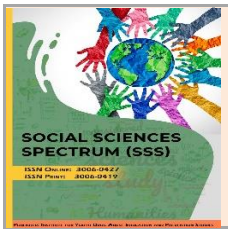

Social Sciences Spectrum

A Double-Blind, Peer-Reviewed, HEC recognized Y-category Research Journal

E-ISSN: 3006-0427 **P-ISSN:** 3006-0419
Volume 04, **Issue** 01, 2025
Web link:https://sss.org.pk/index.php/sss

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Impact of Population Growth and Trade-Driven CO_2 Emissions on Global Sustainability: Evidence from 55 OIC and OECD Nations

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Article Information [YY-MM-DD]

Received 2025-01-13 **Accepted** 2025-03-17

Citation (APA):

Shafi, N., Hussain, F., Ali, M & Zaib, S. (2025). Impact of population growth and trade-driven CO2 emissions on global sustainability: Evidence from 55 OIC and OECD nations. *Social Sciences Spectrum*, *4*(1), 642-659. https://doi.org/10.71085/sss.04.01.248

Abstract

This investigation explores the complex interconnection between population growth and CO2 emissions in the context of export-driven activities, focusing on the global transportation sector. It refers to a gap in the existing literature by examining how demographic trends can influence the environmental impact of international trade. The data from 55 nations, including 22 OIC and 33 OECD countries, are evaluated in this study between 2011 and 2020. Using meteorological data with greenhouse gas and CO2 emissions as climate change markers, a novel empirical analysis of the inverse link between economic development and climate change is proposed. The research indicates that nations with inferior infrastructure, less capacity for adaptation, and more exposure to climate-related threats are more severely affected by climate change in economic development. A cycle of environmental degradation can be initiated by increasing global energy consumption, particularly in emerging market countries, resulting in long-term environmental damage and economic instability. We conducted several tests examining various economic levels, maximum energy consumption, and various measurements of dependent, independent, and control variables to ensure robustness. These assessments demonstrated our results' dependability and consistency in a range of situations and circumstances.

Keywords: Climate Change, Economic Growth, Renewable Energy, Fossil Fuels, Greenhouse Gas Emissions, CO2 Emissions, Energy Consumption, Sustainable Development.

1. Introduction

One of the main worldwide issues in recent memory is environmental change, which has significant outcomes for biological systems, financial aspects, and societies worldwide. The essential drivers of environmental change are human activities, including petroleum product consumption and deforestation, as per the (IBEC) Intergovernmental Board on Environmental Change. Energy creation and mining are two of these exercises that immensely affect the financial scene of nations and nursery gas outflows. Generally, the driver of worldwide monetary development and modernization is the energy business, which generally relies upon petroleum products (coal, oil, and flammable gas) (Kennedy et al., 2019). Indeed, there are significant ecological impacts related to the mining, handling, and utilization of these energy sources, including the environment being impacted due to the arrival of petroleum derivatives and nursery gases, such as carbon dioxide (CO2). As indicated by the Global Energy Office around 73% of the world's ozone-depleting substance outflows in 2019 came from the energy area alone. The money-related composition has separated the nexus between the monetary turn of events and biological degradation, starting with the implied Regular EKC, which displays a positive association between normal corruption and financial improvement to a particular level, past which an extension like the environment allows for each capita pay advancement (Awaworyi Churchill et al., 2018). According to the Intergovernmental Panel on Natural Change Reports (IPCC 2014), renewables could meet, by 2050, 77% of the world's energy needs, concerning the continuous modestly low regard (13%). Besides, the mining area impacts the climate, regardless of being vital for extracting metals and minerals required for contemporary assembly, foundation, and innovation. Compounding the results of environmental change and disturbing biological systems, mining exercises habitually bring about living space obliteration, air, and water contamination, and land corruption.

The unfortunate outcomes of environmental change on the economy and development become more regrettable as they become more regrettable. Outrageous climate events, for example, rising ocean levels, changing precipitation examples, and disturbances to farming creation, are a critical danger to economies, especially in weak nations. Environmental change has irrefutable monetary effects, for example, higher medical service costs, lost horticultural efficiency, and foundation harm (IPCC, 2014). Energy, mining, environmental change, and monetary development are completely associated. However, even with this expanded mindfulness, a more careful review is yet expected to completely comprehend the complicated communications and input circles between these factors. This examination looks at holes in what mining and energy-related enterprises mean and what environmental change means for the development of the economy. Our exploration study expects to look at the valuable impressions of partners, organizations, or state-run administrations attempting to lessen environmental gambles and advance feasible improvement by utilizing thorough procedures and exact information investigation.

