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The Impact of Green Finance on Environmental Performance in the MENA Region under the Moderating Role of Institutional Quality

أثر التمويل الأخضر على الأداء البيئي في منطقة الشرق الأوسط وشمال إفريقيا: الدور المعدل لجودة المؤسسات

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Abstract

The accelerating pace of climate change has emerged as one of the most tremendous challenges of the 21st century, threatening the stability of natural ecosystems and economic stability worldwide. Nowhere is this threat more acute than in the Middle East and North Africa (MENA) region. In response, green finance has emerged as a pivotal mechanism to mobilize investment towards sustainable development initiatives. However, the unresolved question is whether green finance is effective in enhancing environmental performance in the MENA region. In this milieu, this study examines the impact of green finance proxied by the ND Gain Index on environmental performance under the moderating effect of institutional quality across low-middle and high-income MENA countries by applying Pooled OLS, Fixed Effects, Random Effects, GMM, and Quantile Regression models to panel data from 2012 to 2023. The model controls for socio-economic variables, including urban population growth, industrialization, GDP per capita, and foreign direct (FDI) net inflows. In high-income MENA countries, the empirical findings revealed that green finance enhances environmental performance under the moderating role of control of corruption, while FDI net inflows and industrialization exhibit a positive correlation with CO_2 emissions. Conversely, in low-income MENA countries, green Finance, urban population growth deteriorate environmental performance. These findings underscore the importance of enhancing institutional quality and tailoring green finance strategies to the specific socio-economic contexts of MENA countries to maximize their effectiveness in reducing CO_2 emissions.

Keywords: Green finance, Enviromental Performance, Institutional Quality, MENA region .

المستخلص:

تسارع وتيرة التغير المناخي برز كأحد أكبر التحديات في القرن الحادي والعشرين، مهدداً استقرار النظم البيئية الطبيعية والاستقرار الاقتصادي على مستوى العالم. وتعتبر منطقة الشرق الأوسط وشمال أفريقيا من أكثر المناطق تأثراً بهذه التهديدات. وفي هذا السياق، برز التمويل الأخضر كآلية محورية لتعبئة الاستثمارات نحو مبادرات التنمية المستدامة. ومع ذلك، يبقى السؤال المطروح حول مدى فعالية التمويل الأخضر في تحسين الأداء البيئي في منطقة الشرق الأوسط وشمال أفريقيا.

في هذا الإطار، تتناول هذه الدراسة تأثير التمويل الأخضر، الذي تم قياسه من خلال مؤشر ND Gain ، على الأداء البيئي، مع دراسة الدور المعدل لجودة المؤسسات في كل من الدول منخفضة ومتوسطة الدخل والدول ذات الدخل المرتفع في المنطقة. وقد تم تطبيق نماذج الانحدار المجمّع(Pooled OLS) ، التأثيرات الثابتة (Fixed Effects)، التأثيرات العشوائية(Random Effects) ، طريقة العزوم المعممة (GMM)، والانحدار الكمي (Quantile Regression) على بيانات بانل للفترة من ٢٠١٢ إلى ٢٠٢٣. كما تم التحكم في المتغيرات الاجتماعية والاقتصادية مثل نمو السكان الحضريين، التصنيع، نصيب الفرد من الناتج المحلي الإجمالي، وتدفقات الاستثمار الأجنبي المباشر.أظهرت النتائج التجريبية في دول الشرق الأوسط وشمال أفريقيا ذات الدخل المرتفع أن التمويل الأخضر يعزز الأداء البيئي في ظل الدور المعدل للسيطرة على الفساد، بينما ترتبط تدفقات الاستثمار الأجنبي المباشر والتصنيع إيجابياً بانبعاثات ثاني أكسيد الكربون. وعلى النقيض من ذلك، في الدول منخفضة الدخل، يؤدي التمويل الأخضر ونمو السكان الحضريين إلى تدهور الأداء البيئي.

وتؤكد هذه النتائج على أهمية تعزيز جودة المؤسسات وتصميم استراتيجيات التمويل الأخضر بما يتناسب مع السياقات الاجتماعية والاقتصادية الخاصة بدول المنطقة، وذلك لتعظيم فعاليتها في الحد من انبعاثات ثاني أكسيد الكربون.

الكلمات المفتاحية:

التمويل الأخضر، الأداء البيئي، جودة المؤسسات، منطقة الشرق الأوسط وشمال إفريقيا

1. Introduction

The world is experiencing an unprecedented environmental crisis, with global warming and climate change threatening the stability of economies across all continents. Climate change is one of the most pressing global challenges of the 21st century, manifesting in rising temperatures, natural disasters, and socio-economic disruption (IPCC, 2023; Wang & Ma, 2022). Earth's average surface temperature reached approximately 1°C above pre-industrial levels in 2024, marking the highest recorded since systematic observations began in 1880 (NASA, 2024). This historic rise is attributed to accumulated greenhouse gases (GHG) in the atmosphere, especially carbon dioxide (CO_2), identified as the dominant anthropogenic greenhouse gas, accounting for 73.7% of emissions in 2023 (EDGAR, 2024). If left unchecked, CO_2 emissions will cause an additional 1–3.7°C increase in global average temperatures (IPCC,2022). Accordingly, International initiatives, including the Paris Agreement, the Kyoto Protocol, and the Sustainable Development Goals, addressed climate change challenges.

The Middle East and North Africa (MENA) region is one of the most susceptible regions to the detrimental effects of climate change, facing significant challenges despite contributing only 5% to global GHG emissions in 2019 (Lienard, 2022). The region is encountering escalating challenges, including rising temperatures, reductions in precipitation, exacerbating water scarcity, posing risks to economies that are heavily dependent on favorable climatic conditions, causing GDP losses of 6–14% by 2050 without effective mitigation actions (Olawuyi, 2022). Compounding these vulnerabilities is the region's dependence on fossil fuels, holding 59% of global oil and 45% of natural gas reserves. Although renewable energy initiatives are underway, such as Egypt's target of 42% renewable electricity by 2035, Saudi Arabia's Dumat Al-Jandal wind farm, and Morocco's solar projects, renewables still constitute less than 1% of energy consumption in most countries (Masrafeyoun, 2024; ERF, 2023). Accordingly, a significant financing gap persists in the region for climate mitigation and adaptation, requiring billions of dollars annually (IPCC, 2022). Accordingly, scaling up green finance is essential to bridge this gap (Ecofy, 2023).

Green finance is defined as a dynamic financial paradigm encompassing various financial instruments, including green bonds, loans, sukuk, and credit dedicated to funding environmental conservation and renewable energy projects (Zhang et al.,2023). Green finance is a phenomenon merging the business world with environmentally responsible practices, involving a wide range of participants, including investors, producers, and lenders. Its interpretation varies depending on the stakeholder and may be motivated by financial incentives, environmental preservation, or both. Unlike traditional finance, green finance emphasizes ecological benefits, prioritizing investment in environmental protection industries, facilitating the transation towards a climate-resilient economy (Wang and Zhi, 2016).

