aluminum, refined fuels, petrochemicals, and plastics. GCC states' GDP and energy consumption, which are greater than in other emerging

countries, better reflect their economic progress. Most of these nations use fossil fuels for household energy, which contributes to their high per capita GHG emissions (Bekhet, Matar, & Yasmin, 2017).

Despite financial prosperity and relative economic and political stability in most GCC countries, the economic crisis showed the Gulf economy's basic flaws owing to its heavy reliance on oil and gas. Oil-exporting nations seek economic diversification to reduce their dependency on the global oil price. Countries that export a lot of crude oil say they need to diversify, but few businesses can match the hydrocarbon industry's capacity to swiftly and dependably make a profit (Fatima, Mentel, Doğan, Hashim, & Shahzad, 2021). Even while the actual GDP of the GCC countries grew somewhat in 2009, their nominal GDP in U.S. dollars dropped by about 19%, mostly due to reduced oil prices (Bekhet, Matar, & Yasmin, 2017).

Having a diverse economy has been linked in several studies to long-term prosperity. When it comes to economic diversification, some nations have been more successful than others. By diversifying their economies, GCC states want to avoid the volatility that comes with being too dependent on oil revenues (Kasem & Alawin, 2019). Since the oil and gas industries remain significant drivers of GDP, however diversification is becoming increasingly important for the GCC economy. Risks associated with relying on oil earnings, such as fluctuating oil prices and shifts in the structure of the global market, can be mitigated by diversifying into other industries, moreover, another advantage about diversification is preparing for the post-oil future, when demand for fossil fuels is predicted to be declining, and this in turn creates jobs (Fatima, Mentel, Doğan, Hashim, & Shahzad, 2021).

3.3 Environmental Concerns and Climatic Threats

The GCC countries are endowed with significant natural resources, especially oil and natural gas reserves. The region's rapid economic growth, primarily driven by hydrocarbon exports, has led to environmental concerns and climatic threats. This section aims to provide a comprehensive analysis of the environmental challenges and climate-related issues facing the GCC countries, highlighting the potential impacts on their economies, societies, and ecosystems.

GCC countries have faced a multitude of environmental challenges such as pollution in coastal and marine areas, biodiversity loss, and desertification. Over the last few decades, an additional set of environmental problems has arisen, especially demolition debris, construction, and deforestation. It is worth mentioning that all these environmental problems are interconnected. For instance, overgrazing and livestock lead to desertification, waste dumping releases methane, desertification leads to biodiversity loss which contributes to the greenhouse gas emissions, which in turn leads to scarcity of water and many other ecological problems (Ansari, Ahmad, Siddique, & Mansoor, 2020).

About a quarter of global oil output comes from the GCC, and the region also controls forty percent of the world's oil reserves. Architectural, rapid industrialization, and social service initiatives are made possible because of the revenue gained by exporting oil and gas. Investments such as this are undertaken primarily to promote economic growth and broaden the range of goods exported (Alsamara, Mrabet, Saleh, & Anwar, 2018). Increasing rates of globalization, energy consumption, and GDP all create significant challenges for the GCC countries in terms of environmental quality (Baydoun & Aga, 2021). As a result of their contribution to greenhouse gas emissions,

the Gulf states' usage of fossil fuels has a momentous detrimental influence on the environment (Kasem & Alawin, 2019). These regional groups are energy rich nations, in fact fossil fuel based natural resources are the backbone of their economies. Gas and oil exports create cash that is utilized to support economic growth and social welfare initiatives. With rising electrical needs, these nations are generating and consuming vast amounts of fossil fuels. The transition from a low-carbon to a high-carbon economy has had a devastating effect on environmental quality in the GCC (Ansari, Ahmad, Siddique, & Mansoor, 2020). GCC governments rely largely on revenue and economic growth from inexpensive hydrocarbons (Bader & Ganguli, 2019). Moreover, increases in both population and oil exports pose a threat to GCC environment and exacerbate underlying problems with sustainable development (Fatima, Mentel, Doğan, Hashim, & Shahzad, 2021).

However, the GCC nations are still vulnerable to challenges including climate change and excessive dependence on exports of oil and gas and local consumption levels that are significantly subsidized, and from 2000, energy consumption in the GCC region has climbed by 74%. In particular, the usage of non-renewable and fossil fuel energy sources has increased due to the increase in entire energy demand (Fatima, Mentel, Doğan, Hashim, & Shahzad, 2021). Damage to the environment and human health is being caused by the excessive and inefficient use of hydrocarbons to meet the region's high energy needs (Kasem & Alawin, 2019). As a result, The GCC countries are among the world's largest emitters of CO₂, which is a significant greenhouse gas. Increased fossil fuel (oil, gas, and coal) combustion in energy production and widespread use in the region are the primary causes of this CO₂ rise. The environmental health across GCC region has suffered greatly as a result of the high-carbon economy. Almost half of all Arab nations' CO₂ emissions and about 8% of worldwide CO₂ emissions originate from the GCC (Alsamara, Mrabet, Saleh, & Anwar, 2018). Increases in CO₂ emissions

are expected unless governments adopt technology to reduce emissions, find viable alternatives to fossil fuels, and implement considerable energy efficiency measures. While just 0.6% of people in the world live in GCC nations, the area is responsible for 2.4% of all worldwide carbon dioxide emissions. The GCC nations have greater levels of CO₂ emissions per person, energy intensity, and CO₂ emissions per gross domestic product than the average of 25 EU and OECD countries. Considering the foregoing, it is evident that the region's energy efficiency can be enhanced (Bekhet, Matar, & Yasmin, 2017).

Moreover, carbon footprint account around 67% of overall ecological footprint due to GCC nations' heavy usage of fossil fuels, which is highly concerning (Ansari, Ahmad, Siddique, & Mansoor, 2020).

Since the GCC nations are responsible for such a large portion of the world's environmental pollution, it's important to investigate how various pollutants, such carbon dioxide and sulfur dioxide, affect economic growth (Alsamara, Mrabet, Saleh, & Anwar, 2018). Domestic use of these fossil fuels in large quantities through combustion is unsustainable. Due to the high dependency on hydrocarbons as a source of energy, the World Economic Forum predicts that the GCC countries will experience the effects of climate change in the form of growing air pollution and competition for limited water resources. High levels of particulate matter, sulfur dioxide, nitrogen oxides, and other air pollutants pose risks to public health, leading to respiratory illnesses, cardiovascular diseases, and premature deaths (Kasem & Alawin, 2019).

The rising sea level is another significant difficulty brought on by climate change since it threatens to submerge islands in the area. The potential causes of sea-level rise affecting the GCC countries include melting of polar ice caps and glaciers, because of global warming. Moreover, thermal expansion of seawater, which occurs when water

molecules absorb heat and occupy more space, leading to a rise in sea levels. This poses significant threats to the low-lying coastal areas of the GCC countries, where most of the population and critical infrastructure are concentrated. For example, Bahrain stands to lose almost 15 kilometers of shoreline, which would have a devastating impact on the country's marine life (Satrovic, Ahmad, & Muslija, 2021).

However, the persistent high consumption and production in the energy sector, relying heavily on fossil fuels, hinders the efforts to attain sustainable development. Moreover, these countries have higher levels of per capita income because of their dependency on gas and oil exports, which have led to environmental degradation due to large income effect on luxurious consumption (Ansari, Ahmad, Siddique, & Mansoor, 2020).

It is noteworthy that the GCC region is characterized by an arid climate with limited freshwater resources. Rapid population growth, urbanization, and economic development have put enormous pressure on the already scarce water supplies. The reliance on energy-intensive desalination technologies further exacerbates the issue, contributing to greenhouse gas emissions and environmental degradation. The shortage of water is the root cause of these alarming figures, particularly in Saudi Arabia and the United Arab Emirates. In Abu Dhabi, desalination is thought to consume more than half of the city's total energy output (Bekhet, Matar, & Yasmin, 2017).

Environmental concerns and climatic threats are increasingly pressing issues for the GCC countries, with far-reaching implications for their economies, societies, and ecosystems. Addressing these challenges requires coordinated regional and global efforts, as well as the adoption of sustainable development practices and policies that prioritize environmental protection and climate resilience. By doing so, the GCC countries can ensure their long-term prosperity and well-being, while also contributing to global efforts to combat climate change.

3.4 GCC Sustainable Development Initiatives

Sustainable development has become a priority for many countries worldwide, and the GCC countries are no exception. The GCC countries have recognized the importance of sustainable development and have implemented various initiatives and projects to protect the environment and mitigate climate change issues. This section will discuss the initiatives and projects implemented by the GCC countries to diversify their economy resources, adopt renewable energy sources, achieve net-zero emissions, and utilize modern technology and techniques in the industry to reduce emissions.

It is crucial to recognize that the GCC countries' governments all express a strong commitment to sustainable development. As a result, numerous initiatives are demonstrated, which contribute to achieving urban sustainability objectives. GCC countries have joined many international environmental agreements such as The United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol of climate change. The UNFCCC obligated industrialized countries and “transitioning economy” countries to achieve quantified emission reduction targets for GHG. The Kyoto Protocol was signed by 192 parties, including the GCC countries, and it took effect on February 16, 2005, (Satrovic, Ahmad, & Muslija, 2021). Governments in the Gulf region have established policies that encourage more efficient use of energy. The current investigation was inspired by the widespread commitment to environmental conservation shown by economies in the Gulf in recent times. It is important to understand for the GCC countries that they will not be able to depend forever on a petroleum economy and that diversification of energy is crucial. One of the main initiatives taken by the GCC countries to achieve sustainable development is to diversify their economy resources. The GCC countries have been dependent on oil

and gas resources for their economic growth and development for many years. However, this dependence on fossil fuels has made the GCC countries vulnerable to fluctuations in the global oil and gas markets and exposed them to risks associated with climate change. Therefore, diversifying the economy resources has become a priority for the GCC countries to ensure long-term economic stability and sustainability.

Diversification of the economy resources entails developing non-oil sectors such as tourism, renewable energy, technology, and manufacturing, and promoting the private sector's role in the economy. This can create new job opportunities for the local population, increase economic competitiveness, and reduce the dependence on oil and gas resources. Tourism is a crucial sector in the GCC countries' diversification initiatives, as it can contribute significantly to the economy. The GCC countries have launched various initiatives to promote tourism, such as developing tourism infrastructure, promoting cultural heritage, and attracting international events and conferences.

Technology and innovation are also important sectors in the GCC countries' diversification initiatives, as they can enhance economic competitiveness and promote sustainable development. The GCC countries have launched initiatives to promote technology and innovation, such as establishing innovation centers, investing in research and development, and promoting entrepreneurship. Manufacturing is also a critical sector in the GCC countries' diversification initiatives, as it can promote economic competitiveness and create new job opportunities. The GCC countries have launched initiatives to promote manufacturing, such as establishing industrial parks, providing incentives for manufacturing companies, and promoting exports. Promoting the private sector's role in the economy is also an essential aspect of the GCC countries' diversification initiatives. The GCC countries have launched various initiatives to

promote the private sector, such as providing incentives for private sector investments, simplifying business regulations, and enhancing the business environment.

To sum up with, diversifying the economy resources is a crucial initiative that the GCC countries have implemented to achieve sustainable development, reduce dependence on oil and gas resources, and promote non-oil sectors. The initiatives aim to develop non-oil sectors such as tourism, renewable energy, technology, and manufacturing, and promote the private sector's role in the economy. The GCC countries have recognized the importance of diversifying their economy resources and have launched various initiatives to achieve this goal, creating new job opportunities for the local population, increasing economic competitiveness, and ensuring long-term economic stability and sustainability.

Controlling greenhouse gas (GHG) emissions, and particularly CO₂ emissions, which make up the bulk of GHGs, has been addressed by a number of environmental investigations. For all countries, and especially for those in the GCC, figuring out what's driving growing CO₂ emissions and coming up with effective mitigation programs is vital (Baydoun & Aga, 2021).