Worldwide economic prosperity is threatened by climate change, which influences all areas and sectors of the economy. It is critical to comprehend the precise processes by which energy and mining operations impact the causes of climate change on economic development, as countries struggle with the multifaceted interplay of environmental degradation, energy consumption, and monetary expansion. Even while these interrelated processes are becoming more well-acknowledged, several gaps in the literature call for more research. Research that has already been conducted frequently examines the effects of mining or energy production linking economic growth and climate change separately, disregarding the feedback loops and synergistic effects between these industries. Few thorough considers have examined the joint impact of mining and

energy operations on the course of growth and the effects of climate change. There are no longitudinal analysis and predictive modeling attempts, although much research has looked at the historical patterns and current relationships between energy, mining, climate change, and economic strength. It is essential for well-informed policy-making and strategic planning to grasp the temporal evolution of these relations and anticipate future situations. Especially, the study aims to pinpoint the mechanisms by which energy and mining activities influence the economy's ability to withstand the causes of climate change. The issue of climate change is complex and has significant effects on the advancement of the world economy. The mining and energy production industries, which are major contributors to environmental ruin and important engines of economic growth, are at the center of this dilemma. The study highlights the need for policymakers to adopt a multi-strategy approach that includes green finance, technological innovation, low-carbon energy, and supportive government programs (Iqbal, M. A et al., 2025). Depending on the country and area, there may be a distinct relationship between air pollution and dividend yield (Mahmood A, Shaheen, W., & Ullah U, 2024).

The generation of energy and mining operations are closely linked to both economic expansion and climatic change. The processes by which these industries affect how climate change assumes economic growth are not yet well understood. The knowledge gained from this study can help policymakers develop focused plans to increase resource efficiency, promote resilience economies, and switch to low-carbon energy sources. This study advances our knowledge of the intricate relationships between energy, mining, climate change, and economic growth through precise empirical analysis and theoretical frameworks. This study improves the theoretical underpinnings of multidisciplinary research bonds of energy, environmentally friendly, economics, and policy procedure studies by addressing current knowledge gaps. The research's insights can help mining and energy businesses implement sustainable practices, cut back on their carbon footprint, and minimize environmental concerns, using climate variables in strategic decision-making processes can help firms become more resilient and competitive over the long run in a world that is changing quickly. This research examines relations between energy, mining, climate change, and trade and industry expansion. The study suggests that researchers and academics can explore new approaches for interdisciplinary research and cooperation, as well as explore further aspects of this complex connection. The following chapters of this study are shaped to focus on the selected factors: Chapter 1 will cover the outline or introduction part. The research background, problem statement, objective, and significance of the study following possible practical implications of the study. Chapter 2 will focus on thoroughly reviewing existing literature to support the study, establishing the theoretical context of the research. Chapters 3 and 4 describe the research technique, including the data gathering and analysis procedures. The following sections present and evaluate the data before concluding with Chapter 5 which is implications, limitations, and future research directions, and then the conclusion of the study will be added to the end reference section. The studies thorough examination intends to add to the expanding conversation to study the impact of goods and service transport on CO2 emissions, specifically focusing on the moderating role of population growth.

2. Literature Review

The study emphasized the importance of energy security in attaining sustainable financial and GDP growth. Due to its over-reliance on fossil fuels, it was discovered that energy security initially hindered sustainable economic development. However, utilizing renewable energy reduced this effect and encouraged sustainable economic growth. The study examined 26 OECD nations between 1990 and 2018, utilizing data from the (WB) World Bank, the IMF, and the U.S. EIA

(Energy Information Administration). To lessen reliance on fossil fuels and lessen the effects on the environment, it stressed the necessity of diversifying energy sources and making investments in renewable energy technology (Zakari & Oluwaseyi Musibau, 2024).

Time duration from 2000 to 2019, this paper observed 37 countries from the OECD (Organization for Economic Co-operation and Development) in terms of EI (energy force), (EE) energy efficiency, and EG (economic growth) as determined by the kind of RTS (returns to scale). By using four key energy sources—coal, gas, oil, and zero-emission energy sources such as nuclear and renewable energy—in addition to inputs and the GDP, researchers estimated the three measures using a non-parametric approach. In this investigation, two major steps were employed, including window-based and cross-sectional measurements, as efficiency metrics. From empirical research, three conclusions were found (Sueyoshi & Goto, 2023).

The Environmental Kuznets Curve theory examined the impact of urbanization and economic development from nineteen sixty-five to two-thousand eighteen. This work employed the innovative Quantiles Autoregressive Distributed Lag (QARDL) method. The findings demonstrate the validity of E.K.C and a model U-shaped relationship concerning urbanization and climate change over the long and short years. The KRLS estimations validate the QARDL results (Awan at al., 2022). We utilized the Prais Winston model with standard errors and the fixed effects panel model, utilizing panel data from 35 countries that participated in the Institution for Economic Co-operation and Development between 1992 and 2018. The authors presented evidence of a significant correlation between stock market volatility and greenhouse gas emissions. After identifying any potential indigeneity problems, the results continue to be reliable. By adding more empirical support for the financial risk connected to climate change, this study added to the body of literature (Noh & Park, 2023a). Although industrial production increased significantly, the OECD saw a decrease in greenhouse gas emissions in 19 nations between 2012 and 2016. According to the research, the composition impact was the primary driver of the overall decrease in GHG greenhouse gas emissions due to country-specific differences in emission change drivers. The cumulative share of clean sectors in different countries such as Austria, Australia, the Czech Republic, France, Italy, the Slovak Republic, and Spain had configuration effects; on the other hand, technological advancements in emission intensities in nations like Denmark, Hong Kong, Latvia, Nigeria, Poland, Sweden, and the United Kingdom gave rise to method effects. These results indicated that various nations should use different strategies to reduce their emissions (Sun et al., 2022a)