Despite challenges like greenwashing and persistent funding gaps, green finance is a key mechanism for achieving global climate targets, particularly in vulnerable regions like MENA. The global demand for green finance has expanded, with the annual issuance of green, social, and sustainability-linked bonds, reaching USD 1.1 trillion in 2024, where green bonds accounted for the majority share at 57% of this volume (World Bank, 2024). Projections indicate that the global issuance volume could exceed USD 5 trillion by 2025, reflecting an accelerated growth trajectory (UNDP,2024). Europe is the dominant player in the labeled sustainable bond market, contributing 53% of the global total, followed by the US and China. While, The green Sukuk market is gaining prominence, in 2023, green sukuk issuance reached $ 13.378 billion. Leading issuers were Indonesia and Saudi Arabia (UNDP,2024). According to landscape of climate finance 2025" report, global climate finance reached USD 1.9 trillion in 2023, and exceeded USD 2 trillion for the first time in 2024 (CPI, 2025).

2. Research problem

In 2024, the world experienced its warmest year on record, with average surface temperatures rising approximately 1.48°C above pre-industrial levels, while global (CO_2) emissions reached a new high of 37.4 billion tonnes. This warming trend has intensified the severity of climate-related hazards such as heatwaves and droughts, which threaten ecosystems and economic stability (NASA, 2024; Global Carbon Project, 2024). The MENA region is among the most vulnerable regions to climate change. Temperatures in MENA are rising at twice the global average, exacerbating the region's extreme drought, where 86% of the land is desert (World Resources Institute, 2023). These changes threaten water security, food production, and economic growth. Accordingly, green finance has emerged as a critical mechanism supporting sustainable economic growth and environmental preservation by mobilizing financial resources toward low-carbon investments.

Given this context, there is a critical need to understand how green finance can improve environmental performance in the MENA region. Despite MENA's acute vulnerability to climate change, empirical research on the effectiveness of green finance in mitigating environmental degradation within the region remains limited. Existing studies focus on developed economies in Europe and Asia, overlooking the unique socio-economic, institutional, and income heterogeneity challenges in MENA countries. Particularly regarding how institutional quality moderates the impact of green finance on environmental performance across low-middle and high-income MENA economies.

This study aims to address these gaps by providing a comprehensive empirical analysis of green finance's impact on environmental performance in MENA, accounting for institutional quality and socio-economic factors including urban population growth, GDP per capita growth, industry value added, and FDI net inflows, contributing valuable insights to both academic literature and policy formulation. Therefore, the research problem could be "What is the impact of green finance on environmental performance in the Middle East and North Africa (MENA) region, and how does institutional quality moderate this relationship across low-middle income and high-income economies, when accounting for socio-economic factors such as urban population growth, industrialization, GDP per capita dynamics, and FDI net inflows?"

3. Literature review

Green finance traces its origins to the 1970s environmental movement, marked by events like the first Earth Day and the creation of regulatory bodies such as the U.S. EPA (Pressbooks, 2024). In the 1990s, the financial sector integrated enviromental goals, exemplified by the European Investment Bank's first green bond (UNEP FI, 2010; Flaherty et al., 2017). The 2000s saw rapid growth driven by the Kyoto Protocol (2005) and the Clean Development Mechanism, promoting emission reductions in developing countries (Nations, 1998; Pressbooks, 2024). The

2015 Paris Agreement accelerated green finance, fostering issuance instruments like green bonds and loans (Pressbooks, 2024). Emerging technologies like blockchain and AI promised to enhance green finance efficiency. Thus, green finance has evolved from activism to a sophisticated global framework integrating ecological, social, and economic objectives.

Green finance development has progressed through emergence, growth, and rapid expansion stages (Liu et al., 2019). Key green finance instruments include green bonds, loans, credit, insurance, and mortgages, mobilizing capital for pollution control, and climate adaptation (Lindenberg, 2014; UNEP Inquiry, 2016; Kaushal and Mohd, 2018). Green finance has become a central mechanism for addressing climate change through global policy frameworks such as the Kyoto Protocol, Copenhagen Accord, and the Paris Agreement, which emphasize climate mitigation and adaptation, especially in developing countries. Climate finance, as a subset of green finance, channels funds from multilateral and bilateral sources to enhance climate resilience in vulnerable regions.

The sustainable finance market has experienced significant growth in recent years, reaching a size of $6.7 trillion in 2024. It is projected to grow to $8.3 trillion in 2025, with a compound annual growth rate of 23.1% (Sustainable Finance Market Report," 2025). Green bonds made up 40% of the green finance market (Pangarkar,2024). Green bond issuance reached a total of $575 billion in 2023. Europe continues to lead the sustainable bond market, contributing 53% of the global total, followed by the US and China (UNDP,2024). While developed economies have experienced significant growth in the sustainable finance market, attracting 44% of the funding for climate action, emerging markets and developing economies (EMDEs) account for only 14% of global climate finance (CPI,2024). Despite significant green bond issuance growth reaching $135 billion in 2023, with a 34% growth rate (IFC, 2024). EMDES still falls behind in the transition to a low-carbon economy, with an annual climate finance gap 2.4 trillion by 2030 (CPI,2025).

In response, COP29 is shifting the climate finance paradigm by increasing funding commitments to EMDEs to $300 billion annually until 2035, replacing the previous target of $100 billion per year (CPI, 2023). However, challenges remain in reporting green financial flows in developing regions, due to data gaps and a lack of standardized frameworks. In the MENA region, climate change poses acute risks due to extreme weather, droughts, and altered rainfall patterns, exacerbating water scarcity, with over 60% of its population struggling to access safe drinking water. Compounding these vulnerabilities is the region's dependence on fossil fuels, the main driver of GHG emissions, urging the need to shift to renewables. The International Energy Agency projects MENA's renewable capacity to triple by 2030, positioning it as a global renewable energy hub (IEA, 2023).

MENA issuance saw remarkable growth in 2023, particularly in the green financing sector, with green bonds and sukuk doubling to reach $24 billion. The bulk of this issuance came from the UAE and Saudi Arabia. Together, these two powerhouses accounted for 77 % of the total issuances in MENA (Mubasher, 2023). MENA also dominated the global market in green sukuk, achieving sales of around $6.5 billion (Garcia, 2024). Egypt issued the region's first green sovereign bond valued at $750 million, Saudi Electric Company (SEC) developed a framework for "green sukuk" (sharia-compliant bonds) and issued two tranches, each valued at $650 million, and Qatar National Bank issued a $600 million green bond. However, regional issuance still represents only 1% of the global total (Reuters, 2020; Climate Funds Update, 2025). Structural reforms, such as public-private partnership legislation and the introduction of the MENA Climate Change Readiness Index, aim to enhance adaptation and mitigation readiness.

Despite these efforts, the MENA region faces significant climate finance gaps, receiving only $16 billion in 2019-2020 compared to $293 billion in East Asia and the Pacific (Earth.org, 2024). Persistent barriers include macroeconomic instability and institutional challenges, necessitating increased climate finance and robust policy frameworks to support sustainable development and resilience (UN CC: Learn, 2024; Climate Funds Update, 2025).

Environmental quality is defined as the overall state and health of the natural environment. It is a crucial indicator of how natural resources are being maintained or degraded. Given the multifaceted nature of environmental quality, it is essential to identify a quantifiable indicator that accurately reflects its determinants and consequences. Scholarly literature and international organizations identified a range of indicators for assessing environmental performance. OECD highlighted that environmental performance is measured through a set of indicators reflecting environmental pressures (emissions), environmental conditions (air and water quality), and societal responses (policy measures), commonly used indicators include: CO_2 emissions, GHG emissions, ecological footprint, carbon emission intensity, air and water quality metrics, waste generation and management, and access to clean water (OECD,1993).