In recent years, there has been an increasing awareness of the impacts of climate change and the need to mitigate these impacts by reducing greenhouse gas (GHG) emissions. One of the goals of the Paris Agreement, which was signed by 196 countries in 2015, is to limit global warming to well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C. To achieve this goal, many countries and organizations have committed to achieving net-zero emissions. Achieving net-zero emissions is essential in mitigating climate change and limiting the impacts of global warming. The Intergovernmental Panel on Climate Change (IPCC) has highlighted the need to achieve net-zero emissions by mid-century to limit the temperature increase to

1.5°C. Achieving net-zero emissions can also provide various co-benefits, including improving air quality, enhancing energy security, and creating new job opportunities. Net-zero emissions refers to the state in which a country, company, or organization balances the amount of GHG emissions produced with an equivalent amount of GHG removals, resulting in zero net emissions. This can be achieved through reducing GHG emissions, such as carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O), through various measures, including the adoption of renewable energy sources, improving energy efficiency, and carbon capture and storage (CCS) technologies. GHG removals can be achieved through various natural and artificial processes, including afforestation, reforestation, and direct air capture (DAC).

International Energy Agency (IEA): The IEA has released the "Net Zero by 2050 Roadmap," which outlines a global pathway to achieve net-zero emissions by 2050. The roadmap includes measures to promote clean energy, improve energy efficiency, and reduce GHG emissions from the industry, transport, and building sectors. Many countries and organizations worldwide have committed to achieving net-zero emissions. Some examples of countries and organizations committed to achieving net-zero emissions include:

- United Kingdom: The UK has set a legally binding target to achieve net-zero emissions by 2050, and the government has launched the "Ten Point Plan for a Green Industrial Revolution," which includes measures to promote clean energy, green transport, and sustainable living.
- European Union (EU): The EU has set a target to achieve net-zero emissions by 2050, and the European Green Deal aims to transform the EU into a climate-neutral continent by 2050. The EU has also launched the "Fit for 55 Package,"

which includes measures to reduce GHG emissions from the energy, transport, and building sectors.

- United States of America (USA): The USA has set a target to achieve net-zero emissions by 2050, and the government has launched the "Biden-Harris Administration's Climate Agenda," which includes measures to promote clean energy, green infrastructure, and sustainable agriculture.
- China: China has set a target to achieve net-zero emissions by 2060, and the government has launched the "Energy Revolution Strategy Action Plan (2016-2030)," which includes measures to promote renewable energy, improve energy efficiency, and reduce GHG emissions from the industry and transport sectors.

In the GCC countries, the net-zero emissions initiative has gained significant attention, and many countries have made commitments to achieve this goal. The GCC countries have recognized the importance of reducing GHG emissions and mitigating climate change issues, as they are particularly vulnerable to the impacts of climate change, such as sea-level rise, extreme weather events, and water scarcity.

The UAE has set a target to achieve net-zero emissions by 2050, and the government has launched the "UAE Energy Strategy 2050," which aims to increase the contribution of clean energy to 50% of the total energy mix. The UAE has also launched the "Carbon Capture, Utilization and Storage (CCUS) Project," which aims to capture carbon emissions from the Emirates Steel plant and store them underground.

Saudi Arabia has also made significant commitments towards achieving net-zero emissions. The country has launched the "Green Saudi Initiative" and the "Green Middle East Initiative," which aim to achieve net-zero emissions by 2060 and plant 10

billion trees in the region. Saudi Arabia has also launched the "Saudi Green Initiative," which aims to reduce carbon emissions by 60% by 2030.

Qatar has set a target to achieve net-zero emissions by 2050, and the government has launched the "Qatar National Vision 2030," which aims to achieve sustainable development and diversify the economy. Qatar has also invested in renewable energy sources and has installed the "Al-Kharsaah Solar Power Plant," which is one of the largest solar parks in the world.

Bahrain has launched the "Sustainable Energy Unit," which aims to promote renewable energy sources and energy efficiency in the industry, transportation, and building sectors. Bahrain has also implemented the "Bahrain Energy Efficiency National Action Plan," which aims to reduce energy consumption by 6% by 2025. Bahrain has also invested in solar energy, and the "Bahrain International Circuit" has installed a 5.6 MW solar power plant to supply electricity to the circuit.

Oman has set a target to achieve net-zero emissions by 2050, and the government has launched the "Oman Vision 2040," which aims to achieve sustainable development and diversify the economy. Oman has also invested in renewable energy sources and has launched the "Raysut Wind Farm," which is the country's first commercial wind farm. Oman has also implemented the "Oman Energy Efficiency and Renewable Energy Programme," which aims to promote energy efficiency and renewable energy in the industry, transportation, and building sectors.

Kuwait has also made commitments towards achieving net-zero emissions. The country has launched the "Kuwait National Development Plan 2035," which aims to achieve sustainable development and diversify the economy. Kuwait has also invested in renewable energy sources and has launched the "Kuwait Renewable Energy

Programme," which aims to increase the contribution of renewable energy to the total energy mix. Kuwait has also implemented the "Kuwait Energy Efficiency and Conservation Law," which aims to promote energy efficiency in the industry, transportation, and building sectors.

Achieving net-zero emissions is essential in mitigating climate change and limiting the impacts of global warming. Many countries and organizations worldwide have committed to achieving net-zero emissions through various measures, including promoting clean energy, improving energy efficiency, and reducing GHG emissions from different sectors. These commitments demonstrate the increasing awareness of the importance of sustainable development and the need to address climate change issues. Achieving net-zero emissions is not an easy task, and it requires a significant transformation in various sectors, including the energy, transport, and building sectors. However, the benefits of achieving net-zero emissions are significant, and they include improving air quality, enhancing energy security, and creating new job opportunities. The net-zero emissions worldwide initiative is an essential step towards a sustainable and resilient future, and it requires the collective efforts of governments, businesses, and individuals to achieve this goal.

These agreements, in alignment with the GCC environmental policies, encourage and support the usage of RES locally to limit harmful emissions and reduce the negative effects of climate change. Therefore, the GCC governments, along with the private sector and the public, cooperated to shift from being merely oil producers into RES producers (Kasem & Alawin, 2019). Renewable energy is another critical sector in the GCC countries' diversification initiatives, as it can reduce the dependence on fossil fuels and promote sustainable energy sources. The GCC countries have vast potential for renewable energy sources, such as solar and wind power, and have launched

initiatives to promote the adoption of renewable energy sources, such as feed-in-tariffs, net-metering, and renewable energy targets. Increasing the role of renewable energy sources is a fundamental strategy in decreasing environmental pressure. These sources of energy can be a key solution in increasing energy security by reducing the countries' dependency on imported fossil fuels. Furthermore, such sources of energy can decrease the environmental damage because renewables represent a clean source of energy (Al-Mulali, Ozturk, & Solarin, 2016). Growing energy consumption in conjunction with environmental threats poses a practical challenge for GCC countries. There is an urgent need to plan renewable energy (RE) technologies which can combat the future challenges. The GCC countries are best placed to generate more hydrocarbon fuel for export by integrating renewable energy. It is also an important chance to foster economic growth while improving access to safe, affordable energy. In this context, GCC has a unique opportunity to channel more investment projects in placement of RE technologies to enhance future energy security and cutting off CO₂ emissions (Bekhet, Matar, & Yasmin, 2017). Using renewable energy sources such as solar energy can significantly reduce this dependence on hydrocarbon fuels. Interestingly, the political leaders in GCC countries also realize this potential and are making such policies that can promote renewable energy production as a tool of diversification. The GCC has implemented a wide range of policy areas, including business-climate reforms, infrastructure growth, and huge financial support for industry. The Gulf economies have made a strategic decision to expand renewable energy, as they are more stable than other energy importing countries due to the region's oil and gas reserves (Fatima, Mentel, Doğan, Hashim, & Shahzad, 2021).

The GCC's investment in renewable energy development has several important advantages. For example, it promotes energy diversification, arguing that the combination of reliance on conventional fossil fuels and the expropriation of renewable

energy resources will increase long-term energy security. By reducing fossil fuel consumption will increase potential revenue for oil and gas export (Al-Mulali, Ozturk, & Solarin, 2016). Because the nature of the Gulf countries is convenient for RES, these resources are considered as the new vision for future energy. However, many challenges are associated with renewable energy technologies such as economic, technical, social, and environmental. A cost analysis between traditional energy using oil and gas and RES energy finds that many producers accept the concept of cutting subsidies on traditional energy to promote RES. Due to the high cost of the new RES technology, the involvement of the private sector, supported by taxes and customs exemptions, along with the involvement of public and governmental authorities is essential. Financial supports in the form of subsidies, lands for installation, and the operation of RE generating plants are required (Kasem & Alawin, 2019).

The GCC countries have a vast potential for renewable energy sources due to their geographical location and climate conditions. The GCC countries have recognized the importance of promoting renewable energy sources to reduce dependence on fossil fuels, mitigate climate change issues, and achieve sustainable development. There are several types of renewable energy sources that can be used in the GCC countries, including:

- **Solar Energy:** The GCC countries have abundant sunshine throughout the year, making solar energy a promising renewable energy source. The most common technologies for solar energy include photovoltaic (PV) panels, concentrated solar power (CSP), and solar water heaters.
- **Wind Energy:** The GCC countries also have significant potential for wind energy, particularly in coastal areas. The most common technologies for wind energy include onshore and offshore wind turbines.

- **Geothermal Energy:** The GCC countries have limited potential for geothermal energy due to their geological characteristics. However, some areas in Oman and the United Arab Emirates (UAE) have been identified as having potential for geothermal energy.
- **Biomass Energy:** The GCC countries have limited potential for biomass energy due to their arid climate and limited agricultural resources. However, some countries, such as Saudi Arabia, have launched initiatives to promote the use of waste-to-energy technologies.
- **Hydropower Energy:** The GCC countries have limited potential for hydropower energy due to their limited water resources and arid climate. However, some countries, such as Oman, have launched initiatives to promote the use of pumped-storage hydroelectricity.

In the GCC countries, solar energy is the most widely used and developed renewable energy source. The countries have launched several initiatives to promote solar energy, such as feed-in-tariffs, net-metering, and renewable energy targets. The UAE has launched the "Mohammed bin Rashid Al Maktoum Solar Park," which is one of the largest solar parks in the world. Saudi Arabia has launched the "King Salman Renewable Energy Initiative," which aims to produce 9.5 GW of renewable energy by 2023. Qatar has launched the "Al-Kharsaah Solar Power Plant," which is one of the largest solar parks in the world. Oman has launched the "Sohar Solar Project," which is one of the largest solar projects in the region. Bahrain has launched the "Sustainable Energy Unit," which aims to promote renewable energy sources and energy efficiency.

GCC countries have vast potential for renewable energy sources, and they have recognized the importance of promoting renewable energy sources to achieve sustainable development and reduce dependence on fossil fuels. The most widely used

and developed renewable energy source in the GCC countries is solar energy, and the countries have launched several initiatives to promote solar energy. However, there is potential for other types of renewable energy sources, such as wind energy, geothermal energy, biomass energy, and hydropower energy, which the countries can explore to diversify their energy mix and reduce dependence on fossil fuels.

In conclusion, the GCC countries have recognized the importance of reducing GHG emissions and mitigating climate change issues, and they have made significant commitments towards achieving net-zero emissions. The GCC countries' initiatives include promoting renewable energy sources, improving energy efficiency, implementing carbon capture and storage (CCS) technologies, and investing in low-carbon technologies. The net-zero emissions initiative is a significant step towards a sustainable and resilient future in the GCC countries, and it requires the collective efforts of governments, businesses, and individuals to achieve this goal.