According to research conducted in Shenzhen, China, low-carbon policies frequently ignore the greenhouse gases (GHGs) produced by sewage treatment, even though it is an essential technique for protecting the environment and purifying water. The study, which included data envelopment analysis, life cycle analysis, and questionnaire surveys, discovered that indirect emissions from the disposal of sludge were the primary cause of high usage of GHG emissions from manure treatment facilities, the equation of CO2 in two-thousand five was .022 MT and it increases in 1.16 MT in two-thousand twenty. Since 2012, there have been drops in GHG emissions, with 2020 showing the highest effectiveness (Xian et al., 2023). Changes in greenhouse gas emissions after COVID-19 must be evaluated as a supply shock because of Iran's commitment to the Paris Agreement. When supply capacity was removed, the most important economic activities in lowering emissions were identified utilizing the (EPHE) Environmental Partial Hypothetical Extraction approach. Based on Iran's 2016 input-output table, three lockdown scenarios were modeled: a low-slung-risk situation involving a fifty percent drop in production capacity, a medium-risk scenario involving a seventy percent loss of supply capacity, and a high-risk scenario involving a total stop of activity.

In Iran, greenhouse gas emissions fell in every economic sector, according to the research, with agriculture seeing the greatest drop in CO2 emissions under the low-slung-risk situation (*Impact of COVID-19 Pandemic on Greenhouse Gas Emissions in Iran . Pdf*, 2024).

The study looked at the financial, social ethical, environmental sustainability, and economic advantages of utilizing nuclear and renewable energy sources in economic development. Data from 1993 to 2020 were analyzed using quantile regression and panel methods. The findings indicated that although geopolitical risk and economic development are poor ways to decrease greenhouse gas, nuclear energy, renewable energy, and technologies connected to the environment can. The report suggested policy measures to remove glasshouse gas emissions in the BRICS. Million tons of CO2 equivalent were used to assess greenhouse gas emissions, while the right applications submitted under the production and consumption technologies category were used to measure environmental technology (Tauseef Hassan et al., 2024).

The study examined important variables in all OECD nations from 1990 to 2022 using diagnostic tests and analytical methods such as Moments Quantile Regression. It discovered a significant link between rising economic activity and greenhouse gas emissions. Policymakers may utilize this study to address the adverse consequences of atmosphere change, shrink greenhouse gas emissions, and promote sustainable economic growth. The results are essential for OECD nations to consider as they address the environmental sustainability and climate change challenges. The results bear important ramifications for nations tackling these problems (Wahab et al., 2024).

The Renewable, Sustainable Energy Reviews (RSER) journal published approximately 350 papers at the SEEP 2018 conference. The dawn developments in renewable energy or nuclear sources and approaches for protecting the environment against the risks associated with fossil fuels were aimed at global experts. Several policy recommendations for promoting renewable energy, limiting greenhouse gas emissions, and current advancements in CO2 absorption were among the main topics of the conference. The development of energy conversion technologies with a minimal environmental impact was within the same framework. Green protection and sustainable energy were the two primary categories of the chosen works. As it stated approved submissions, the editorial emphasized the advancements in renewable energy and how they mitigated climate changes (Olabi & Abdelkareem, 2022).

This research assessed how the members of the Organization of the Black Sea Economic Cooperation's urbanization, economic growth, and generation of renewable energy interrelate, granting new insights into the energy sector. This study examined the factors influencing renewable energy for emerging nations by utilizing sophisticated panel integration tests and yearly data guarding from 1995 to 2020. The conclusions demonstrated a deep correlation between growth, emissions, urbanization, and the creation of renewable energy. These results emphasize the crucial role that renewable energy participates in reducing climate change in poor countries and have significant policy implications (Dilanchiev et al., 2023).

The analysis examined the collision of ecological and economic issues on greenhouse gases and carbon dioxide in 29 OECD nations from 1990 to 2018. It concluded that while export diversification increases carbon emissions, it also affects them. Emissions are decreased but not eliminated by financial development, economic expansion, and institutional excellence. While trade directness has a refusal influence on greenhouse gas emissions, it has a sympathetic impact on carbon emissions. Degradation of the environment is mostly caused by urbanization. The report offers policymakers, governors, and academics cutting-edge policy ideas (Bashir eet all., 2022). The study examined the effects of informality on the utilization of mineral resources, including

unrenewable energy, economic development, and CO2 emissions in 19 Eastern and South African nations. In contrast to renewable energy usage, the results indicated a strong correspondence between nonrenewable energy use and CO2 emissions. The link between (CO2) carbon dioxide emissions and economic enhancement or growth was nonlinear, and the correlation between informality and CO2 emissions was also nonlinear. Also, the research discovered a unidirectional causal relationship among GDP growth, nonrenewable energy, renewable energy, informality, and CO2 emissions. The 25-year period covered by the data was 1991–2015 (Mawejje, 2023).