Global research employed a combination of these indicators, with a particular focus on CO_2 emissions, ecological footprint, and GHG emissions as proxies for environmental performance and degradation. For instance, Permana et al., (2024); Bakry et al., (2023); Fu & Irfan (2022); Wang et al., (2021) utilized CO_2 emissions as an indicator for environmental performance, while Iqbal et al., (2025) Liu et al., (2023); Elsherif (2023) used GHG emissions as an indicator for environmental performance. Additionally, Sadiq et al., (2025); Kashif et al., (2024); Vardar et al., (2023) employed the ecological footprint for measuring environmental performance.

However, numerous recent studies have emphasized CO_2 centrality as a key indicator of environmental performance, due to its significant contribution to climate change and global warming (Abbasi and Riaz, 2016). CO_2 emissions, accounted for 73.7% of emissions in 2023, contributing significantly to global warming and rising sea levels, making CO_2 a key metric for assessing environmental performance (EDGAR, 2024). CO_2 reduction has become a central objective of international frameworks such as the Paris Agreement and SDG 13 (UNFCCC, 1997; IPCC, 2023). In summary, CO_2 emissions are selected as the main dependent variable in this study due to their ability to capture the multifaceted environmental, economic, and institutional dynamics. This choice provides a globally standardized metric, aligning with the study's goal of evaluating green finance efficacy and informing region-specific climate policies in MENA. In the MENA region, CO_2 emissions have reached phenomenal levels, increasing by over 200% from 1990-2009 (EIA, 2024). High emissions are attributed to oil production and slow adoption of renewables. (Fehaid & Babiker, 2011). Without accelerated action, CO_2 emissions in the Persian Gulf States are projected to increase by 7.7% annually, intensifying climate vulnerabilities (Sab & Al-Mulali, 2024).

Empirical evidence demonstrates that green finance mechanisms have a significant negative impact on carbon emissions through resource allocation toward low-carbon technologies, but its effectiveness can vary due to regional heterogeneity, regulatory quality, and technology adoption (Zhu & Liu, 2024; Sohail et al., 2024). Environmental performance in developing countries and MENA are influenced by socioeconomic factors, including industrialization, urbanization, economic growth, and FDI net inflows, all moderated by institutional quality.

Institutional quality is crucial for effective green finance and climate policy, robust institutions enhance the impact of green finance, while weak institutions hinder progress (IEA, 2023). Thus, institutional quality is a vital moderating factor in carbon mitigation outcomes. Multiple studies across various regions suggest that green finance generally improve environmental performance by reducing emissions. However, the effectiveness of this impact can vary depending on institutional quality, financial market development, and levels of economic development (Nguyen & Tran, 2024; Zhang et al., 2023). For instance, countries with strong governance and mature financial markets tend to leverage green finance more effectively, while in developing nations, challenges including limited access to capital and weaker institutions can hinder green finance efficacy.

The Academic literature on green finance's environmental impact is commonly divided into two main strands. The first strand examines the impact of green finance in developed countries, where mature financial markets, robust regulatory frameworks, and higher institutional quality facilitate green finance efficacy in mitigating emissions. The second strand focuses on developing countries, where the impact of green finance is shaped by challenges and opportunities, including limited access to capital, weaker institutional structures, and socioeconomic factors.

The following review will explore these two strands, highlighting the outcomes observed in developed and developing economies.

Developed Economies: Li et al., (2023) showed that green bonds asymmetrically decrease GHG emissions in nine of the top ten issuing countries, with the strongest negative impact in high-emission countries like the US. Zhang et al., (2022) found that green finance and renewable energy adoption significantly reduce CO_2 emissions in G20 countries, while economic growth, energy consumption, and FDI exacerbate them. Meo and Karim (2022) reported that green finance immediately reduces CO_2 emissions in the US, the UK, and Switzerland, with stronger effects in high-emission quantiles, while effects are mixed in Japan and Canada.

Developing Economies: Permana et al., (2024) revealed that while digital finance reduces CO_2 emissions, green finance elevates them in 23 developing countries. This reflects how poor institutional quality can lead to "greenwashed" projects. Gong et al., (2024) examined the impact of green finance on carbon footprint in BRICS+6 countries, including Egypt, Saudi Arabia, Iran, and the UAE, and found that green finance negatively affects the carbon footprint in most economies, with the most significant impact in high-pollution scenarios. Saudi Arabia and the UAE show strong negative correlations due to investments in renewable energy projects, while Egypt and Ethiopia display mixed results. Bakry et al., (2023) affirmed the inhibitory influence of Green Finance on CO_2 emissions across 76 developing countries, in both the long and short run, mitigating climate change and achieving SDGs. Mumuni and Lefe (2023) explored 41 African countries and found that climate finance and renewable energy consumption initially increase CO_2 emissions due to transitional inefficiencies but yield long-term emission reduction aligning with the EKC. Elsherif (2023) found that a 1% increase in the green finance index reduces greenhouse gas (GHG) emissions by 0.2%, emphasizing GF's role in decoupling economic activities from carbon-intensive pathways. Empirical evidence revealed that green finance practices significantly enhance environmental performance across Chinese provinces with regional variations observed. For instance, Wang and Ma (2022) found that green finance significantly reduces CO_2 emissions in developed eastern and central regions, but less significant in underdeveloped western areas due to inefficient policy implementation. Zhou et al., (2020) confirmed the EKC hypothesis in China, showing that green finance helps reduce emissions after a certain development threshold. Liu et al., (2019) highlighted that green finance enhanced ecological efficiency in developing chinese provinces but had neutral or negative effects in developed chinese provinces due to saturated green investment.

In summary, the literature demonstrates that green finance improves environmental quality across regions, but its effectiveness is shaped by local economic structures, policy frameworks, and institutional quality. While advanced economies benefit from institutional coherence and innovation, regions like MENA face unique challenges that require adaptive, region-specific strategies to fully realize green finance's efficacy. Then a more comprehensive understanding of the determinants of environmental outcomes in the MENA region can be achieved by reviewing the influence of control variables, key socioeconomic factors on CO_2 emissions.

Urbanization is a major driver of energy consumption and CO_2 emissions. Kaneko and Poumanyvong (2010) describe urbanization as a shift from rural to urban economies, intensifying resource use and emissions. The UN (2008) notes that the global urban population more than doubled from 1975 to 2008, with the MENA region's urban population exceeding 61% in 2009, resulting in higher energy use and CO_2 emissions. The empirical literature is divided into three categories, the first strand of literature highlights detrimental impact of urbanization on environmental performance: (Neumayer & Cole, 2004; Poumanyvong & Kaneko 2010; Hossain, 2011) find urbanization rise energy use, driving CO_2 emissions, especially in middle- and high-income countries. The second strand shows environment-conserving effects: Chen et al., (2008) report that higher urban density reduce per capita energy use and emissions. Barla et al. (2011) find a negative correlation between urbanization and emissions due to economies of scale. The third category supports an inverted U-shaped (EKC) effect: (Maruotti & Martínez-Zarzoso, 2011; Abdallh & Abugamos, 2017) found that emissions initially rise with urbanization, then decline as urbanization progresses and infrastructure improves.