Chapter Four:

Methods and Procedures

Chapter Four

Methods and Procedures

4.1 Chapter Overview

This chapter represents the methodology used to accomplish the study; it represents a sequence of steps that the author chose to follow according to his beliefs and requirement, the chapter starts with an explanation of the research philosophy types and the chosen philosophy by the researcher, as well as, research methods are being discussed in their various types, followed by a discussion of the data collection techniques, introducing the study variables, and the research model. Moreover, details on the panel data approach and the EKC are also discussed in this chapter, in addition, the chapter ends with a brief conclusion of the detailed methodology.

4.2 Research philosophy

Several philosophies are integrated with research paradigms, however, there are four main popular philosophies that are usually used widely among researchers, which are the positivism, interpretivism, pragmatism, and realism, in addition to other philosophies which are rarely used. Starting with positivism, it is related to the philosophical attitude of natural scientists who study demonstratable facts in a community driving to the generalizability. Positivism philosophy is linked to the significance of general givens, as well as it focuses on reality and refined unbiased data (Alharahsheh & Pius, 2020). However, interpretivism is created by criticizing positivism through an individual view. Interpretivism focuses on the profundity of the

variables, and the context related factors. It distinguishes mankind from physical phenomena, relating this to the fact that humans cannot be explored in the same way as physical phenomena. It differs from positivism as it seeks to collect abundance perspectives about something, other than seeking a generalizability and applying it, and this is because cultures differ from each other.

On the other hand, the pragmatism philosophy is related to the suggestion that scholars must utilize the best fit method to a specific study problem in which they are exploring. Pragmatism is often focused on the impact and the outcome of the research study, as well as, on the research question, more than focusing on the methodology used. This type of philosophy preserves the fact that no typically similar conditions or status happen twice, so that the outcomes and how researchers think about the situation are interim (Kaushik & Walsh, 2019). Moreover, the realism philosophy heads for the fact that our current thoughts and beliefs are just approximation to the reality which still require advancement to understand clearly (Wikgren, 2005).

In the current study the researcher will choose the positivism philosophy.

4.3 Research Methodology

There are three main types of research, quantitative research, qualitative research, and mixed research. The application of the quantitative researchers' procedure starts with the author who is responsible for picking up a subject to study.

This subject may be his area of expertise or a particular interest. The second step includes a narrowing and a focus on a particular topic in this expertise or interest, in which a research question is being formed to clear up the main goal of the study. While

looking for the specific research question, researchers must conduct a profound literature review, which leads to the formation of the research hypotheses. Then the author must select an appropriate sample type (usually random samples are used) and the typical data collection tool that will serve for answering the research question.

Quantitative research develops quantitative data that can be used to study correlations between study variables and the study results. Such research results with a big quantity of output data, which requires an interpretation to be meaningful (Choy, 2014).

However, the qualitative research studies start with a personal evaluation and a self-reverberation, it reflects the author's situation in society. The qualitative approach does not focus on a particular research question, instead, the researcher adopts a certain insight and view. Usually in this type of approach, purposive sampling is used, and the structured and semi-structured interviews are common data collection tools. Qualitative research follows same steps as the quantitative one, however, at the end of the research the researcher concludes and develops new theory, or make advancements on as existing one (Choy, 2014).

The third approach to be discussed in this chapter is the mixed approach, in which the superior features of both quantitative and qualitative approaches are being benefited from. This provides the author with extreme pliancy. It helps to guarantee that the assumptions related to the study objectives are confirmed with both approaches, the qualitative and the quantitative one (Fassinger & Morrow, 2013).

In this study the author had chosen the quantitative approach to conduct the study.

4.4 Data Collection

In the scientific research discipline, there exist two main types of data, the primary data, and the secondary data. The primary data refers to the authentic data being gathered for a particular study objective and problem statement; it is collected by utilizing ultimate processes that fit best. This type of data brings novel data during the collection procedure, which provides a richness to the research area added to the available knowledge. This primary data after being interpreted, confirmed, and published, becomes available for other researchers to use, and then is called secondary data (Hox & Boeije, 2005). However, the secondary data are original data being collected for a certain goal, and then are reused by other researchers for another research question and problem existence's confirmation. Moreover, official statistics and administrative records are two main examples of the reuse of data (Hox & Boeije, 2005). In addition, the secondary data are significant sources and foundation of the systematic review research type, research analysis, and content analysis (Daas & Arends-Tóth, 2012), where the researchers, search for relevant and reliable published data to integrate in their reviews, also secondary data are critically used for the discussion of the results in the research. This type of data can be found in the educational institutions' databases, and the reliable publishers and international journals available online or bookstores, as well as, in the conferences' proceedings and government reports and records.

In the current study, the author chose to use secondary data.

4.5 Study Variables

4.5.1 Carbon Footprint and Greenhouse Gas Emissions

The Carbon Footprint is now a popular term being used in discussions related to the responsibility toward climate change, where media, governments and public had becoming familiar with. In conclusion, Carbon Footprint stands for the number of gases emitted during the production and consumption activities of human (Wiedmann & Minx, 2008). However, this term is initially derived from the term 'Ecological Footprint' which was introduced in 1996 (Pandey et al., 2011), so that this is the origin of the term Carbon Footprint. Moreover, Pandey et al. (2011) define the Ecological Footprint as 'the biologically productive land and sea area required to sustain a given human population expressed as global hectares', on the other hand they defined the Carbon Footprint as 'the land area required to assimilate the entire CO₂ produced by the mankind during its lifetime'.

Thus, the concept of Carbon footprint is not new, and had been used for several decades, but recently this concept had been modified and started to be used widely due to the recent global threat of global warming and climate change. As a conclusion, Carbon Footprint is the global warming potential indicator (Pandey et al., 2011).

The concept of Greenhouse gases or GHGs is related to the gaseous components of the atmosphere which absorb the solar energy that the surface of the earth had reflected and known as the infrared radiation. Major gases of Greenhouse gases are the Nitrogen and the Oxygen. These GHGs causes the raised temperature in the lower atmosphere, and they are significant gases for maintaining and adjusting the temperature of the earth surface. However, with the rise of industrial activities the emission of Greenhouse gases had been boosted exponentially during the period from 1970 till 2004. As a result, the

temperature of surface of the earth increases by 0.6°C since 1800s and is expected for further increase by 2100 with extra 1°C to 5°C (Klein et al., 2008).

These dramatic changes of the earth's surface temperature are a threatening factor for mankind and are going to result in the extinction of many creatures, which have already started to happen. Climate change is then reflected by the increase in natural disasters, including floods, droughts, melting of the ice in the two-earth pole, wildfires, hurricanes, and landslides. However, the first global attempt to reduce Greenhouse gases emissions was the Kyoto protocol in 1997, which was then applied by the year 2005, and the United Nations Framework Convention on Climate Change (UNFCCC) that confirmed this protocol. Moreover, Lamb et al. (2021) stated that the Greenhouse gases emissions resulted from the land use and from the fossil fuels production and consumption had an increase starting the 19th century and attained their peak by the year 2019. As an action call of the global countries, Paris agreement was held in the year 2015 as a response for the reduction necessity of the earth temperature. In addition, Lamb et al. (2021) introduced five main sectors of the global Greenhouse gases emissions roots, which are: (1) the Intergovernmental Panel on Climate Change (IPCC) Working Group III (WG3) as energy systems, (2) industry, (3) buildings, (4) transport, and (5) AFOLU (agriculture, forestry, and other land uses).

4.5.2 Gross Domestic Product

The Gross domestic product or widely known as the (GDP) is an indicator of economic activity. The GDP measures the total value of all final products and services, which are recently generated from the production process inside a certain country during a period of year (Callen, 2012; O'Neill, 2014). It represents the most complicated indicator of a

country's outcomes; it is calculated in the quarters of the year and at the end of the year. The quarter calculation process of the GDP occupies a significant role in developing the condition once for the outcome of the national economy, also it acquires precise data the current and future growth of the national economy (Anghelache et al., 2020). Moreover, Callen (2012) defined the role of the GDP that it measures the pecuniary worth of the latter products and services which are purchased by the final client, and which are produced inside a certain country in a certain period, mainly 3 months period, and 12 months period. The GDP includes two types of productions, the first is the type in which goods and services are presented for sale in stores, and other productions that cannot be exposed for markets, for example the educational services being provided by the government (Callen, 2012).

An alternate concept of the GDP is the Gross National Product or what is known as (GNP) which represents all the output of the inhabitants within a country (Callen, 2012; O'Neill, 2014).

4.5.3 Import Goods and Services

Imports of Goods and Services is an indicator used by the World Bank to measure the value of all goods and other market services received from the rest of the world. This indicator is expressed as a percentage of a country's Gross Domestic Product (GDP). The value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services are included in this indicator. However, compensation of employees and investment income (formerly called factor services) and transfer payments are excluded. Data on exports and imports are compiled from

customs reports and balance of payments data. Although the data from the payments side provide reasonably reliable records of cross-border transactions, they may not adhere strictly to the appropriate standards for recording international transactions (World Bank , 2023).

4.5.4 Export Goods and Services

Exports of Goods and Services is an indicator used by the World Bank to measure the value of all goods and other market services provided to the rest of the world. This indicator is expressed as a percentage of a country's Gross Domestic Product (GDP). The value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services are included in this indicator. However, compensation of employees and investment income (formerly called factor services) and transfer payments are excluded (World Bank, 2023).

4.5.5 Population Growth

The population growth is known as the rise in the number of individuals in a population or scattered cohort. Globally, the population growth rate had risen lingeringly during the period from 1700 till 1950, after that a sudden boost occurred in the number of populations till 1965. Records reported that during the period from 1800 till 2011 there was a rise of 7 times in the population rate, which occurred in parallel with the world economic growth (Lee, 2011). However, there exist two major opinions which relate the growth of population with that of the economy. Scholars stated that the population

growth replies to an income signal that unfavorably relies on the number of populations in respect to the economy's exchequer foundation, by holding the standards of living balanced. Moreover, the revolution in technology has increased the wages and requires a relative raise in the population. In addition, population growth is the main factor in the encouragement of new advanced technology innovation (Lee, 2011).

4.5.6 Energy Generation

The production of the modern economy products needs energy. Even though the alternate is available, but the fossil fuels are still the most trivial among the sources. It had been the foundation of the energy production systems in the developing countries and developed ones (Martins et al., 2018). Unluckily the fossil fuels are non-renewable natural sources and therefore may run out (Barreto, 2018). Moreover, the danger imposed by the dramatic change in the climate, that is hugely is caused by the combustion of fossil fuels, and from this point, countries realized the significance of shifting to a new renewable source of energy and the way they produce and consume energy (York & Bell, 2019). Scholars stated that countries already started their journey for the transition into renewable energy sources, even though the increase is still slow, the expectations are promising. New information regarding global energy production and consumption revealed that carbon emissions rates are in their middle way for shifting process, as the global carbon emissions between the year 2014 and 2016 were constant (York & Bell, 2019).

4.5.7 Electricity Consumption

Electricity consumption from fossil fuel is non-renewable energy, and is the number one climate change increased rate, and the top factor of global carbon emissions and global warming. Scholars found that there is a profound linkage between the consumption of energy, pollution of air, water, and natural resources (Martins et al., 2019). The production and consumption of energy have a positive relation, so that, countries who signed for the agreements of reducing carbon emissions, had started the consumption of renewable energy such as wind and solar energy, in which they preserve their natural resources at the same time (Martins et al., 2018).

4.6 The Research Model

4.6.1 Environmental Kuznets Curve Hypothesis

The Environmental Kuznets Curve hypothesis had turned to be the mainstay of the technical discussions that tackled the policies related to the environment starting the year 1991, as the economy's experts notified methodical linkage among the variations in income and the environmental quality (Yandle et al., 2002). Moreover, the EKC corresponds to statistical tools which epitomize significant sides of collective human behavior in 2D space. On the other hand, (Stern, 2017) stated that the EKC had been the controlling tactic between economists for the purpose of designing overall emissions of pollution and surrounding pollution concentrations during the last 25 years. Regardless of this, the EKC was criticized from the beginning and decomposition methods were much more common among else discipline that tackled climate change. However, Stern (2003) considered the EKC as an assumed linkage among different

environmental degradation indicators and income per capita. Also, it was added that during the early phases of the degradation of economic growth and the rise in pollution, the trend had inverted, in which at the high levels of income the economic growth resulted in improvement of the environment. Moreover, the environmental degradation around the world leads to individuals' concerns about the relationship among the economic growth and the environmental degradation, and most of the previous studies had shown the EKC as an empirical phenomenon, and that a transition from insufficient to sufficient allocation of capital is the foundation of the EKC (Dinda, 2005).