According to (Ngarava et al., 2023), who utilized a parsimonious vector autoregressive (VAR) model, the study investigates the link between greenhouse gas emissions and aquaculture production (AQUAP) in Southern Sudan (SSA). West and Central Africa dominated the sector, it was discovered, and AQUAP was repressed until 2006. AQUAP had a short- and long-term negative impact on GHG emissions, although both had a beneficial impact on GDP. GHG emissions decreased intermittently until 1991. This points toward the early stages of the industry, or the first stage of the Environmental Kuznets Curves (EKC). Because AQUAP is still relatively new, has great economic potential, is sustainable, and has low greenhouse gas emission potential, the research suggests that it be scaled up in SSA. However, any expansion should be founded on ecologically sound practices.

Eldowma et al. (2023) examined the connections between Sudan's population, economic growth, carbon dioxide emissions, and energy usage between 1971 and 2019. It was discovered that Sudan has not supplied enough energy to support population growth and economic development. The study demonstrated strong correlations between population increase, environmental deterioration, and economic expansion. According to the Granger causality, Sudan's population expansion boosts economic growth but increases the need for power and causes environmental harm.

The study investigates how agricultural output, ICT, and internet surveillance affect carbon dioxide and economic growth in the BRICS nations. It discovered a significant period of more than one year of correlation between IS, ICT, EG, AP, and CO2 emissions. ICT acts oppositely from IS, EG, and AP in terms of emissions. According to the research, the BRICS nations should adopt a circular economy to promote both economic expansion and environmental sustainability. The ICT sector needs to be reorganized with the environment, economy, and sustainability in mind. The World Development Indicator and Our World in Data are the data from 2000 to 2019 (Naseem et al., 2023).

The study utilized a control panel dataset of 25 Indian Ocean territories from 2002 to 2019, to investigate the impact of trade, GDP growth, and greenhouse gases on the Biosphere Reserve (BE). CS-ARDL is a technique that employed a significant long-term connection, although the short-term results were not statistically significant. The initial two-step methods of the moment (GMM) test and the PCSE model were both supported by divergence. The findings demonstrated that whereas economic expansion and greenhouse gas emissions increase the BE, trade has a negative impact on it. To achieve the Natural Progress Goals, particularly SDG 14 (Life Under Water), the report recommends that nations incorporate ocean-based solutions in their climate plans (Hossain et al., 2024).

The research examines the collision of geothermic energy on gross domestic product and GHG greenhouse gas emissions in both industrialized and developing nations from 2000 to 2019. It demonstrates a destructive outcome on GDP in the near term but a positive contribution to GDP in the long term, particularly in industrialized nations, using Autoregressive Distributed Lag (ARDL) estimates. Long-term effects on GHG levels are similarly shown to be favorable in both

countries, with a smaller coefficient in developed nations. The (D-H) Dumitrescu Hurlin causality model, which demonstrates a unidirectional causal relationship between growing economy and geothermal energy, is founded on the findings (Idroes et al., 2024).

The study examined the dissociation of GDP growth and greenhouse gas emissions in Morocco, a developing nation with aggressive climate change targets. The Engle-Granger cointegration technique and Tapio elastic analysis were analyzed from 1990 to 2018. The data demonstrated a significant long-term link (coefficient of 0.85) between GDP and greenhouse gas emissions. However, overall emissions exhibited a modest decoupling, increasing at a slower rate than GDP. The results indicated that to achieve the absolute decoupling objectives established by the Moroccan government, more assertive carbon pricing measures could be needed (Ben Azzeddine et al., 2024).

Throughout the G-20 countries, the research examines the connection between economic development, energy resources, and CO2 emissions between 1990 and 2020. It looks at dynamic linkages and endogeneity problems using FMOLS and DOLS approaches together with robustness analysis. Relative to CO2 emissions from gas and oil, the study is divided in half. As a result, CO2 emissions are directly increased by gas and oil energy, but they are normally decreased by hydro and renewable energy sources. The GDP quantile shift suggests that efficient growth can reduce CO2 emissions by reducing the amount of energy sources and renewables. The report emphasizes how to meet the Environmental Development Goals for 2030, we must switch from damaging conventional energy sources to renewable ones (Naseem et al., 2024).