The EKC hypothesis, supported by Bandyopadhyay and Shafik (1992), suggests that economic growth worsen environmental quality initially, after reaching a certain income threshold, environmental quality improves, forming an inverted U-shaped relationship between per capita GDP and pollution. Empirical studies confirm this for various regions: Alam et al., (2016) for Brazil, China, and Indonesia; Cole et al., (2011) for Chinese provinces; Narayan and Narayan (2010) for developing countries. However, other studies Tutulmaz (2015); Jaunky (2011) reject the EKC hypothesis, finding a linear or even N-shaped relationship between economic growth and CO_2 emissions. Granger causality analyses reveal mixed results: Wang et al., (2016); Chang (2010) found economic growth Granger-cause CO_2 emissions, while Hossain (2011); Soytas et al., (2009) report no causal link.

In summary, economic growth is linked to increased CO_2 emissions, with empirical evidence supporting the EKC hypothesis, linear relationships, and causality tests revealing direct and indirect links that vary by country, methodology, and development stage.

Hansen and Rand (2006) define FDI as net inflows/outflows as a percentage of GDP, emphasizing its role in capital transfer. Tang and Tan (2015) highlight FDI as a key factor shaping environmental quality. Cole et al., (2010); Elliott (2005) argue that FDI inflows often deteriorate the environment by targeting carbon-intensive industries in countries with lax regulations, supporting the pollution Haven hypothesis. However, Khan et al. (2021); Adam and Tweneboah (2009) support the pollution Halo hypothesis, arguing that FDI can encourage environmental improvements by introducing green technologies that support sustainable economic growth. Acharya (2009) highlighted that FDI brings both advantages (capital, technology, exports) and disadvantages to host countries. Thus, empirical results are mixed between supporters and opponents: Zheng et al.,(2019) report that FDI reduces pollution in China. In contrast, Al-Mulali (2012), showed that FDI increases emissions, especially in low- and middle-income countries. Atici (2011) found no significant effect of FDI on emissions.

The environmental implications of industrialization are profound. Industrialization drives energy consumption, which relies heavily on fossil fuels, and higher emissions of GHGs, particularly CO_2. The relationship between industrialization and environmental performance is context-dependent, varying across stages of development and the stringency of environmental regulations.

Empirical studies have demonstrated both positive and negative impacts of industrialization on CO_2 emissions. For instance, Jaunky (2011) highlighted that rapid industrialization reduces emissions in high-income countries due to the adoption of advanced technologies and stricter regulations. Halicioglu (2009) showed that rapid industrial growth in developing countries is positively correlated with CO_2 emissions due to higher energy demand and limited adoption of clean technologies.

4. Research Objectives:

The main objective of this study is to explore the impact of green finance on environmental performance in the MENA region, while examining the moderating role of institutional quality.

- To empirically examine the impact of green finance on environmental performance in the MENA region.
- To evaluate the moderating role of institutional quality in shaping the effectiveness of green finance in mitigating environmental degradation.
- To measure the Effectiveness of Green Finance in Low-Middle Income and High-Income MENA Countries.
- To discover the relationship between control variables (urban population growth, GDP per capita growth, industry value added, and FDI inflows and environmental performance in the context of green finance.
- To provide policy recommendations to enhance the effectiveness of green finance in supporting climate resilience and sustainable development in MENA region.

5. Research importance:

The role of green finance in improving environmental performance and promoting sustainability in the MENA region has important implications for balancing economic growth with environmental performance. Understanding this role will empower policymakers to develop tailored green finance strategies that address the region's economic and institutional conditions. This study's insights will help identify finance gaps and institutional barriers, improving green finance deployment in the MENA region. The findings are relevant to other developing countries facing similar challenges, contributing to regional policy development and the global discourse on climate finance.

6. Research Methodology

The research uses the cause-and-effect method in exploring the impact of Green Finance (Notre Dame index) on Environmental Performance (CO_2 emissions) by using panel data analysis. Panel data is a combination of time series data and cross-sectional data. Data panel analysis techniques in this study can be done by pooled OLS, fixed effect, random-effect, GMM, and Quantile Regression. The Hausman test is used to determine which method is more proper for this research. Moreover, data was processed using the statistics Stata software. Countries' data are collected for all variables from the World Bank and the CID. The data was collected for 18 low, middle-income, and High-Income MENA region countries between 2012 - 2023. The statistical analysis of the data was conducted to test hypotheses and draw conclusions.

7. Research sample

The targeted sample is the MENA region countries, including Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, UAE, and Yemen, from 2012 to 2023. Countries were selected based on data availability, covering most MENA region.

8. Research Data

The study comprises three components: the dependent variables, the independent variables, and the control variables, as described below:

Variables	Name /symbol	Measurement
Dependent Variable: Carbon Dioxide emissions (metric tons per capita)	This defines the amount of emissions resulting from the burning of fossil fuels and cement manufacturing. The variable also measures the level CO_2 production during the consumption of solid, liquid, and gas fuels.	(World Bank, 2025)
Independent Variable: ND Gain Index	This is a global free index that measures the country’s fluctuations to climate disruptions and changes. It examines the country’s ability to leverage private, public-sector investments to take the correct actions that solve climate disruptions.	(CID, 2025)
Regulatory Quality: Estimate	This indicator depicts the role of the government in implementing adequate regulations that enhance the private sector's role.	(World Bank, 2025)
Control of corruption index: Estimate	This index measures to what extent does public power is exercised for various forms of corruption, which are captured by the authorized people and elite. Also, it examines the level of of the country’s legal and institutional framework in fighting against corruption.	(Millenium Challenge Corporation, 2024)
Rule of law: Estimate	This index measures the level of government compliance to the law, having justice accessible, the absence of corruption, and applying transparency in all services.	(OurWorldinData, 2025)
Government Effectiveness: Estimate	It analyses the quality of the public services, civil services, and to what extent it was independent from any political pressures. Also, the indicator examines the strength of policy implementation and the government's capability to apply such measures.	(World Bank, 2025)

Control Variable: GDP per Capita growth %	This indicator is a measurement of the average living standards of the people in the country. The living standards are reflected in terms of the amount of goods and services produced.	(World Bank, 2025)
Control Variable: FDI net Inflows % of GDP	The value of all the direct investments entering an economy by non-residents.	(World Bank, 2024)
Control Variable: Industry including construction value added % of GDP	The value added comes from mining, manufacturing, electricity, water, and gas. The value added is calculated from the net output of a sector after the addition of all output after excluding all the intermediate inputs. It is calculated without subtracting for depreciation of assets or depletion of natural resources.	(World Development Indicators, 2024)
Control Variable: Urban Population % growth	The growth in the rate of people who are living in urban areas in a country	(World Bank, 2025)

9. Model and proposed hypotheses

Given the previous research problem and the previous studies indicating that there is a significant relationship between Green Finance and Environmental performance, it is possible to formulate the following research hypotheses and model .

H1: Green finance (ND-Gain Index) has a significant negative impact on Environmental Performance (CO_2 Emissions) in the MENA region.

H2: Institutional quality has a significant negative impact on Environmental performance.

H3: Institutional quality significantly moderates the negative relationship between green finance and Environmental Performance.

10. Data results and analysis

The main aim of the following section is to examine all the statistical and econometric methods needed to investigate the impact of Green Finance on Environmental Performance. The paper used panel data analysis, which is better than time series in terms of bias, variability, and accuracy. Stata software was used to examine all the econometric tools needed.