4.6.2 Panel Data Approach

Panel data consists of repeated observations over time on the same set of cross-sectional units. These units can be individuals, firms, schools, cities, or any collection of units one can follow over time. Special econometric methods have been developed to recognize and exploit the rich information available in panel data sets. Because the time dimension is a key feature of panel data sets, issues of serial correlation and dynamic effects need to be considered. Further, unlike the analysis of cross-sectional data, panel data sets allow the presence of systematic, unobserved differences across units that can be correlated with observed factors whose effects are to be measured. Distinguishing between persistence due to unobserved heterogeneity and that due to dynamics in the underlying process is a leading challenge for interpreting estimates from panel data models.

Panel data methods are the econometric tools used to estimate parameters, compute partial effects of interest in nonlinear models, quantify dynamic linkages, and perform valid inference when data are available on repeated cross sections. For linear models,

the basis for many panel data methods are ordinary least squares applied to suitably transformed data. The challenge is to develop estimators' assumptions with good properties under reasonable assumptions, and to ensure that statistical inference is valid. Maximum likelihood estimation plays a key role in the estimation of nonlinear panel data models (Wooldridge, 2009). Panel data analysis is at the watershed of time series and cross-section econometrics. While the identification of time series parameters traditionally relied on notions of stationarity, predetermined Ness and uncorrelated shocks, cross-sectional parameters appealed to exogenous instrumental variables and random sampling for identification.

By combining the time series and cross-sectional dimensions, panel datasets have enriched the set of possible identification arrangements and forced economists to think more carefully about the nature and sources of identification of parameters of potential interest. (Arellano & Honoré, 2001) Having argued that panel data provide greater leverage on issues of causal ordering than static cross-sectional data, it is important to note that panel designs are still observational in nature and are, therefore, no panacea for problems of endogeneity and omitted variable bias. If we observe change in X to be related to change in Y , in most situations we cannot exclude the possibility that the two processes are independent, conditional on an unobserved, time-varying Z . Similarly, consider a panel data set with the first wave of observations taken at time 1 t . If X measured at time 1 t influences Y at time 2 t , we cannot exclude the possibility that a measure of Y at time 0 t does not itself exert a causal influence on X at 1 t . Thus, although panel data represents a considerable improvement on cross-sectional data for understanding dynamic processes, it is important to note its fundamental limitation in unequivocally identifying causal relationships. (Berrington et al., 2006).

4.7 Research Context

This research employed a diverse set of econometric tests, including the panel data approach, cointegration analysis, and causality tests, to investigate the complex economic relationships and phenomena under consideration. These models were chosen strategically to address different aspects of my research questions, and each makes a unique contribution to the overall methodology of the study.

The panel data approach was employed as the foundation of my analysis. It allowed me to combine both cross-sectional and time-series data, which is especially valuable when examining economic phenomena with multiple dimensions. By using this model, I was able to capture individual and time-specific effects, which is essential for understanding the dynamics of my research variables over time and across different entities. Moreover, cointegration analysis played a crucial role in my thesis, primarily because it enables the examination of long-term relationships among variables. This is particularly important when investigating economic variables that are expected to move together in the long run, such as in the case of exchange rates and inflation. The cointegration analysis helped identify these stable relationships and assess whether they were statistically significant. This contribution added depth to my research by revealing the underlying equilibrium relationships that might not be apparent when solely using the panel data approach. Added to that, the causality tests were employed to explore the direction and strength of causal relationships among key variables in my study. Establishing causality is essential in economics to make policy recommendations and understand the impact of changes in one variable on others. These tests allowed me to identify whether certain variables were leading or lagging indicators, which can have important policy implications. The causality tests complemented the panel data and

cointegration analyses by providing insights into the dynamic aspects of my research questions.

4.8 Chapter Summary

This chapter provides a comprehensive detailed view of the used methodology that will be followed to conduct the study. Details on each of the nine study variables were proposed, in addition to the main philosophy, method, and data collection technique that the author had chosen.

Chapter Five:

Results and Discussion

Chapter Five

Results and Discussion

5.1 Chapter Overview

This chapter presents the discussions of various econometrics test conducted which consists of the Environmental Kuznets Curve, descriptive statistics, unit root test, the pardoni test for co-integration, serial correlation test, causality test and the panel data estimation framework to examine the of GDP-Climate change nexus.

5.2 Empirical Results

The Environmental Kuznets Curve (EKC) hypothesis states that pollution levels increase as a country develops but begin to decrease as rising incomes pass beyond a turning point. This is reflected as an inverted-U curve, expressing the relationship between pollution levels and income. This hypothesis was first proposed by Grossman and Krueger in 1992 (Grossman and Krueger, 1992), and restated by them in 1995.

Literature on EKC such as Ansari (2022) tested the Inverted U shape hypothesis, however this study aims to investigate the inverted U shape shaped EKC relationship between pollution and economic growth like Fakher (2023).

This panel study uses annual data from 2001 to 2020 for six countries i.e., Bahrain, Saudi Arabia, Kuwait, Oman, Qatar, and United Arab Emirates in order to investigate the N-shaped EKC hypothesis, following equation is estimated:

$$co_{2it} = a + \beta_1 GDP_{it} + \beta_2 GDP^2_{it} + \beta_3 IMP_{it} + \beta_4 EXP_{it} + \beta_5 POP_{it} + \beta_6 ENG_{it} + \beta_7 ELC_{it} + \varepsilon_{it} +$$

Inverted U-shaped EKC exist when if $\beta_1 > 0$ and $\beta_2 < 0$

N-shaped EKC exist if $\beta_1 > 0$, $\beta_2 < 0$ and $\beta_3 > 0$

5.2.1 Descriptive Statics

The below table shows the descriptive statistics of different variables and the total number of observations included in this analysis are (120). The mean value of CO₂ is (4.505) and the standard deviation is equal to (0.978). The average value of GDP is equal to (25.394) and the change in the variation of the observation is equal to (1.143). The mean value of export and import is approximately similar, and population mean value of migration is equal to (15.177). The energy consumption mean value is higher as compared to energy production. Moreover, these variables are showing the non-stationary behavior due to economic shocks appearing in the economy and to check the stationary of the data we are using panel unit root test and the result is given below.

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
CO₂ Emissions	120	4.505	.978	2.645	6.482
GDP	120	25.394	1.143	22.918	27.428
GDP^2	120	646.141	57.909	525.227	752.317
Import Goods and Services	120	24.514	1.111	22.291	26.412
Exports Goods and Services	120	24.926	1.104	22.611	26.725
Population	120	15.177	1.103	13.329	17.366
Energy Consumption	120	6.152	.942	4.752	8.039
Electricity Generation	120	3.84	.972	2.214	5.891

Source: Author

5.2.2 Stationary Test

Table 3: Unit root tests

	LLC		IPS		PP	
	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
CO ₂	-4.18516*	0.0000	-1.13459	0.1283	26.5804*	0.0089
Δ CO ₂	-10.6462*	0.0000	-8.88233*	0.0000	89.302*	0.0000
GDP	-5.41689*	0.0000	-2.78711*	0.0027	41.2614*	0.0000
ΔGDP	-4.98138*	0.0000	-3.6484*	0.0001	33.8451*	0.0007
GDP2	-5.2772*	0.0000	-2.63212*	0.0042	39.4868*	0.0001
ΔGDP2	-5.03771*	0.0000	-3.72622*	0.0001	34.4992*	0.0006
IMP	-5.54707*	0.0000	-3.42755*	0.0003	48.2687*	0.0000
ΔIMP	-4.3357*	0.0000	-3.1404*	0.0008	29.9676*	0.0028
EXP	-4.01962*	0.0000	-2.05831	0.0198	25.3169*	0.0134
ΔEXP	-5.301*	0.0000	-3.70265*	0.0001	33.1381*	0.0009
POP	-6.17201*	0.0000	-8.1989*	0.0000	14.2029	0.2879
ΔPOP	1.97344	0.9758	0.63758	0.7381	5.09945	0.9546
ENG	-5.50841*	0.0000	-2.2327*	0.0128	26.3099*	0.0097
ΔENG	-4.01737*	0.0000	-3.19933*	0.0007	37.9133*	0.0002
ELC	-5.66847*	0.0000	-2.13236*	0.0165	21.9*	0.0387
ΔELC	-4.18849*	0.0000	-3.66057*	0.0001	51.9504*	0.0000

Source: Author

*Note: *indicate level of significance at 5%,.*

Three-unit root tests have been applied to test the stationarity of variables, namely Levin, Lin & Chu (LLC), Im, Pesaran and Shin (IPS) and Phillips & Perron (PP). Unit tests were applied at level and their first difference as well and with intercept and with intercept and trend also.

Using unit root tests on the panel data in the preceding table, it is confirmed that the series is stationary. The tests of Levin et al. (2002) known as the LLC in the empirical literature on panel data, were applied to confirm the reliability of the findings. The findings of these tests were compared to those of Maddala and Wu (1999), who suggested employing a Fisher-type test, a nonparametric unit root test that is based on the ADF test (Dickey & Fuller, 1981) but does not account for temporal effects. The results in the table above show that the series have an integration order of $I(0)$, which indicates where panel regression can be directly applied.

5.2.3 Panel Regression Models

According to pooled OLS GDP is positively related to CO₂ and GDP² is negatively related between CO₂ emission and economic growth exist in the panel. Energy consumption increases CO₂ emission while imports decrease the CO₂ emission in the panel. Results for other variables are insignificant.

Table 4: Pooled OLS

CO₂	Coef.	Std. Err.	t	P> t
GDP	1.579184	0.543893	2.903486	0.0044
GDP^2	-0.023159	0.011423	-2.027497	0.0450
IMP	-0.337515	0.048376	-6.976934	0.0000
EXP	0.015467	0.069255	0.223343	0.8237
POP	0.044862	0.034358	1.305737	0.1943
ENG	0.797755	0.086193	9.255460	0.0000
ELC	0.057150	0.049087	1.164250	0.2468
_cons	-18.55223	6.831842	-2.715554	0.0077
F stat	941.3585*			
P value	0.000			
R2	0.983			
Adj R2	0.982			

Source: Author

*Note: *, **, *** indicate level of significance at 1%, 5%, 10% respectively.*

Table 5: Fixed effect Model

CO₂	Coef.	Std. Err.	T	P> t
GDP	1.633938	0.409802	3.987143	0.0001
GDP^2	-0.034418	0.008386	-4.104209	0.0001
IMP	0.124704	0.056203	2.218827	0.0286
EXP	0.094900	0.053591	1.770844	0.0794
POP	-0.089282	0.080055	-1.115259	0.2672
ENG	-0.016439	0.143464	-0.114589	0.9090
ELC	0.633242	0.116223	5.448520	0.0000
_cons	-21.14640	4.946107	-4.275363	0.0000
F stat	1391.446			
P value	0.000			
R2	0.994			
Adj R2	0.993			

Source: Author

*Note: *, **, *** indicate level of significance at 1%, 5%, 10% respectively.*

According to the fixed effect model GDP is positively related to CO₂ and GDP² is negatively related which indicates the inverted U-shaped relationship between CO₂ emission and economic growth exist in the panel. Electricity generation and exports increase the CO₂ emission in the panel. Results for other variables are insignificant.