The link between green economic development and renewable energy in big, industrialized nations is examined in this study using dynamic ARDL simulations. With long-term cointegration across variables, the calculations demonstrate that globalization and green economic growth greatly boost the usage of renewable energy. Emissions are still high in some nations even if renewable energy has been adopted. Being the world's biggest carbon emitters and accounting for 80% of the global economy, the G-20 countries can perform a significant role in encouraging a sustainable future through their commitment to renewable energy transition, green job creation, energy efficiency improvements, innovation promotion, and enhanced international cooperation. The most industrialized nations and top emitters of carbon dioxide are the G-20. Since the G-20 nations' data was only available from 1990 to 2018, it was the data period that was used (Ashfaq et al., 2024).

Over the previous three decades, the study examined the linkage between energy use, economic development, and carbon emissions in ASEAN countries. Due to the zone's dependence on fossil fuels, pollution, CO2 emissions, and environmental damage, it has increased. For long-run approximate methodologies, the study retained a panel vector autoregressive test. Between 2000 and 2020, the region's entire energy supply grew by almost 80%. The results revealed that energy consumption rather than renewable energy has a significant influence on economic growth. Renewable-produced energy for ASEAN countries to achieve economic growth and reduce CO2 emissions, which would eventually improve environmental quality. This bidirectional Granger causation is validated (Tran et al., 2024).

The study examined the recompenses of biochar-derived bricks and insulation materials, with particular attention to their preparation techniques, material characteristics, capacity to reduce emissions, efficacy in mitigating carbon emissions, improvement of thermal insulation, and financial opportunities. Heat insulation and the carbon footprint of buildings may be significantly reduced due to the use of materials based on biochar. They made a substantial contribution to the decrease of energy usage and greenhouse gas emissions. For example, Biochar may significantly

reduce CO2 emissions when used in place of one ton of cement during the brick-making process. There are definite financial advantages to using biochar insulation, which reduces carbon dioxide emissions by 59–65 kg per ton. Energy-saving benefits more than make up for the increased cost despite being more expensive than conventional insulating materials. (*Ahmed I. Osman at el, 2023*).

Consider the challenges of climate change such as Global warming, social, greenhouse gas emissions, CO2 emissions, environmental disasters, populations, etc. The detailed knowledge of how certain industries, such as mining and energy, modify the link between GDP growth and climate change is a major obstacle in the current study of economic allegations of climate change. Without highlighting the distinct consequences and functions of mining, most studies either focus only on the energy sector or aggregate the effects of climate change throughout the economy. This supervision is crucial because the mining industry reacts to climate change differently than other energy-related industries do, especially when it comes to market dynamics, operational hazards, and regulatory obstacles. A critical need is for in-depth sector-specific evaluations that distinguish between different kinds of mining operations and energy resources and look at how each one either directly contributes to or mitigates the economic effects of climate change.

To address the gap, empirical and longitudinal research that breaks down these sectors separately and together must be the main emphasis. Such research ought to examine how varying climates, resource dependence, and regulatory environments impact the mining and energy industries' economic contributions. Comparative international research may also shed further light on how different economic reliance on various sectors affect the resilience or susceptibility of national GDP to climate change. This would provide the body of knowledge in academia and provide policymakers with useful guidance in maintaining economic stability in the aftermath of environmental crises.

3. Research Methodology

3.1. Operationalization of Variables

This study will examine the starring role of financial indicators in encouraging economic growth. This study takes climate change as an independent variable and the dependent variable is economic growth. This study takes Urbanization and inflation, consumer price as a controlled variable.

3.1.1. Dependent Variable

The inter-dependent variable is economic growth. Economic growth was measured by different indicators i.e., economy per head of population, As % of the USA (USA = 100), Current US $_Annual, In GDP attaining the sustainable of an economy (Constant, 2015 US $), Entirety of emission and carbon dioxide (CO2) emission damage, net natural resource, and net forest depletion times of GDP, Real GDP US dollars 2010, etc. In different contexts (Noh & Park, 2023b) (Naseem at el., 2023) (Idroes et al., 2024) (Ashfaq et al., 2024).To measure economic growth, various researchers employed different indicators, yet we will measure economic growth with GDP growth (Mele et al., 2021).

3.1.2. Independent Variable

This is a different measure of climate change that is used in literature. Many researchers used total greenhouse gas emission / GDP, CO2 emission, In GHG to Quantify CO2 emission from burning fossil fuels (Kilo Tones), etc. to measure greenhouse gas (Noh & Park, 2023a) (Ben Azzeddine et al., 2024) (Sun et al., 2022b). However, few researchers use Environmental protection production

or Agricultural land, etc. (Mele et al., 2021). This study will use Greenhouse gas emissions as a proxy to measure climate change.

3.1.3. Controlled Variables

This study demonstrates that the controlled variables are Urbanization and Inflation. Focus on measuring urbanization with the proportion of the urban population (Awan et al., 2022). Inflation with consumer price (Annual %).

3.1.4. Other Variable

This study takes moderating variables i.e., energy and mining. This variable is not employed as a moderator in the circumstances of economic growth and climate change in the literature. This variable is utilized in various studies as an independent or controlled variable dependent variable, etc. (Mawejje, 2023) (Sueyoshi & Goto, 2023). Many researchers used Energy commencing all renewable reserves: hydro, solid biofuels, wind, solar, liquid biofuels, biogas, geothermal, marine, and waste per million people, etc. to measure the proxy renewable energy consumption of mining or energy, the assign of renewable energy in total energy consumption (Ashfaq et al., 2024), but a study used reusable energy consumption as a proxy to measure energy and mining.