10.1 Table 1: Descriptive Analysis for the low-middle income countries:

	CO2-Emissions in MT/cap	ND Gain Index	COC	Reg.Quality	Rule of Law	Gov. Effect	GDP per Cap Growth %	FDI Inf %	Industry Value added%	Urb.Pop Growth %
Mean	2.248	0.456	-0.57	-0.507	-0.579	-0.531	546.722	537.965	5.921	2.392
Maximum	16.302	0.619	1.618	1.053	1.011	1.146	1100	1095	7.003	0.619
Minimum	0	0.275	-1.799	-2.369	-2.098	-2.228	1	1	0	0.275
Standard Deviation	2.402	0.075	0.597	0.61	0.59	0.624	316.95	320.9	1.212	1.753

The descriptive analysis of low-middle income MENA countries revealed that most variables depicted a small variation over the years. The main dependent variable, CO_2 emissions, showed low deviation, with a standard deviation of 2.4 points. Despite rapid population growth, with higher emissions generated, their recent sustainability initiatives net-zero pledges by 60%, helped in reducing emissions. The emissions values varied heavily across the MENA countries. For example, Egypt, Tunisia & Morocco, located in North Africa, have lower emissions mainly due to not being energy-producing countries such as the GCC and shifting to renewables (Consultancy-me, 2023). The independent variable, ND-gain index measuring green finance efforts, also displayed low variation with a very low standard deviation of 0.075. This reflects the region's minor efforts in developing green finance. Countries like Libya, with vast crude oil reserves, didn't invest any revenues in addressing massive environmental disruptions (Moneer, 2024). Institutional quality indices, including control of corruption (COC) and regulatory quality, showed consistent scores with standard deviations equal to 0.597,0.61 respectively. The MENA region's moderate improvements indicate ongoing efforts to combat corruption and reinforce institutions. Tunisia witnessed a significant transformation in democracy, enhancing transparency and the rule of law. Some MENA region countries started in e-governance to reduce contact tracing. Apart from this, challenges such as bureaucracy and informal activities persist, undermining institutional effectiveness, as seen in Lebanon's academic crisis linked to corruption and policy failure. (MENA-forum, 2021; Kırsanli, 2022). In contrast, GDP per capita growth and the FDI net inflows depicted significant variations. GDP per capita growth deviated from the mean by 316.95 points. Reflecting disparities driven by cuts in oil production, high political instability, low female employment, and public sector inefficiency. FDI inflows showed a huge variation with a standard deviation of 320.9, driven by political uncertainty and macroeconomic instability. On the other hand, Algeria, Egypt, Morocco and Tunisia attracted significant FDI percentages, fostering employment opportunities. (Caccia et al., 2018). Lastly, industry value added as a percentage of GDP and urban population growth rates experienced minor fluctuations, reflecting low concentration in advanced manufacturing (Aboushady & Zaki, 2019). While urbanization growth standard deviation scored 1.75, with minimal variation due to inadequate residential capacity (Elgendy & Abaza, 2020).

Table 2: Descriptive analysis for the high-income countries:

	CO2-Emissions in MT/cap	ND Gain Index	COC	Reg.Quality	Rule of Law	Gov. Effect	GDP per Cap Growth %	FDI Inf %	Industry Value added%	Urb.Pop Growth %
Mean	18.346	0.573	0.484	0.513	0.431	0.509	0.596	4.096	102.5	1.728
Maximum	202.865	0.693	1.648	1.536	1.349	1.604	17.761	28.175	204	16.022
Minimum	1.886	0.487	-1.105	-1.142	-1.197	-0.712	-21.659	-7.096	1	-10.884
Standard Deviation	22.194	0.052	0.696	0.507	0.498	0.527	4.812	4.544	59.034	2.674

The descriptive analysis of high-income MENA countries reveals substantial variation in CO_2 emissions per capita, ranging from 1.886 to 202.865 metric tons, primarily driven by oil-dependent GCC countries (Mohtadi & Bogetić, 2025). However, emissions have declined regionally due to sustainability initiatives such as Qatar's carbon program and Saudi Arabia's 2060 net-zero strategy (Clean Energy Business Council, 2025). The ND-GAIN index, measuring green finance, showed minor variation, supported by significant financial investments of $2–3 billion since 2012. The UAE green bond issuances reached $10.7 billion, alongside Saudi Arabia, together accounting for 77% of MENA's green bonds (Garcia, 2024). Institutional quality indices reflected steady progress aligned with UNCAC treaty standards aimed at combating corruption (Beschel et al., 2024). GDP per capita growth showed a low average deviation (4.8 points) but a wide range (−21.65% to 17.76%), with Saudi Arabia, Qatar and UAE experiencing notable growth due to diversification, technological advancement and industrial expansion (Garcia, 2025). FDI net inflows varied significantly (−7.096% to 28.175%), with high inflows in GCC countries due to improved business environments, while negative inflows were linked to political instability (Depetris Chauvin, 2013). Urban population growth ranged from −10.88% to 16%, with declines due to inadequate services (Walnycki, 2014). Industry value added as a percentage of GDP showed wide variation with a 59.034-point deviation, reflecting high industrialization levels that enhance productivity in high-income countries. Also, GCC countries have intensified efforts to accumulate capital, improve ICT infrastructure, and diversify economies (Ecology, Environment and Urban Development, 2024; Mimoune, 2024)

10.2 Table 3: Correlation analysis for the low-middle-income countries :

The figures show correlation matrices for low-middle and high-income countries. Strong correlations between independent variables indicate multicollinearity, requiring one variable to be dropped (Kusawa, 2023).

	CO2 emissions	ND Gain	Urban G%	GDPCG	FDII	LINDC	COC	GOV EFF	Rule Law	Reg Q
CO2 emissions	1.000									
ND Gain	0.6271***	1.000								
Urban G%	-0.3232***	-0.5826***	1.000							
GDPCG	0.0525*	0.2500***	-0.1296***	1.000						
FDII	-0.0204	0.2009***	-0.0141	0.1697***	1.000					
LINDC	0.2864***	0.2097***	0.0523*	0.0959***	0.064**	1.000				
COC	0.0944***	0.5802***	-0.2602***	0.1853***	0.1798***	-0.0947***	1.000			
Gov Eff	0.3840***	0.7873***	-0.2767***	0.2524***	0.2425***	0.1557***	0.7603***	1.000		
Rule Law	0.1544***	0.6627***	-0.2441***	0.2017***	0.2266***	-0.002	0.8783***	0.8284***	1.000	
Reg. Q	0.1772***	0.7186***	-0.2708***	0.1947***	0.3732***	0.1482***	0.6457***	0.8022***	0.748***	1.000

(* significant at 10%- ** significant at 5%- *** significant at 1%)

The correlation analysis revealed high and significant correlations (above 74%) among institutional quality indicators, government effectiveness, rule of law, COC, and regulatory quality, indicating multicollinearity. Government effectiveness and rule of law indices were dropped from the model. A significant negative correlation (-58.26%) was found between the ND-GAIN index and urbanization, reflecting increased environmental degradation with urbanization (Zakari & Khan, 2022). Moderate positive correlations existed between ND-GAIN index, COC (58.02%) and regulatory quality (71.86%), supporting the role of governance in effective environmental policy implementation (Tawiah et al., 2023). some variables showed minor correlations, minimizing model bias