Table 6: Random effect Model

CO₂	Coef.	Std. Err.	T	P> t
GDP	1.579184	0.560452	2.817697	0.0057
GDP2	-0.023159	0.011770	-1.967591	0.0516
IMP	-0.337515	0.049849	-6.770787	0.0000
EXP	0.015467	0.071363	0.216744	0.8288
POP	0.044862	0.035404	1.267157	0.2077
ENG	0.797755	0.088817	8.981990	0.0000
ELC	0.057150	0.050582	1.129850	0.2610
_cons	-18.55223	7.039848	-2.635318	0.0096
F stat	6900.74			
P value	0.000			
R2	0.983			
Adj R2	0.982			

Source: Author

*Note: *, **, *** indicate level of significance at 1%, 5%, 10% respectively.*

According to random effect model GDP is positively related to CO₂ and GDP2 is negatively related, and which indicate the inverted U-shaped relationship between CO₂ emission and economic growth exist in the panel. Energy consumption increases CO₂ emission while imports decrease the CO₂ emission in the panel. Results for other variables are insignificant.

Table 7: Differentiate Between Models

	Lagrange	Hausman
Type of Model	Pooled Vs Fixed & Random	Fixed Vs Random
Chi-square test value	6.139	238.99
P-value	0.013	0.000
Conclusion	Accept H_a	Accept H_a
Decision	Fixed & Random Effect Model	Fixed Effect Model

Source: Author

In order to choose between the fixed effects and random effects models, the Hausman test (1978) was used. So, for each panel, the model that was most in line with the test results was chosen.

The Hausman test is applied to choose the better model from random effect and fixed effect model. The Hausman test has the null hypothesis that random effect model is appropriate, since p value is less than (0.01) null hypothesis is rejected, and alternate hypothesis is accepted which is fixed effect model is appropriate. Therefore, results of fixed effect model are appropriate and valid.

5.2.4 Cointegration Test

Pedroni (1999, 2004) devised the heterogeneous panel cointegration test, which enables us to take into account cross-sectional dependency with various individual effects, to assess whether long-run equilibrium exists. With the use of seven repressors based on

seven residual statistics, this analytical approach enables cointegration testing in heterogeneous and homogeneous panels.

Table 8: Padroni test for cointegration

	Statistics	p-value	Conclusion
Modified Phillips Perron t	2.1356	0.0164	Reject H0
Phillips perron t	-3.1095	0.0009	
ADF t	-2.8551	0.0022	

Source: Author

The results of Pedroni's incorporation of the seven statistics are displayed in the above table (Table 8). At various levels of significance, the t-statistics for each set of nations do not allow the cointegration null hypothesis to be rejected. These findings therefore show that GDP and CO₂ emissions per capita have been moving together and simultaneously in all groupings of nations between 2001 and 2020. We now provide a summary of the study's goal using empirical estimation.

5.2.5 Causality Test

Pairwise Dumitrescu Hurlin Panel Causality Tests has been applied to test the causality between variables in the panel. It has a null hypothesis of no causality from one variable to another.

According to panel causality test there is one way causality from GDP to CO₂, Population to CO₂, energy consumption to CO₂, electricity generation to CO₂ and from import to CO₂. These results indicate that economic growth, imports, population,

energy consumption and electricity generation are causing carbon emission in the panel.

Table 9: Panel causality test

Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.
GDP $\rightarrow$ CO₂	4.798**	2.099	0.036
CO₂ $\rightarrow$ GDP	0.788	-1.358	0.174
IMP $\rightarrow$ CO₂	4.475***	1.820	0.069
CO₂ $\rightarrow$ IMP	2.522	0.136	0.892
EXPT $\rightarrow$ CO₂	2.847	0.417	0.677
CO₂ $\rightarrow$ EXPT	0.490	-1.616	0.106
POP $\rightarrow$ CO₂	5.383*	2.604	0.009
CO₂ $\rightarrow$ POP	3.731	1.179	0.238
ENG $\rightarrow$ CO₂	5.651*	2.834	0.005
CO₂ $\rightarrow$ ENG	3.046	0.588	0.557
ELC $\rightarrow$ CO₂	7.189*	4.161	0.000
CO₂ $\rightarrow$ ELC	2.760	0.342	0.732

Source: Author

*Note: *, **, *** indicate level of significance at 1%, 5%, 10% respectively.*

5.2.6 Examine Research Output

1. GDP has positive impact on CO₂ emission for the panel according to fixed effect model which indicates that increase in GDP leads to increase in carbon emissions

in the panel of countries. Panel causality results also confirm that GDP causes carbon emission to increase in the panel.

2. There is no impact of import on CO₂ emissions for the panel according to fixed effect model. However, there is one way causality from imports to CO₂ emission at 10% level of significance which indicates imports causing CO₂ emission.
3. There is no impact of population on CO₂ emissions for the panel according to fixed effect model and. However, there is one way causality from population to co2 emission which indicates population causing CO₂ emission in the panel.
4. Export of goods and services has a positive impact on CO₂ emission for the panel according to fixed effect model which indicates that increase in export of goods and services leads to increase in carbon emissions in the panel of countries. Panel causality results indicate no causality between carbon emission and export in the panel.
5. There is no impact of energy consumption on CO₂ emissions for the panel according to fixed effect model. However, there is one way causality from energy consumption to CO₂ emission which indicates energy consumption causing CO₂ emission in the panel.
6. Electricity generation has a positive impact on CO₂ emission for the panel according to fixed effect model which indicates that increase in electricity generation leads to increase in carbon emissions in the panel of countries. Panel causality results also confirm that electricity generation causes carbon emission in the panel.

Table 10: Comparative Result

Variable	Impact	Causality Direction
GDP	Positive *	Unidirectional *
GDP²	Negative *	No Direction
IMP	Positive *	Unidirectional *
EXP	Positive	No Direction
POP	Negative	Unidirectional *
ENG	Negative	Unidirectional *
ELC	Positive *	Unidirectional *

Source: Author

5.2.7 Examine Environmental Kuznets Curve Hypotheses

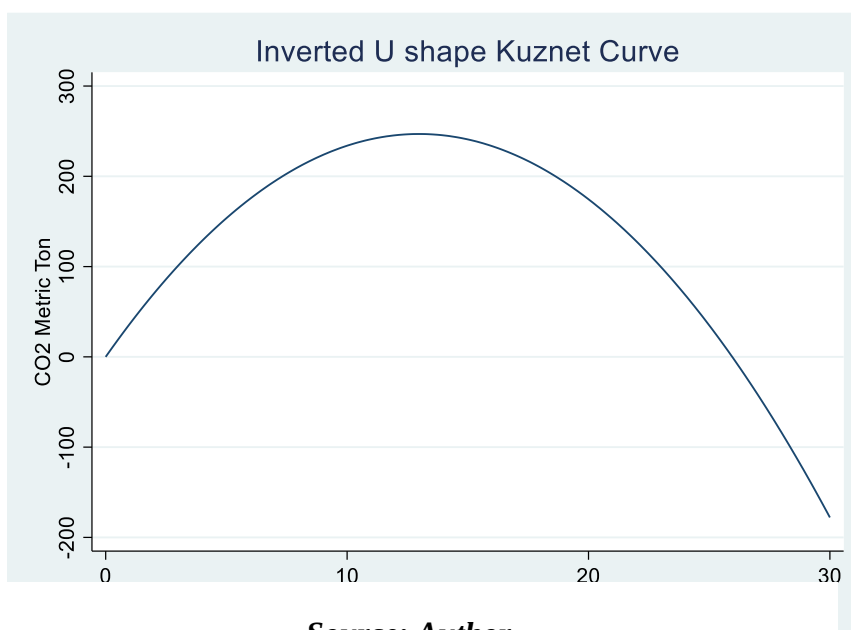
Furthermore, Shahni and Raghuvansi's (2016) investigation confirms that the GDP square has a negative impact on CO₂ emissions, meaning that when both variables increase at some point, CO₂ emissions fall (2020). These findings form a U-shape that supports the EKC and are consistent with the theory.

The growth rate of the GDP does, however, have a positive and considerable beginning impact on CO₂ emissions in Middle Eastern countries, which changes to a negative and significant effect as it rises. Since the GDP coefficient is initially positive and

eventually turns negative in the quadratic term and is extremely significant at the 1% level, the Kuznets curve hypothesis curve is satisfied. The outcome is further evidence in the form of the following examples.

This outcome validates the EKC and its functional inverted U shape (Tingval & Poldahl, 2006). Moreover, imports have a negative influence on the first model and are highly significant but favorable in the case of fixed effects and random effects models. They also have a negative impact and are significant at the 1% level. Although weakly significant at the 10% level in the fixed effect case, the export coefficient is positive in all three scenarios. Although the correlation between energy use and electricity production is positive, its importance is unclear. In all three instances, the coefficient of constant has a negative effect and is highly significant at the 1% level.

Figure 8: Inverted U-shaped Kuznets Curve



Source: Author

In exploring the validity of the Environmental Kuznets Curve Hypothesis Approach (EKC) in CC States,

inverted U shaped EKC relationship is found in the panel according to fixed effect model.

5.3 Result Discussion

5.3.1 CO₂ Emissions and Gross Domestic Product (GDP)

GDP growth and CO₂ emissions are considered as one of the most important empirical relationships in our time with variations in climate change as a major concern currently. Global climatic change is primarily driven by greenhouse gases and especially by CO₂ emissions. CO₂ emissions can be produced from burning fossil fuels and other industrial processes. Since the drivers of emissions evolve over time, the responses of emissions to the changing factors might be time varying. Raupach et. al, (2007) asserted that the strong global fossil-fuel emissions growth since 2000 was driven not only by long-term increases in population and per-capita global GDP but also by a cessation or reversal of earlier declining trends in the energy intensity of GDP and the carbon intensity of energy. The standard approach here is to examine the relationship between the CO₂ emissions and GDP and the direct proportionality of the increase in GDP to CO₂ emissions. From the results obtained in this study, it was evident that GDP was positively related to CO₂ emissions ($p < 0.05$) hence there was a statistically significant relationship. Income elasticity might change through time due to the factors affecting the drivers of the CO₂ emissions, (Mikayilov et. al, 2018).

A previous study by Magazzino (2016) that investigated the dynamic causal relationships among carbon emissions, financial development, economic growth, and energy consumption for Gulf Cooperation Council (GCC) countries from 1980 through

2011 is in accordance with this study. The results indicated that there were a long-run and causal relationships among carbon emissions, financial development, gross domestic product (GDP), and energy use in all GCC countries except United Arab Emirates (UAE). The evidence suggests that financial systems should take into account environmental aspects in their current operations in these countries.

This study indicated that there was a one-way panel causality from GDP to CO₂ and that was statistically significant ($p < 0.05$). The null hypothesis that there is no causality from GDP to CO₂ emissions is rejected since the causal relationship is statistically significant at (0.05) level. Therefore, the implication here is that an increase in the GDP activities results in an increase in CO₂ emissions. The causal relationship between GDP and CO₂ emissions is directly proportional. As similar study done by Ajmi et. al, (2015, p.1) which reported that an environment that controls the relationships between energy consumption, carbon dioxide (CO₂) emissions and gross domestic product (GDP) changes over time due to variations in economic growth, policy and regulations and technology, in the G7 countries. A suggestion should thus be adopted by the GCC panel countries to ensure that there are no variations in economic growth, policy and regulations and technology so that the environment does not depict any contradictory changes over time but maintain constant sustainable development goals since economic growth has a positive impact on CO₂ emissions. The goal is to reduce CO₂ emissions in these panel countries.

This present study was in accordance with a study done by Al-Mulali, (2014) which indicated that nuclear energy consumption is co-integrated with both GDP growth and CO₂ emission. The growth of GDP leads to an increase in CO₂ emissions. Thus, based on the panel causality test in our study, it is clear that panel causality results also confirm that GDP causes carbon emission to increase in the panel.

In yet another similar study in Malaysia, it was shown that both consumption of energy per capita and per capita GDP has long term positive impact with per capita CO₂ emissions (Begum et. al, 2015). This is in accordance with this study which we observed that GDP causes carbon emission to increase in the panel countries.