Table 1: *Description of Variable*

Variable name	Abbreviation	Proxy	Data source
Dependent Variable			
Economic Growth	EG	Current US $ __ Annual	(WDI)
Independent Variable			
Climate Change	CC	GHG emissions	OECD statistics/(WDI)
Moderator			
Energy and mining	EM/REC	Renewable energy consumption	World Bank and Our Data
Control Variable			
Urban Population	TP	Percentage urban population	World Bank
Inflation, Consumer price	Inflation/ CP	(annual %)	World Bank

3.2. Data Composition and Collection

This research employed secondary data from different bases. The facts regarding economic growth were gained from the WDI website and data on Climate Change from the OECD statistics and WDI. The World Bank Indicators obtained data on additional variables. The data availability limited the study to the 55 nations in the world. Due to the availability of financial assistance, the years were extended from 2011 to 2020.

3.3. Hypothesis

Climate change is believed to impact economic growth through its impact on agricultural productivity, labor productivity, and health. Rising temperatures can decrease agricultural outputs

in regions dependent on rain-fed agriculture, affecting food availability and income. Additionally, increased temperatures can reduce labor capacity, particularly in the outdoor and manual labor industries, further diminishing economic productivity. As climate change intensifies, countries, particularly in warmer or tropical regions, will experience significant declines in GDP growth rates due to these interconnected factors (Idroes et al., 2024). The economic impact of climate change is not uniformly distributed, with developing countries facing more severe consequences than developed nations due to differences in adaptive capacities, infrastructure, and economic dependencies on climate-sensitive resources (Naseem et al., 2023). Economically reliant or less adaptable economies are particularly vulnerable, and the financial strain from adaptation and mitigation strategies can further strain their economic growth. This hypothesis highlights a global economic imbalance exacerbated by zone change.

H1: *Greenhouse gas emissions have significantly a detrimental effect on economic growth.*

Mining & energy are two industries impacted by climate change and may see slower economic growth. While places investing in renewable energy technology may profit from new job creation, prolonged growth, and technical innovation, countries with ample energy resources may see short-term economic advantages because of rising global energy costs. Adaptation techniques are essential to understand how the mining industry modifies economic growth under climate change. Despite the potential economic benefits from increased demand caused by climate change, extracting industries, particularly those involved in renewable energy technologies, may also have difficulties from its effects, such as water scarcity (Ngarava et al., 2023). Responses to climate change from the mining and energy sectors, including innovative and sustainable practices, can either mitigate or intensify the economic effects, influencing the resilience of areas that depend on these industries.

H2: *Energy and mining have a moderating impact on the association between climate change and economic growth.*

3.4. Empirical Model

3.4.1. Model 1

The hypothesis is that climate change is directly affecting economic growth. Furthermore, the change in climate variable means (such as Greenhouse gas emissions, temperature change, and CO2 emissions, etc.) impact the rate of a country's economic growth. Additionally, to empirically test this hypothesis, you might consider a regression model where economic growth is the dependent variable, and climate change is the independent variable which is measured with other control variables that also affect the GDP growth rate.

$$EG_{it} = \beta_0 + \beta_1 CC_{it} + \beta_2 X_{it} + \epsilon_{it} \text{ ---------- } (1)$$

- EG_{it} economic growth rate of country i in year t.
- CC_{it} represents climate change variables such as greenhouse gas emissions or average temperature, etc., for country i in year t.
- X_{it} includes control variables such as initial urbanization, total population, inflation, etc.
- B_0, β_1, and β_2 are parameters to be estimated.
- ϵ_{it} is the error term.

3.4.2 Model 1

The causality of weather change on economy growth is exacerbated by the energy and mining companies. This means we expect the link between climate change and economic growth to differ depending on the levels of activity within these sectors.

$$EG_{it} = \beta_0 + \beta_1 CC_{it} + \beta_2 \text{EM activity}_{it} + \beta_3 (CC_{it} \text{ X EM activity}_{it}) + \beta_4 X_{it} + \epsilon_{it} \text{ ---------- (2)}$$

- EG_{it} is the economic growth rate of country i in year t.
- CC_{it} represents climate change variables such as greenhouse gas emissions or average temperature, etc., for nation i in year t.
- EM activity_{it} is a proxy for the level of activity in the energy and mining sectors, which could be measured by the sectors' contribution to GDP, employment levels, or production volumes.
- (CC_{it} X EM activity_{it}) represents the interaction terms between climate change variables and energy and mining activities.
- X_{it} includes other control variables.
- ϵ_{it} is the error term.

3.5. Sample Size of Countries

This study will use the sample of OECD and OIC countries, but the final sample size will be selected according to the panel and availability of data on major variables. This study will employ different diagnostic and main regression tests and target the period from 2011 to 2020.