Table 4: Correlation analysis for the high-income countries:

	CO2 emissions	ND Gain	Urban G%	GDPCG	FDII	LINDC	COC	GOV EFF	Rule Law	Reg Q
CO2 emissions	1.000									
ND Gain	-0.328***	1.000								
Urban G%	0.132*	-0.177**	1.000							
GDPCG	-0.159**	0.126	-0.360***	1.000						
FDII	0.311***	-0.116	-0.154**	0.099	1.000					
LINDC	0.458***	-0.274***	0.405***	-0.112	-0.213***	1.000				
COC	-0.134*	0.439***	-0.023	-0.051	0.109	-0.212***	1.000			
GOV EFF	-0.14**	0.553***	0.092	-0.055	0.014	-0.071	0.782***	1.000		
Rule Law	0.227***	0.368***	0.114	-0.099	0.274***	0.053	0.776***	0.733***	1.000	
Reg. Q	-0.271***	0.563***	0.068	0.030	0.044	-0.139**	0.610***	0.772***	0.698***	1.000

(* significant at 10%- ** significant at 5%- *** significant at 1%)

In high-income countries, most independent variables showed moderate correlations, except government effectiveness and rule of law, which had high positive correlations with COC (78.2% and 77.6%) and regulatory quality (77.2% and 73.3%), all significant at 1%. Due to multicollinearity, government effectiveness and rule of law were dropped from the model. COC and regulatory quality had a moderate positive correlation of 61%, reflecting the link between good governance, service accessibility, and reduced corruption.

10.3 Unit root test (Stationarity test):

This test aims to examine whether each variable fluctuates across the chosen time. Large volatility indicates non-stationary data caused by external shocks affecting stability. The null hypothesis states the existence of a unit root and stationary data (WallstreetMojoteam, 2023). For non-stationary data, lagged effects or first differences must be used for consistency. Methods to test fluctuations include Phillips-Perron, Im Peasaran Shin, Harris Tzavalis, and Levin Lin Chu unit root tests. Unit root test (Stationarity test): ***H0: p*** = 1 ***H: p*** < 1

Table 5: Unit root test for the low-middle income countries:

Variables	ADF		PP		Breitung		LLC		IPS		HT
	Level	1st difference	Level	1st difference	Level	1st difference	Level	1st difference	Level	1st difference	Level
Carbon-Dioxide emissions (MT/CAP)	6.15***	5.74***	6.14***	7.4***	-3.59***	2.3684	-14.17***	-13.74***	-1.75**	-0.72	17.87***
ND-Gain Index	19.32***	17.21***	7.06***	9.57***	5.38	4.442	-21.84***	-30.4***	-2.28**	-4.13***	12.84***
COC	16.52***	20.97***	-0.28	0.3867	-0.06	-0.35	-18.04***	-18.04***	-4.77***	-2.74***	21.32***
Regulatory-Quality	17.3***	19.13***	1.27	1.57*	-0.84	-0.033	-14.7***	-14.7***	-5.21***	-1.14	23.9***
IND Value added%	19.93***	17.76***	4.35***	3.96***	1.02	0.88	-10.58***	-10.58***	-5.14***	0.86	14.27***
GDP per capita Growth %	34.92***	25.56***	18.74***	21.88***	-6.49***	-2.83***	-16.18***	-16.18***	-11.67***	-4.86***	4.79***
FDI net inflows %	33.11***	21.73***	24.06***	25.86***	-5.86***	-1.2**	-12.11***	-12.11***	-11.39***	-2.33***	3.02***
Urban Population %	16.06***	19.93***	7.01***	6.67***	3.26	-0.018	-21.71***	-21.71***	-2.21**	-6.86***	16.2***

(* significant at 10%- ** significant at 5%- *** significant at 1%)

The stationarity test shows that most variables, including urban population, FDI net inflows, GDP per capita growth, and CO_2 emissions, are stationary at level, meaning that the lagged variables didn't have a long-term impact on the current values and do not require differencing. However, COC and regulatory quality weren't significant in some tests, indicating they need more time to be effective, and first differencing may be insufficient. The Breitung test found industry value added % insignificant at both levels, though other tests showed statistical significance at level.

Table 6: Unit root test for the high-income countries:

Variables	ADF		PP		Breitung		LLC		IPS		HT
	Level	1st difference	Level	1st difference	Level	1st difference	Level	1st difference	Level	1st difference	Level
Carbon-Dioxide emissions (MT/CAP)	12.34***	2.84***	12.34***	12.44***	-0.50	-0.88	-57.6***	1.72	1.72	1.72	8.88***
ND-Gain Index	6.03***	5.66***	6.03***	11.12***	-0.52	-0.77	-8.99***	-8.99***	-2.49***	-1.75**	5.94***
COC	-1.69	-0.29	-1.69	-1.58	0.12	0.32	-5.23***	-5.23***	-0.97	0.47	10.42***
Regulatory -Quality	1.72**	0.38	1.72**	2.20**	0.12	-0.82	-5.4***	-5.4***	-1.75**	-0.02	10.48***
IND Value added%	-1.71	-0.86	-1.71	-1.43	-0.06	-0.21	-5.62***	-5.62***	-2.24**	0.27	3.39***
GDP per capita Growth %	10.95***	12.37***	10.96***	12.25***	-4***	-2.57***	-10.39***	-10.39***	-6.23***	-5.03***	-1.1
FDI net inflows %	6.08***	-0.03	6.08***	6.54***	-0.5	-0.02	-3.55***	-3.55***	-3.9***	0.14	1.25
Urban Population %	2.09**	19.08***	2.09**	3.39***	1.57	0.57	-16.33***	-16.33***	-1.32*	-6.68***	2.94***

(* significant at 10%- ** significant at 5%- *** significant at 1%)

The stationarity test for high-income countries (2012–2023) shows that most variables, CO_2 emissions, ND-Gain Index, regulatory quality, GDP per capita growth, and FDI net inflows, are stationary at level. COC and industry value added were statistically insignificant at both levels and the first difference in ADF, PP, and Breitung tests. Urban population growth was moderately significant at the level and became more stationary at first difference, especially in ADF, PP, and IPS tests.

10.4 Regression Model:

The next section applies various regression models to analyze panel data measuring green finance's impact on environmental performance. It includes control variables, FDI net inflows, GDP per capita growth, urban population %, industry value added % of GDP, and interaction terms between COC, regulatory quality, and the ND-GAIN index to assess institutional quality's moderating effects.