In conclusion, the results of this study may be of great importance for policy and decision makers in developing energy policies for GCC countries that contribute to curbing carbon emissions while preserving economic growth. The findings of this study will provide policymakers some understanding about the relationship between the carbon emission and GDP growth and economic growth, hence help the policy makers to design policies that can tackle the environmental problems without creating hindrance for the growth of GDP.

5.3.2 CO₂ Emissions and Import Goods & Services

CO₂ emissions result from burning fossil fuels largely. Importation of goods such as fuel will eventually lead to an increase in CO₂ emissions through consumption, and this underscores the amount of CO₂ embodied on imports to a country. Through goods imported in an interdependent nation, the consumption is linked to greenhouse gas emissions in other countries using the same goods and services.

In this study, we observed that there was no impact of imports on CO₂ emissions for the panel, however there is one way causality from imports to CO₂ emission at 10% level of significance which indicate imports causing CO₂ emission, ($p < 0.1$). At 10% significance level, we reject the null hypothesis that there is no one way causality from imports to CO₂ emissions. In their findings they revealed that liberalization of international trade from developed countries to developing countries increases transfer

of CO₂ emissions. Through international trade on imports, very significant environmental impacts can be shifted from one country to another, and that does not necessarily result in globally increased CO₂ emissions. According to Mahmood (2022) study, he asserted that imports in GCC countries have positive spillovers and direct effects on territory-based CO₂ emissions and have positive spillovers effects on consumer-based CO₂ emissions. Our study is in accordance with this study since we observed a causal effect of imports to CO₂ emission in the panel countries which is like the spillover effects observed in the previous study.

In their study, Mahmood et. al (2020) assessed exports, imports, foreign direct investment, and CO₂ emissions in North Africa. It was shown that imports of North Africa are accelerating pollution through increasing energy consumption. The indirect effect of energy consumption towards CO₂ emission is negative, which shows the positive environmental spillover effects of imports on the CO₂ emissions of neighboring countries. This is in accordance with our study where we observed that there is no impact of imports on CO₂ emissions for the panel. But the causality from imports to CO₂ emissions in the panel concurs with the study done by Mahmood and colleagues on imports and CO₂ emissions in North Africa.

This present study concurs with a similar study done by Kari & Saddam (2012) excerpt on GCC countries, which indicated that commodity imports coefficient was statistically insignificant, which implies that imports have no relation with the air pollution, CO₂ emission in the UAE between 1998 to 2008. To explain this further, we assert that most capital import goods are characterized in the high advanced technology in the UAE, and thus help to maintain the environment. In Bahrain also, imports were statistically insignificant. Bahrain has low level of oil production and therefore imports have no impact on air pollution through CO₂ emissions in Bahrain. In other words, the low level

of products does not lead to pollution of the environment. Furthermore, the findings indicated that the existence of increased CO₂ emissions in Bahrain resulted from transboundary pollution, especially from Qatar, Kuwait, and Saudi Arabia. In Saudi Arabia, the estimated model indicated that the foreign direct investment inflows through was the major cause of air pollution in Saudi Arabia. Increasing FDI inflows led to a significant increase in the per capita carbon dioxide emissions. However, an increase in commodity imports led to a decrease in the per capita carbon dioxide emissions. This means that there is a negative relationship between imports and CO₂ emissions in Saudi Arabia, and this is in accordance with this study. In this respect of the commodity imports, we noted that there is a negative relation between the increased level of imports and CO₂ emissions, hence there is no significant impact of imported goods on CO₂ emissions. The results reflect that polluted capital goods are substituted with advanced capital goods according to Hussien (2010).

In Oman, the coefficients of FDI inflows and commodity imports are statistically significant at the (0.01) level in Kari and Saddam (2012). This means that the effect of FDI inflows is positive, where a unit increase in FDI inflows leads to an increase in the per capita carbon dioxide emissions by about (0.004010) times over the period 1998-2008. However, the relationship between commodity imports and the level of pollution regarding CO₂ emissions is negative, where a unit increase or change leads to a reduction in the carbon dioxide emissions by (-0.003441) times. This reiterates that imported goods have no positive impact on CO₂ emissions but have a one-way causal effect on CO₂ emissions. Further, the imported capital goods characterized in advanced technology led to reduced carbon dioxide emissions over period of assessment. Therefore, the result of the specific model confirms that the carbon dioxide emissions are resulting from the FDI inflows to Oman, which is the main reason for air pollution in Oman over the period of study.

In Qatar, commodity imports have an impact in CO₂ emissions. The estimated results indicated that a unit increase/change in commodity imports led to an increase in the per capita carbon dioxide emission by (0.001428) times, with a positive relation between the commodity imports and CO₂ emissions. This contradicts the findings of our study which is that imports have no impact on CO₂ emissions in the panel. Therefore, we can assert that the main cause of increased pollution is due to importing polluted capital goods, such as transportation equipment, and other capital goods that are characterized by diss advanced technology which contain carbon embodied content that led to CO₂ emissions.

This study analyzed the impact and causality of imported goods on CO₂ emissions for the panel countries as a group instead of individual countries. An analysis of an individual country would give a detailed and more robust estimation of the results instead of basing the findings on the general model, which might be biased. Further studies can focus on the individual countries in the panel GCC countries to give a well detailed and more specific findings for decision making and for global authorities to make inferences.

5.3.3 CO₂ Emissions and Export Goods & Services

Exportation of goods and services in trade depends on the trade policies of the panel countries involved in the trade circle. Export diversification policies have consequences that might harm the environment of the country. The export trade policies for developing and developed economies might conflict with sustainable development goals and with the environmental preservation objectives of the countries. This further raises a question as to whether such trade policies are good or bad for the environment and for cleaner

production in the economies. This is because diversification of exports is involved with energy usage. In this study, it was observed that the export of goods and services has a positive impact on CO₂ emission for the panel according to fixed effect model ($p < 0.05$), with the rejection of the null hypothesis, which indicate that increase in export of goods and services leads to increase in carbon emissions in the panel of countries.

In tandem with export goods and services to CO₂ emissions, introduction to export diversification is imperative to validate the argument here. Shahbaz et al., (2019) conducted a study on human capital and export diversification as new determinants of energy demand in the United States. They found out that export diversification causes energy demand, and this energy demand led to CO₂ emissions, and in return, energy demand causes export diversification. This outcome by Shahbaz study concurs with this present study, as we observed earlier, that increase in export of goods and services leads to increase in carbon emissions.

The export product diversification represents the economic complexity and overall structural change in an economy. Dennis & Shepherd, (2011) argues that export diversification is a modification in the export basket of a region, ideally the panel countries. They described export diversification as a widening of the range of products that a country export. The countries can change the export product diversification by either increasing the available exports from the region, which is the intensive margin or, secondly, by increasing the number of products exported by the region i.e., extensive margin (Cadot et al., 2011).

While in our study, it is clear that panel causality results indicate no causality between carbon emission and export in the panel, ($p > 0.05$), this is different from other recent literature, For instance, in China, Wang et. al, (2020, p. 73-82), assessed the causal relationships between CO₂ emissions and economic factors. Their results showed that

there is unidirectional causality from per capita GDP to CO₂ emissions in eastern and central provinces. However, there is unidirectional causality between CO₂ emissions to export volume only in eastern provinces. Their study is not in accordance however with our present study on the causality between carbon emission and export in the panel countries.

5.3.4 CO₂ Emissions and Population

Population is a group of individuals at a particular place with a common characteristic. The population in this study was derived from the panel countries; Bahrain, Saudi Arabia, Kuwait, Oman, Qatar and United Arab Emirates, which are the member states of the Arab League. These countries form the Gulf Cooperation Council (GCC) since they are part of the Persian Gulf. We have observed in this study that there is no impact of population on CO₂ emissions ($p > 0.05$) for the panel according to fixed effect model. This is similar to a study done by Begum et. al, (2015, p. 594 – 601) on CO₂ emissions, energy consumption, economic and population growth, where they found that population growth rate has no significant impacts on per capita CO₂ emission. While population grows and consumption increases, there tends to be an increase in emissions of climate-changing greenhouse gases, however this is not the case with this study. The results in this study might be as a result of proper governance policies that the panel countries have put in place to control the greenhouse gases' emission to their growing population.

The population size of the GCC panel countries have been in constant growth over the decades also with urbanization being strengthened in these countries. As Dodman (2009) argues, there is some evidence of the links between urban population density

and mitigation of greenhouse gases emissions. Much of this relies on the initiatives taken by authorities and organizations in relation to processes of urban growth and good governance at all levels of administration. Most of the population growth in the region is taking place in urban areas. This raises a concern for how the growth in the urban population in these panel countries' population influences CO₂ emissions. Assessment can be done on the contribution to CO₂ emissions of urban centers or the growth in urban populations in these countries can be handled by considering the where the CO₂ emissions are produced by assessing the source of the proportion of CO₂ emissions emitted by human activities within the confines of urban areas. Also, another way to handle the situation is by taking into account the consumption perspective by assessing all the CO₂ emitted because of the consumption and waste generation of urban populations no matter where they originated. This implies that for any individual or household to contribute to CO₂ emissions, they must consume the goods and services that generate CO₂ emissions, (Abou-Ali & Abdelfattah, 2016).

Bargaoui et. al, (2014) in their study revealed that in the Arab countries, there is an inverse relationship between poverty and the per capita CO₂ emission. This relation might be because poor people have little access to goods and services that have high levels of CO₂ emissions. However, as stated above, their access to energy efficient sources is also very low therefore it is possible that this will slow reductions in CO₂ emissions. The study concurs with the present study on the impact of population on CO₂ emissions. These six countries are prominent oil and natural gas producing countries. According to Reiche, (2010), the population of GCC countries constitute only 0.6% of the global population, however they produce 2.4% of the global greenhouse gas emissions.

It is evident in this study that there is one way causality from population to CO₂

emission which indicate population causing CO₂ emission in the panel. This study is similar to the studies of Abou-Ali & Abdelfattah, (2016), where they found that population growth significantly leads to demand in more energy which in turn results in increase in CO₂ emissions. Theoretically, population growth is believed to increase CO₂ emissions through the increase in human activities with implies more energy consumption. Even though population is not a determinant of CO₂ emissions as earlier observed, however the increase in human activities that lead to more energy consumption and productions determines the CO₂ emissions, hence the causality from population to CO₂ emission.

In yet another similar study by Sulaiman and Abdul-Rahim (2018) on population growth and CO₂ emission in Nigeria using a recursive ARDL approach, they indicated that CO₂ emission in Nigeria is driven by economic growth through massive fossil fuel energy consumption. This similarly infers that population growth causes CO₂ emission through increased human activities which normally accompany growth in population. This causality is similar and in accordance with this current study where population has one way causality with CO₂ emission, ($p < 0.05$) implying statistical significance.

5.3.5 CO₂ Emissions and Energy Consumption

Energy consumption refers to all energy used to perform an activity, it can be in industries, in households or anywhere. This energy is derived from burning fossil fuel, oil, coal, and gas and this therefore leads to CO₂ emissions. The panel countries produce large amounts of fossil fuels as indicated in the study hence the consumption is also high due to the growing population. There appears to be uneven distribution of energy consumption across countries in GCC. Among six-member panel countries of GCC,

the highest energy consuming country appears to be UAE followed by Oman. Bahrain exceptionally appears to be the only country which has relatively stabilized its energy consumption as depicted by Asif et. al, (2015). Similarly, in CO₂ emission, UAE is the highest emitting country followed by Oman and Saudi Arabia.