3.6. Data Analysis Tools and Tests

This study will use STATA 17 package for data analysis and empirical results. Stata is a popular statistical program used by social scientists, economists, and academics for data analysis. It provides a range of statistical techniques, including regression analysis, data analysis across time, and modeling. Microsoft Excel Office is software that can be utilized to analyze and analyze data. It provides regression analysis along with common statistical operations like calculating averages, medians, and standard deviations.

4. Data Analysis

4.1 Descriptive Statistics

Table 2: *Descriptive Statistics*

Variables	No.	A.Mean	Std. Dev.p	Min	Max
EG	550	0.964	0.936	-5.39	4.464
GHGs	550	11.48	1.504	7.884	15.65
REC	550	2.615	1.692	-4.61	4.416
URB	550	4.153	0.391	2.786	4.597
Inf	549	0.6	1.335	-4.79	5.095

The descriptive statistics provided for the variables EG, GHGs, REC, URB, and Inf give us a comprehensive overview of the data's central tendency, variability, and range. For the variable EG (Economic Growth), the lead-to avg. value is 0.964 with a sigma or standard deviation (SD) of 0.936, indicating that economic growth is close to 1 with a moderate spread of values ranging from -5.393 to 4.464. The GHGs (Greenhouse Gas Emissions) variable mean of 11.48 and a standard

deviation of 1.504, indicating that greenhouse gas emissions are typically around 11.48, with values ranging from 7.884 to 15.649, with moderate variation. The REC (Renewable Energy Consumption) variable should have an arithmetic mean or average of 2.615 and a relatively high standard deviation or sigma of 1.692, highlighting greater variation in renewable energy consumption, ranging from -4.605 to 4.416. The URB (Urbanization Rate) variable has an average of 4.153 and a low standard deviation of 0.391, implying that urbanization rates are closely linked to the mean, with a range from 2.786 to 4.597. Finally, the Inf (Inflation Rate) variable has a mean of 0.6 and a standard deviation of 1.335, reflecting a moderate spread in inflation rates, with values ranging from -4.791 to 5.095.

4.2. Correlation Matrix

Table 3: *Matrix of Correlations*

Variables	VIF	EG	GHGs	REC	URB	INF
EG	-----	1.000				
GHGs	1.402	-0.089	1.000			
REC	1.278	0.017	-0.429	1.000		
URB	1.245	-0.215	0.195	-0.382	1.000	
INF	1.108	0.164	0.125	-0.074	-0.232	1.000

The provided matrix of correlations and Variance Inflation Factors (VIFs) offers insights into the relationships between the variables EG, GHGs, REC, URB, and Inf, as well as the potential for multicollinearity among them. The VIF values below 2 indicate that multicollinearity is not a concern in this dataset. Specifically, the VIFs for EG, GHGs, REC, URB, and Inf are 1.402, 1.278, 1.245, 1.108, and 1.258, respectively, within the acceptable range.

The correlation matrix reveals mostly weak relationships between the variables. EG has weak negative correlations with GHGs (-0.089) and URB (-0.215), and weak positive correlations with REC (0.017) and Inf (0.164). GHGs show a moderate negative correlation with REC (-0.429), indicating that higher glass house gas emissions are associated with lower renewable energy consumption, while its correlations with URB (0.195) and Inf (0.125) are weak and positive. REC has a weak negative correlation with URB (-0.382) and an even weaker negative correlation with Inf (-0.074). URB is weakly negatively correlated with EG (-0.215) and Inf (-0.232) and weakly positively correlated with GHGs (0.195). Finally, Inf has weak positive correlations with EG (0.164) and GHGs (0.125), and weak negative correlations with REC (-0.074) and URB (-0.232).

The analysis indicates that there are no significant multicollinearity issues among the variables, as suggested by the VIFs. The correlations between most variables are weak, suggesting that there are no strong linear relationships among them, except for a moderate negative correlation between GHGs (Greenhouse gas emissions) and REC (renewable energy consumption).

4.3. Pesaran Panel Unit Root Test

Table 4: *Stationarity Tests*

Variables	**CADF**		**CIPS**	
	I (0)	*I (1)*	*I (0)*	*I (1)*
EG	-1.978	-2.893***	-1.978	-2.893***
GHGs	-1.856	-2.773***	-1.856	-2.773***
REC	-2.269**	-2.855***	-2.269***	------

Note ***, ** & * represents 1%, 5%, & 10% significant level

The (Cross-Sectionally Augmented Dickey-Fuller) CADF and (Cross-Sectional Im Pesaran and Shin) CIPS tests are unit root tests used to review the stationarity of variables in control panel informational data with cross-sectional dependence. The results for each variable, EG (Economic Growth.), GHGs (Greenhouse Gas Emissions), and REC (Renewable Energy Consumption), are clarified separately.