<u>Table 7: Regression Model for low-middle income countries</u>

Variable	Pooled OLS	Fixed Effect Model	Random Effect Model	GMM	Quantile regression
C	-17.92	-17.94	-2.65		-9.51
ND-Gain Index	37.07 (1.488) ***	6.14 (1.28) ***	9.83 (1.25) ***	13.75 (0.522) ***	19.98 (1.14) ***
COC	2.86 (0.906) ***	-0.62 (0.423)	-0.38 (0.439)	2.26 (0.41) ***	1.13 (0.694)
Regulatory-Quality	-8.315 (0.837) ***	-0.47 (0.515)	-0.612 (0.524)	-3.92 (0.421) ***	-3.29 (0.641) ***
COC*ND-GAIN index	-7.36 (1.897) ***	1.69 (0.909) *	0.979 (0.94)	-4.93 (0.800) ***	-3.47 (1.45) **
REG.Q*ND-GAIN Index	14.35 (1.73) ***	1.17 (1.08)	1.28 (1.10)	6.95 (0.788) ***	5.53 (1.33) ***
L.IND Value added%	0.316 (0.048) ***	0.047 (0.015) ***	0.048 (0.016) ***	0.262 (0.051) ***	0.178 (0.037) ***
GDP per capita Growth %	-0.0002 (0.0002)	0.00006 (0.0004) *	0.00006 (0.00004)	-0.00012 (0.00007) *	-0.00013 (0.00013)
FDI net inflows %	-0.0004 (0.0002) **	0.00003 (0.00005)	0.00004 (0.00005)	-0.00005 (0.00008)	-0.00013 (0.00013)
Urban Population %	0.102 (0.0402) **	0.023 (0.015)	0.02 (0.016)	-0.038 (0.022) *	-0.0100 (0.031)
Prob (F-Statistic)	0.0000	0.0000	-	-	-
R-Squared	0.603	0.2901	0.3957	-	-

(* significant at 10%- ** significant at 5%- *** significant at 1%)

The regression analysis employed multiple models to examine green finance's impact on environmental performance in low and middle-income countries.

<u>The Pooled OLS model</u> showed that a 1 point increase in the ND-GAIN index significantly increases CO_2 emissions by 37.7%, reflecting adaptation inefficiencies derived from financial constraints, macroeconomic instability, and food insecurity in low- and middle-income MENA countries, undermining the environmental gains of green finance (Mishra,2023). When the COC increases by 1 point, CO_2 emissions significantly increase by 2.86%, as COC strengthens in one country, regulatory framework efficiency increases, enhancing productivity and

driving emissions. While improved regulatory quality reduced emissions by 8.3 metric tons per capita, as regulatory framework improvement enhances implementation of renewable energy initiatives, lowering emissions. A rise in industry value added by 1% increases emissions by 0.316% metric tons per capita, as industrial expansion definitely drives emissions (Enviroliteracy team, 2024). FDI inflows slightly reduce emissions due to adopting innovative technologies, which reduce emissions (Marques & Caetano, 2020). Urban population growth increased emissions by 0.10 metric tons per capita, mainly due to high transportation demand and energy-intensive activities (Martinez-Zarzoso, 2008).

The Fixed Effect model confirmed a positive significant impact of ND-GAIN on CO_2, but with a smaller coefficient (6.14). COC significantly moderates the positive relationship between ND-GAIN and CO_2, which means that as the government combats corruption effectively, emissions rose as the authorities didn't take the right adaptive solutions to reduce emissions. Industry value added and GDP per capita growth also increased emissions, as income growth increased consumption.

Random Effect model confirmed the significant positive impact of ND-GAIN and industry value added on CO_2 emissions

The GMM model aligned mostly with Pooled OLS except for GDP per capita growth and urban population growth, which have a significant negative impact on emissions, which means that as income improves, people shift towards innovative eco-friendly alternatives (Wan et al., 2022). Urbanization reduces emissions by improving infrastructure (Luqman et al., 2022).

The Quantile Regression: The quantile regression at the 25th percentile showed that the ND-Gain index and industrialization have a positive significant impact on CO_2 emissions.

Table 8:Regression models for the High-income countries

Variable	Pooled OLS	Fixed Effect Model	Random Effect Model	GMM	Quantile regression
C	-18.66	40.09	43.29	-	-17.8
ND-Gain Index	29.27 (47.59)	-44.9 (21.9) **	-50.8 (22.7) **	4.85 (2.33) **	30.7 (27.9)
COC	78.34 (25.2) ***	-22.7 (10.2) **	-21.7 (10.7) **	4.89 (1.64) ***	25.8 (14.8) *
Regulatory-Quality	10.1 (31.7)	23.2 (12.5) *	24.8 (12.9) *	4.26 (1.93) **	-16.5 (18.6)
COC*ND-GAIN index	-138.5 (45.2) ***	42.7 (17.4) **	41.2 (18.16) **	-8.63 (2.9) ***	-42.9 (26.6)
REG.Q*ND-GAIN Index	-12.3 (54.9)	-35.4 (22.1)	-38 (23.1) *	-6.85 (3.28) **	22.3 (32.3)
IND Value added%	0.135 (0.021) ***	0.004 (0.005)	0.005 (0.005)	0.006 (0.001) ***	0.108 (0.01) ***
GDP per capita Growth %	-0.57 (0.21) ***	0.018 (0.029)	0.017 (0.031)	-0.03 (0.014) **	-0.02 (0.123)
FDI net inflows %	1.92 (0.23) ***	0.04 (0.05)	0.049 (0.053)	0.069 (0.010) ***	-0.04 (0.137)
Urban Population %	-0.11 (0.52)	-0.081 (0.07)	-0.084 (0.078)	-0.002 (0.04)	1.022 (0.31) ***
Prob (F-Statistic)	0.0000	0.004	-	-	-
R-Squared	0.528	0.131	0.129	-	-

(* significant at 10%- ** significant at 5%- *** significant at 1%)

The pooled OLS model reported that COC, its interaction with the ND-GAIN index, industry value added %, GDP per capita growth, and urbanization significantly affected CO_2 emissions in high-income countries. The moderating effect of COC negatively affected emissions at 1%, indicating that combating corruption strengthens the ND-GAIN index's emission-reducing effect by taking corrective actions needed for promoting green finance (Bersalli et al., 2023). Industry value added increased emissions by 0.135 metric tons per capita due to increased energy consumption. GDP per capita growth reduced emissions by 0.57 metric tons per capita, reflecting a shift toward eco-friendly alternatives. However, a 1% increase in FDI inflows rises emissions by a 1.92 metric tons per capita, mainly due to reliance on energy-intensive industries (Mahmood et al., 2023). These variables significantly explained 52.8% of emission changes.

The fixed-effect model showed the ND-GAIN index significantly reduced emissions by 44.9 metric tons per capita. This proves the efficiency of the corrective actions and strategies taken by high-income countries to combat environmental degradation. COC lowered emissions by 22.7 metric tons per capita. The model's R^2 was low (13%), indicating that the time factor and unobserved external factors affect emissions.

The random-effect model revealed that the interaction between regulatory quality and the ND-GAIN index reduced emissions by 38 metric tons per capita (10% significance), highlighting the role of effective regulations in fostering green finance through subsidies and incentives (Kadri, 2024). Its R^2 was similar to the fixed-effect model, proving the existence of external factors affecting emissions.

The GMM model aligned with pooled OLS except that the ND-GAIN index significantly increased emissions by 4.85 metric tons per capita (5% significance), with other variables consistent.

The quantile regression showed that a 1% rise in urban population increased emissions by 1.022 metric tons per capita (1% significance), due to higher energy consumption and transportation demand in urban areas (Chen et al., 2022).

10.5 Diagnostic tests:

The upcoming section will demonstrate all the diagnostic tests required after running the regression model to ensure their level of validity and accuracy.