The growing energy consumption in the GCC panel countries is supporting economic growth but consequentially contributing to the environmental degradation due to emissions of CO₂. The GCC panel countries are one of the world's most urbanized economic regions in the world. According to Asif et. al, (2015) study on relationship between energy consumption, urbanization, and CO₂ emission, they alluded that urbanization has a positive impact on energy consumption and that energy consumption has a positive impact on CO₂ and CO₂ has a positive impact on energy consumption. Their findings clearly differ from the findings of this study which indicate that there is no impact of energy consumption on CO₂ emissions for the panel according to fixed effect model. There is statistical insignificance, ($p > 0.05$), hence we fail to reject the null hypothesis and thus the conclusion from the observation made. In China, Zhang & Lin (2012) highlighted the relationship between urbanization, energy consumption and CO₂ emission not only at national level but also at regional levels in China. Their result showed that urbanization has increased energy consumption and CO₂ emission in China although the effects vary across different regions. This explains the causality effect similar to our study findings.

Nnaji, Chukwu, and Nnaji (2013) affirmed that economic growth in Nigeria, for instance, is linked with an increase in CO₂ emissions and that emissions are facilitated by fossil fuel consumption which is essentially energy consumption. The study concurs with the findings of our study which is that there is one way causality from energy consumption to CO₂ emission which indicate energy consumption causing CO₂

emission in the panel, although the direct impact of energy consumption is insignificant but there is the causal effect in that regard that leads to CO₂ emissions. Nonetheless, human activities such as bush burning, deforestation, and other human activities are believed to aid CO₂ emissions. These activities are assumed to further increase with population growth. This is because as population rises, human activities are also expected to rise which leads to a rise in consumption of energy that eventually leads to CO₂ emissions. This is evident in this study on the causal effect of energy consumption and CO₂ emission being statistically significant with ($p < 0.05$).

Sulaiman (2014) applied the Toda and Yamamoto causality test, he revealed that energy consumption increases CO₂ emissions, and that there exists two-way causality between energy consumption and growth in Nigeria. This slightly differs with our study since we observed a one-way causality between energy consumption in the panel countries and CO₂ emissions. Still, there needs to be policies and strategies set in place by governing authorities in these panel countries to govern the consumption rate of energy which generates a linkage to increased GHG emissions that contain the carbon content that led to CO₂ emissions.

5.3.6 CO₂ Emissions and Electricity Generations

Electricity generation is a process of generating power/electricity from the primary sources of energy. Electricity is generated from fossil fuels, nuclear power plants, hydro power plants, geothermal systems, solar panels, biofuels, wind, among others. When burning fossil fuels to generate electricity, CO₂ emissions are produced. Electricity consumption and the related CO₂ equivalent gas emissions result from oil and gas combustion for the six countries that comprise of the GCC. The CO₂ emissions in these

countries are concentrated in the energy extraction and conversion sectors, mainly from oil drilling and electricity production.

It is shown in this study that electricity generation has positive impact on CO₂ emission for the panel according to fixed effect model, ($p < 0.05$), which indicate that increase in electricity generation leads to increase in carbon emissions in the panel of countries. There is statistical significance hence the null hypothesis is rejected at this point. Further, the panel causality results also confirm that electricity generation causes carbon emission in the panel. The demand for electricity is increasing worldwide as populations' consumption of electricity is rising constantly, as people are increasingly having the willingness and the ability to add more electrically powered devices that are highly used in their daily activities increasing consumption of electricity. The most common and cheap technology at the moment is the combustion of fossil fuels to convert thermal energy into mechanical motion and finally into electricity. The current rates of electricity consumption and related CO₂ emissions in GCC countries are higher than other developed countries of similar population but lower economic and technological development according to Qader (2009). He further also conducted an analysis of electricity consumption and GHG emissions in GCC countries and consequently found out that GCC countries contribute significantly to the global CO₂ emissions, and that the majority of their CO₂ emissions are concentrated in the energy extraction and conversion sectors, mainly from oil drilling and electricity production. Some of the reasons behind the excessive increase in electrical demand is linked to a non-rational pattern of electricity consumption.

Similar studies by Dantama, Abdullahi and Inuwa (2012) opined that energy consumption in the form of petroleum and electricity consumption promotes economic growth, and the generation of electricity leads to an increase in the emission of CO₂.

This study is in accordance with the study done by Abdullahi and Inuwa in Nigeria. Further, a similar study by Akpan and Akpan (2012) also showed that economic growth is associated with increased carbon emissions, which are accelerated by electricity consumption and agrees with the findings in this current study in the six GCC panel countries. An increase in electricity consumption implies an increase in electricity generation which leads to an increase in CO₂ emissions.

Electricity is generated in the GCC countries mostly by fossil-fueled (oil or gas) power plants. Laura (2019) provided a comprehensive overview of developments in the GCC countries. In the study, the forecast for the electrical demand in GCC countries by 2015 showed an excess of 80% with respect to the current installed base of generators, and this creates the challenge of finding new cleaner sources of power generation, because in the normal scenario, in which the same sources of electricity generation are used, the global CO₂ emissions would also increase by about 80%.

This study is in accordance with the previous literature on the impact of electricity generation on CO₂ emissions and the causal effect of electricity and CO₂ emissions as one-way.

5.4 Chapter Summary

In this chapter, the results of the study show that there is a statistically significant relationship between GDP and CO₂ emissions. GDP has positive impact on CO₂ emission for the panel and this indicates that increase in GDP leads to increase in carbon emissions in the panel of countries. There is a direct proportionality between GDP and CO₂ emissions. Panel causality results also confirmed that GDP causes

carbon emission to increase in the panel. Also, the findings indicated that at 10% confidence level, there was no impact of import on CO₂ emissions for the panel. However, there was one way causality from imports to CO₂ emission at 10% level of significance which indicate imports causing CO₂ emission. This causal effect results in consumption of energy arising from imports and hence the increase in CO₂ emissions. Population was also found to be statistically insignificant in predicting CO₂ emissions, but however, there was one way causality from population to CO₂ emission which indicated that population caused CO₂ emission in the panel. This is a result in growth of population which results in an increase in anthropogenic activities that lead to increase in energy consumption resulting in an increase in CO₂ emissions.

Export of goods and services was found to have a positive impact on CO₂ emission for the panel due to the carbon component in the export products, however, there was statistically insignificant, no causal effect of exported goods to CO₂ emission. There was no impact of energy consumption on CO₂ emissions, there was a statistically insignificant relationship between energy consumption and CO₂ emissions. However, there was one way causality from energy consumption to CO₂ emission which indicates energy consumption causing CO₂ emission in the panel. This was due to the demand for energy consumption that led to an increase in energy production resulting in CO₂ emissions. Electricity generation had a positive impact on CO₂ emission for the panel and this indicated that an increase in electricity generation leads to an increase in carbon emissions in the panel of countries. Similarly, panel causality also confirmed that electricity generation caused carbon emission in the panel. From the findings in this study, we suggest that the panel countries can adopt methods to shift to renewable clean energy to reduce the emissions of carbon dioxide and other greenhouse gases to the environment to avoid air pollution that result in global warming. While doing this, it is important to consider and take into account

sustainable economic growth of these countries without altering anything for sustainable development goals. In addition, the study findings suggest that the governing authorities should adopt policies and regulations to control CO₂ emissions and ensure their environments are free of air pollution and global warming. We recommend that further future research be focused on individual panel countries for comparison of the findings and draw clear inferences.

Chapter Six:

Conclusion and Recommendations

Chapter Six

Conclusion and Recommendations

6.1 Chapter Overview

This chapter will be divided into subsections sections such as summary of research methods, major findings and contribution, implication for policy practice, limitations of the study, future research direction and finally, the conclusion.

6.2 Restate the Research Question and Objectives

This study was focused on finding the solution to the research questions, such as the concepts of climate change and Gross Domestic Product, examining the relationship between climate change and GDP, and defining the Environmental Kuznets Curve hypothesis. The study also aimed to assess the Sustainable Development Goals for climate change and evaluate the current situation in GCC countries regarding GDP and climate change. The objectives of this study were to shed light on the Environmental Kuznets Curve hypothesis, two, to add some weight to the literature by analyzing the relationship between Gross Domestic Product and Climate Change through the lens of the Environmental Kuznets Curve hypothesis, three, to examine the review of previous literature that focuses with economic growth and climate based emission, four, to explore about the long term implication and challenges of Climate Change GCC states. Finally, to fill the knowledge gap in sustainable economic growth within the Climate Change problem of the GCC states.

6.3 Summary of Research Methods

The data used in the study were extracted from annual panel data for the six GCC countries from 2001 to 2020. Stationarity tests, serial correlation tests, pooled ordinary most minor squares tests, fixed effects models, random effects models, chi-square tests, cointegration tests, and causality tests were some of the diagnostic tests used to draw conclusions in this research. Levin, Lin & Chu (LLC), Im, Pesaran and Shin (IPS) and Phillips and Perron (PP) unit root tests done to test the stationarity of variables found that the variables were stationary from the series of panel data.

6.4 Key Findings and Contributions

The relationship between carbon dioxide emissions, the main gas responsible for global warming, and economic growth is among the most researched environmental economics topics. The focus and interest of sustainable development is the potential for reducing overall CO₂ emissions while maintaining a high pace of economic development.

Economists prefer cases when CO₂ emissions decrease more rapidly than the pace of economic growth, but the stalemate has been reducing CO₂ emissions without having a reverse impact on economic growth. This has become a major source of concern for global economies. This issue requires an empirical analysis of the CO₂ emissions and GDP relationship. In the GCC states, the study of this relationship has particular importance for the GCC countries since they have been historically the main contributors to global warming due to their large-scale production of fossil fuels, which contribute primarily to CO₂ emissions in the present world. The response of the CO₂ emissions to economic growth is an alternative way to consider

the decoupling issue, as alluded to by (Mikayilov et al., 2018,). In this regard, the question to be addressed is whether the GCC economies can be considered to have attained sustainable development goals with the global concern of climate change.

The literature on the CO₂ emissions and GDP relationship is vast; it has used various econometric methods based on a panel of grouped country analyses in the GCC, among other features. This study has used a time-varying coefficient cointegration approach to investigate the CO₂ emissions and GDP relationship for six GCC panel countries from 2001 to 2020.

In the methodologies used, based on the Ordinary Least Squares Method (OLS), estimation results show that there is a positive relationship between GDP and Climate Change concerning CO₂ emissions. Energy consumption increases CO₂ emission while imports decrease the CO₂ emission in the panel.

The main finding of this present study is that the GCC countries' GDP positively impacts CO₂ emission for the panel according to the fixed effect model. This implies that when GDP is increased, there is a consequential increase in carbon emissions in the panel of countries, and this is attributed to the increase in the level of consumption, which in turn increases the level of production that is reliant on energy consumption. The panel causality results also confirm that GDP has a causal effect on carbon emissions increase in the panel GCC countries. In the case of the relationship between imported goods and services to CO₂ emissions, it was found that import has no impact on CO₂ emissions for the GCC states. The carbon embodiment of these imports to the GCC states explains this. When the goods don't have carbon embodiment, there is no way the imported goods will contribute to CO₂ emissions. This is also because the GCC states are the leading producers of fossil fuels, which are the primary source of greenhouse gas emissions and CO₂ emissions,

and they won't need any more goods with carbon content hence the logical impression of this result.

However, a one-way causality from imports to CO₂ emission indicated imports cause CO₂ emissions in a series of stages. According to Mahmood's (2022) study, this is asserted that imports in GCC countries have positive spillovers and direct effects on territory-based CO₂ emissions and have positive spillover effects on consumer-based CO₂ emissions, thus the causality witnessed in this present study. This does not imply that active climate policy may induce a reduction in absolute CO₂ emissions levels, as the spillover effects of imported goods are spread over to CO₂ emissions passively.

The third main finding is that we find evidence that the export of goods and services positively impacts CO₂ emission for the GCC countries, which indicates that an increase in the export of goods and services leads to an increase in carbon emissions in the panel of countries. The explanation for this finding is that export diversification causes energy demand, which leads to CO₂ emissions, and in return, energy demand causes export diversification. The causality test for this study also confirms the positive relationship between carbon emission and the export of goods in the GCC states.