In the CADF test, EG and GHGs exhibit CADF statistics of -1.978 and -1.856, respectively. Both values indicate that EG and GHGs are connected to order 1 (I (1)), implying they are not stationary. Nonetheless, neither statistic is statistically significant at conventional levels. REC has a CADF statistic of -2.269, indicating non-stationarity at the 5% significance level, referred to as **.

Turning to the CIPS test, both EG and GHGs demonstrate CIPS statistics of -2.893 and -2.773, respectively. These values indicate that EG and GHGs are part of order 1 (I (1)) and non-stationary. Additionally, both data are statistically significant at the 1% level, indicating robust evidence of non-stationarity. The CIPS statistic for REC is not provided, so its stationarity cannot be determined using this test. The CADF and CIPS tests indicate that EG and GHGs are non-stationary variables (I (1)), while the stationarity of REC is inconclusive, with weaker evidence of non-stationarity provided by the CADF test compared to the CIPS test. These findings are essential to understand the time series properties of the variables and to conduct further econometric analysis in panel datasets with cross-sectional dependence.

4.4. Gmm Test Run

Table 5: *GMM Results*

EG	**Coeft.**	**St.Err.**	**t-value**	**p-value**	**[95% Conf**	**Interval]**	**Sig**
L	0.4	0.117	3.41	0.001	0.17	0.63	***
GHGs	-2.355	0.641	-3.67	0	-3.613	-1.098	***

Mean dependent var	0.955	SD dependent var	0.89
No. of obs	439	Chi-square	..

*** p<.01, ** p<.05, * p<.1

The GMM (Generalized Method of Moments) Test Run recent regression results indicating the relationship between the dependent variable, such as Economic Growth (EG), and two independent variables: the lagged value of EG (L) and Greenhouse Gas Emissions (GHGs). The analysis provides significant insights into the determinants of EG. The coefficient of 0.4 indicates that an increase in one unit in the lagged EG value corresponds to a 0.4-unit increase in EG in the current period. This coefficient is statistically significant at the 1% level, signified by ***. It states that past economic performance has a significant impact on current economic growth, indicating a degree of persistence in EG dynamics over time. The coefficient for GHGs is -2.355, indicating a per-unit expansion in GHGs manages to a decrease of 2.355 units in EG. The negative sign suggests that higher levels of GHGs are associated with lower economic growth, highlighting the importance of environmental factors in determining economic outcomes.

4.2. Detail Discussion and Findings

The study focuses on the validity of climate change on economic growth, utilizing various financial indicators and regulating urbanization and inflation. The findings indicate that greenhouse gas emissions inversely affect economic growth, significantly reducing economic performance as emissions increase. Renewable energy consumption, which is significantly causative to economic growth, also has a negative impression, indicating possible challenges in transitioning to renewable energy. Urbanization negatively affects economic growth, indicating difficulties in urban development. On the other hand, inflation positively correlates, highlighting its intricate role in economic dynamics. The regression analysis confirms these relationships, with robust evidence from slope heterogeneity and cointegration tests supporting these variables' variability and long-term interconnectedness across different nations. Additionally, the General Method of Moments (GMM) emphasizes the persistence of economic advance dynamics and the significant negative impact of greenhouse gas emissions. These findings emphasize the necessity for stable environmental and economic policies to foster sustainable enhancement/ growth.

4.3. Summary of the Result

The study exposes numerous key findings affecting the interplay between recoverable energy intake, glass/hothouse gas emissions, and economic growth in selected nations. The analysis also indicates a negative short-term case of renewable energy on economic growth, which could be due to the high initial costs and infrastructural investments required. Despite this, the high time of the year benefits of renewable energy for sustainable economic development are emphasized, as the transition costs are expected to decrease over time. Overall, the study underscores the importance of supportive policies and investments in renewable energy to achieve both environmental and economic goals.

5.1. Conclusion

It effectively covers various aspects of the research process, including the introduction section clearly outlining the problem statement, highlighting the negative consequences of climate change on financial resources growth, and the role of the energy and mining sectors. It emphasizes the knowledge gap regarding the interplay between these factors. Research Gap: This section delves deeper into the specific areas where current research lacks sufficient detail. It emphasizes the need for sector-specific analyses and the importance of considering regional variations and resource dependence. Research Methodology: This section details the study proposal, involving the operationalization of variables, data sources, and the theoretical framework. The chosen model incorporates economic growth as the dependent variable, climate change as the independent variable, and energy and mining as a moderating variable. Two regression models are presented to explore the direct and moderating effects. Data source Analysis: This section presents the results of descriptive statistics, correlation matrix analysis, and linear regression analysis. Conversely, a definite relationship is observed between economic growth and inflation rate. The slope heterogeneity test highlights the presence of variations in these relationships across different groups within the dataset. (Note: The excerpt stops before the Unit Root Test Results section)

Overall, the paper utilizes a well-structured approach to investigate the complex interplay between climate change, energy and mining sectors, and economic growth. The analysis employs appropriate statistical methods to test the hypotheses and provides valuable insights for policymakers and stakeholders.

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