The fourth main finding of this study is that there is no evidence of the impact of population on CO₂ emissions for the panel GCC countries. The explanation of this finding comes from the population distribution of the GCC states, where most of the population is found in urban areas. An increase in population due to urbanization can only produce a causal effect on CO₂ emissions when human activities have increased due to the growing population to produce more fossil fuel energy for

consumption, which is going to increase CO₂ emission from the combustion of fossil fuels.

Fifth, another key finding in this study is that direct energy consumption is insignificant in impacting CO₂ emissions. This can be explained by whether the energy consumed in the GCC states is renewable energy which significantly reduces CO₂ emissions or non-renewable energy which comes from fossil fuels and increases CO₂ emissions. The possibility of support for this finding is that most of the GCC states have shifted to using clean, renewable energy sources to tackle the issue of CO₂ emissions that cause climate change. However, there is a causal relationship between energy consumption and CO₂ emissions concerning increased human activities that lead to the burning of fossil fuels, oil, and gas which lead to CO₂ emissions.

Finally, another key finding of this research is that electricity generation has a positive impact on CO₂ emission, indicating a direct proportionality between electricity generation and carbon emissions in the panel of GCC countries. This is also supported by the panel causality of electricity generation to CO₂ emissions. In half of the cases assessing the hypothesis of the study, the analysis confirms that there is a statistically significant relationship between CO₂ emissions with variables under study and vice versa is true.

In the remaining cases, some variables of measurement on the GDP and climate change are not statistically significant. Pairwise Dumitrescu Hurlin Panel Causality test explores the causal direction between GDPs per capita growth and CO₂ emissions. The findings have reported the causality relationship under the EKC framework. Approximately 100% of the panel data show that the causality relationship runs from GDP growth to CO₂ emissions in one way. This confirms the

usefulness of our time-varying coefficient cointegration analysis to consider cross-sectional dependency with various individual effects, to assess whether long-run equilibrium exists. The findings show that GDP and CO₂ emissions per capita have been moving hand in hand simultaneously in all groupings of nations in GCC between 2001 and 2020.

6.5 Economics and Financial Implications

The results of the study carry several significant economic and financial insights:

- **Economic Growth and Carbon Emissions:** The finding that an increase in GDP leads to higher CO₂ emissions underscores the challenge of decoupling economic growth from environmental degradation. Policymakers in the examined countries should be aware that economic expansion can put pressure on carbon emissions. This insight highlights the need for sustainable economic development strategies that prioritize clean technologies and energy efficiency to mitigate the environmental impact of growth.
- **Trade and Environmental Impact:** The positive impact of exports on CO₂ emissions suggests that international trade can contribute to carbon emissions in the examined panel of countries. This has implications for trade policies and agreements, emphasizing the importance of incorporating environmental considerations into trade negotiations. It also suggests that countries should monitor and manage the environmental impact of their export-oriented industries.
- **Population and Environmental Pressure:** While population was not found to have a significant impact on CO₂ emissions in the fixed effect model, the one-way causality from population to emissions indicates that a growing

population can contribute to increased emissions. This underscores the importance of considering population dynamics in environmental planning and resource allocation to manage the environmental pressures associated with population growth.

- **Energy Consumption and Electricity Generation:** The study's results regarding energy consumption and electricity generation highlight the significance of the energy sector in carbon emissions. An increase in electricity generation and its positive impact on emissions underscores the need for transitioning to cleaner energy sources and improving energy efficiency. This has financial implications for energy investments, as transitioning to cleaner technologies may entail upfront costs but could lead to long-term environmental and financial benefits.
- **Causality and Policy Considerations:** The study's identification of causal relationships between economic variables and CO₂ emissions informs policymakers about the direction of influence. For example, knowing that GDP causes carbon emissions can guide policies aimed at decoupling economic growth from emissions. Similarly, understanding that energy consumption and electricity generation cause emissions highlights the need for targeted energy policies and regulations to mitigate carbon output.
- **Financial Opportunities:** The findings suggest that there may be financial opportunities in sustainable and clean technologies. As GDP growth drives emissions, businesses and investors in renewable energy, energy efficiency, and sustainable practices may find growing markets and profitability in the pursuit of environmentally responsible solutions.

6.6 Implications for Policy and Practice

The implications of the findings highlighted in the study for policymakers and practitioners working in the field of economics and sustainability is that impact of GDP on CO₂ emissions for GCC economies can be considered by decision-makers as a call to take quick and relevant measures to mitigate the CO₂ emissions level without harming the economic development. The finding on energy consumption and population of the GCC countries allows us to conclude that, although the investigated developed GCC countries might pursue the policies to mitigate environmental degradation and gain results, there is still some way to go in terms of reducing CO₂ emissions and adopting new and renewable sources of energy that will completely replace the no-renewable carbon loaded sources of energy which cause climate change. That is to say that even though CO₂ emissions grow less rapidly than economic development, the growth in GDP still increases CO₂ emissions. In this regard, the GCC countries should continue to follow good governing policies, such as carbon taxation, carbon pricing, and promoting less carbon-intensive technologies, to mitigate the CO₂ emissions level.

As discussed from the findings in the study, the empirical results show that climate change comes because of changes in primary conditions of the atmosphere, such as temperature, pressure, humidity, clouds, and precipitation. One of the significant factors that cause climate change is global warming, caused by the emission of greenhouse gases such as carbon dioxide. When the global temperature rises in what is termed global warming, mainly due to the increasing concentrations of greenhouse gases in the atmosphere, climate changes are also experienced.

Most importantly, this study tests the validity of the Environmental Kuznets Curve (EKC) using both panel-based and time-series-based methodological cointegration

approaches. Given that the EKC hypothesis postulates an inverted U-shaped relationship between emissions and output, the study tests for cointegration between per capita CO₂ emissions, per capita real GDP, per capita imports and exports of goods and services, per capita energy consumption, and per capita electricity production. In empirical studies, the magnitude of emissions or the concentration rate (the density of particles in a specific volume) is the two variables that are usually measured. The EKC originated from Simon Kuznets' contribution to economics in explaining the complex and complicated relationship between nature and economy. Such a contribution by Simon Kuznets brought about great optimism against the dominant negativity in economics.

6.7 Limitations of the Study

- Specificity to GCC Countries

Acknowledge that the study findings are specific to GCC countries, which are unique in terms of their economic and social structures, particularly as oil exporters. Caution that generalizing the results to other oil-exporting nations in the Middle East may not be appropriate, as regional variations can significantly impact outcomes.

- Exclusion of Technological Advancements

Note that the study did not incorporate the potential influence of technological advancements as a factor. Highlight the importance of considering technological changes in future research, as they can play a significant role in shaping the relationship between economic development and environmental sustainability.

6.8 Future Research Directions

Future research studies should explore the EKC in the individual GCC states since this study generalized the results of all the six member states of the GCC. That way, it will be comprehensive to draw a comparison between the countries on their state of Climate Change and Gross Domestic Product. Further, future research should focus on current data from the panel countries about adopting renewable energy sources to avoid overdependence on oil and gas produced by the states in the GCC. This way, it will find a solution to developing governing principles on carbon taxation on exports and imports and regulating the rate of carbon content produced in the regions. These recommendations for future studies will help discover the new directions that should be explored to promote the solutions to the problems it poses in the research gaps found in this study.

Further, a deep dive into the variables of the Gross Domestic Product in the GCC states that were statistically insignificant in this study is encouraged, as the implications to the economies of these countries. This is to guide on a clear concept of the relationship between GDP and Climate Change in those areas that have posed research gaps in this study. Knowing the direct relationship without any causality involved is a great way to find a solution to the existing problem by coming up with policies, methods, and ways to mitigate the issue of emissions of greenhouse gases. For more contributions to this research topic, further implementations should be made, such as developing more dynamic testable hypotheses against a wider GDP and Climate Change connection that could better explain the sources and causes of change in the type of such relationships. Having adequate more variable far beyond those discussed in this study could explain external shocks in the GDP and Climate Change connection.

6.9 Chapter Summary

As noted, this review confirms many inconclusive or conflicting results in the EKC study in this case. On this ground, we argue that such inconclusiveness is most likely due to the dynamic nature of the connection or relationship between nature and economy throughout development processes rather than being recognized as a problem, having in mind the sustainable development goals achievement. In other words, all shapes of EKC and all types of causalities between per capita (GDP) output and environmental degradations or pollution due to CO₂ emissions may be possible for a country or region under different developmental impediments over time. But this study assumes that all the six GCC states have the same developmental progress, which is conflicting and leaves a gap for further research. Changes in cultures, regulations, and, most importantly, technologies should form the basis of any study when comparing panel data to underscore the difference in economic growth patterns and inform decision-making based on Climate Change in those countries.

Apart from what has been discussed in this study, many other parameters should be considered when judging a study's quality and influence. This chapter has summarized the key findings of this study and has implications in the present world scenario on the Climate Change problem. This study will be relevant to the six GCC states and form part of decision-making for other developed and developing economies worldwide. Some of the recommendations in this study will guide potential and interested researchers to create a vast and rich knowledge of the nexus between nature and economy and build a strong empirical case in the EKC model. When developing policies, from the findings of this study, other nations struggling

with the problem of severe global warming will have a solution to mitigating the emissions of greenhouse gases, most specifically carbon dioxide.

Another significant and essential portion of this study is the issue of urbanization. Countries will be able to move towards industrialization with their growing population to solve the problem of energy consumption and electricity production in line with CO₂ emissions. Finally, this study will be vital for policy and decision-makers on sustainable renewable energy sources and capitalize on them to reduce the emissions of CO₂. This way, global warming will be history, and sustainable development goals will be easily achieved with a clean, well-managed environment.

7. References

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المستخلص

شهدت دول مجلس التعاون الخليجي، نمو اقتصاديا كبيرا في السنوات الأخيرة. ومع ذلك، فقد أدى هذا النمو أيضا إلى زيادة انبعاثات غازات الدفيئة وغيرها من الآثار البيئية الضارة. تهدف الدراسة إلى التحقيق في العلاقة السببية بين النمو الاقتصادي وتغير المناخ في هذه البلدان من أجل فهم هذه القضية. وطبق البحث المنهجية الكمية وتم استخدام العديد من اختبارات الاقتصاد القياسي منها منحنى كوزنتس البيئي (EKC) للفترة (2001-2020). تم استخدام هذه الطرق لدراسة التأثير بين انبعاثات ثاني أكسيد الكربون كمؤشر مناخي والنتائج المحلي الإجمالي والمتغيرات المختلفة ذات الصلة، مثل الاستيراد والتصدير والسكان وتوليد الطاقة واستهلاك الكهرباء. النتيجة الرئيسية لهذه الدراسة الحالية هي أن دول مجلس التعاون الخليجي تشير إلى أن شكل U المقلوب لعلاقة الناتج المحلي الإجمالي لتغير المناخ والناتج المحلي الإجمالي يؤثر بشكل إيجابي على انبعاثات CO₂ للوحة وفقا لنموذج التأثير الثابت. وهذا يعني أنه عند زيادة الناتج المحلي الإجمالي، هناك زيادة تبعية في انبعاثات الكربون في مجموعة البلدان، ويعزى ذلك إلى الزيادة في مستوى الاستهلاك، مما يؤدي بدوره إلى زيادة مستوى الإنتاج الذي يعتمد على استهلاك الطاقة.

الكلمات المفتاحية: دول مجلس التعاون الخليجي، الناتج المحلي الإجمالي، تغير المناخ، منحنى كوزنتس البيئي.

جامعة البحرين

برنامج البيئة والتنمية المستدامة

كلية العلوم



العلاقة بين تغير المناخ والنااتج المحلي الإجمالي لدول مجلس التعاون
الخليجي: مقارنة ديناميكية وفق فرضية منحني كوزنتس البيئي

تم تسليم هذه الرسالة كجزء من متطلبات شهادة الدكتوراه في الفلسفة
في البيئة والتنمية المستدامة

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