Table 9: Hausman test for the low-middle income countries:

The main aim of running the Hausman test is to understand whether the variables or regressors are predicted from each other or not. This will conclude whether the fixed or random effect was better.

$$H_0: Random\ Effect\ is\ better$$

$$H_1: Fixed\ effect\ is\ better$$

Chi-Squared	Probability
83.02	0.0000

Since the probability of the Hausman test examined did not exceed 5%, this means that the null hypothesis cannot be accepted, and the fixed effect model is better.**Table 10: Hausman test for the high-income countries:**

Chi-Squared	Probability
21.59	0.003

According to the probability of the Hausman test, which was also less than 5%, it proved that the fixed effect model is better than the random effect model.

Table 11: VIF (Variance Inflation factor) test for the low-middle income countries:

It is a measurement of the level of the multicollinearity for each of the independent variables with in the model.

Variables	VIF
ND-Gain Index	3.17
COC	2.104
Regulatory-Quality	2.922
IND Value added%	1.21
GDP per capita Growth %	1.109
FDI net inflows %	1.177
Mean VIF	1.905

Referring to the above table, VIF test proved the non existence of a multicollinearity problem since the VIF values are below10.

Table 12 : VIF (Variance Inflation factor) test for the high-income countries:

Variables	VIF
ND-Gain Index	1.88
COC	1.82
Regulatory-Quality	2.1
IND Value added%	1.26
GDP per capita Growth %	1.16
FDI net inflows %	1.16
Mean VIF	1.53

As mentioned before, since the VIF scores were all below 10, this rejects the concept of having a multicollinearity problem.

Table 13: Heteroscedasticity test for the low-middle income countries:

This test demonstrates the problem of having non-constant variance or a relationship between the error term with the main independent variables.

$$H_0: Residuals\ are\ homoscedastic$$
$$H_1: Residuals\ are\ heteroscedastic$$

Chi-Squared	Probability
2.0e+06	0.0000

Since the probability was less than 5%, this means that the null hypothesis is rejected and that the residuals suffer from a heteroscedasticity problem.

Table 14: GLS model for the low-middle income countries:

GLS is similar to OLS regression model, but the main difference is that the GLS model deals with data where the residuals are not independent. Solving the heteroscedasticity problem.

Variables	Coefficients
C	-17.94
ND-Gain Index	37.08 (1.479) ***
COC	2.869 (0.9) ***
Regulatory-Quality	-8.32 (0.832) ***
COC*ND-GAIN index	-7.38 (0.9) ***
REG.Q*ND-GAIN Index	14.37 (1.72) ***
L.IND Value added%	0.316 (0.048) ***
GDP per capita Growth %	0.00002 (0.0002)

(* significant at 10%- ** significant at 5%- *** significant at 1%)

According to the GLS model and after solving for the heteroscedasticity problem, the results were somewhat similar to the pooled OLS model in terms of coefficients and significance.

Table 15: Heteroscedasticity test for the high-income countries:

Chi-Squared	Probability
8425.86	0.0000

Regarding the high-income countries, the model also suffers from a heteroscedasticity problem since the probability is less than 5%.

Table 16: GLS model for the high-income countries:

Variables	Coefficients
C	-138.5
ND-Gain Index	29.27 (46)
COC	78.34 (24.37) ***
Regulatory-Quality	10.07 (30.65)
COC*ND-GAIN index	-138.47 (43.66) ***
REG.Q*ND-GAIN Index	-12.34 (53.04)
L.IND Value added%	0.135 (0.02) ***
GDP per capita Growth %	-0.569 (0.202) ***
FDI net inflows %	1.916 (0.225) ***
Urban Population %	-0.114 (0.502)

(* significant at 10%- ** significant at 5%- *** significant at 1%)

The same results were conducted before in the Pooled-OLS model, the Random and fixed effect models in terms of coefficients and significance.

Table 17: Serial Correlation test (Wooldridge test) for the low-middle income countries:

This test detects the existence of first-order autocorrelation in the residuals for the panel data analysis.

$$H_0: No\ Serial\ Correlation$$
$$H_1: Serial\ Correlation\ exists$$

Chi-Squared	Probability
27.265	0.0000

The probability gave an indication of a serial correlation problem since it was less than 5%.

Table 18: Panel Corrected Standard errors model for the low-middle income countries:

This model accounts for the existing correlations to achieve unbiased results. Hence, it solves the serial correlation problem.

Variables	Coefficients
C	-17.93
ND-Gain Index	37.07 (0.717) ***
COC	2.869 (0.454) ***
Regulatory-Quality	-8.33 (0.491) ***
COC*ND-GAIN index	-7.38 (0.983) ***
REG.Q*ND-GAIN Index	14.37 (0.978) ***
L.IND Value added%	0.316 (0.047) ***
GDP per capita Growth %	--0.0002 (0.0002)
FDI net inflows %	-0.0003 (0.0002) **
Urban Population %	0.102 (0.718) ***

(* significant at 10%- ** significant at 5%- * significant at 1%)**

Based on the panel-corrected standard errors model, ND-Gain index, COC, logged industry value added and urban population had a positive significant impact CO_2 emissions. The rest of the variables had an adverse effect causing emissions to decline except for the GDP per capita didn't have a significant impact.

Table 19: Serial Correlation test (Wooldridge test) for the high-income countries:

Chi-Squared	Probability
16.558	0.0009

Due to having a probability less than 5%. Therefore, the serial correlation problem exists within the high-income countries.

Table 20: Panel Corrected Standard errors model for the high-income countries

Variables	Coefficients
C	-18.66
ND-Gain Index	29.27 (43.11)
COC	78.34 (27.54) ***
Regulatory-Quality	10.07 (28.56)
COC*ND-GAIN index	-138.48 (49.52) ***
REG.Q*ND-GAIN Index	-12.34 (48.15)
IND Value added%	0.135 (0.031) ***
GDP per capita Growth %	--0.569 (0.271) **
FDI net inflows %	1.916 (0.354) ***
Urban Population %	-0.114 (0.767)

(* significant at 10%- ** significant at 5%- *** significant at 1%)

After solving the serial correlation problem, COC, FDI net inflows, and industry value added had a significant positive effect on CO_2 emissions. In contrast, GDP per capita growth and the moderating effect of COC reduces emissions in the high-income countries.

Table 21: Normality test (Jarque-bera test) for the low-middle income countries:

This test shows to what extent the data and the observations selected are drawn from a normally distributed population.

Jarque-bera	Probability
11.21	0.0037

Since the probability was less than 5%, this concluded that the data was not normally distributed due to the existence of outliers that led to skewness in the data.

Table 22: Normality test (Jarque-bera test) for the high-income countries:

Jarque-bera	Probability
57.92	2.6e-13

Concerning the normality test for the high-income countries, it was proven that the data was also not normally distributed since the probability was less than 5%.

11. Summary and Concluded Remarks:

Green finance has rapidly gained prominence worldwide as a powerful mechanism to combat climate change, which presents one of the most pressing challenges facing the globe, particularly in regions like the Middle East and North Africa (MENA), where environmental vulnerabilities intersect with institutional challenges and complex socio-economic factors. Therefore, this study conducted an empirical investigation on the impact of

Green finance, proxied by the ND-Gain index, on environmental performance across low, middle, and high-income MENA countries, focusing on the moderating role of institutional quality. Employing advanced econometric techniques, including Pooled OLS, Fixed Effects, Random Effects, GMM, and Quantile Regression on panel data spanning 2012-2023, the analysis controlled for critical socio-economic variables such as urbanization, industrialization, GDP per capita, and foreign direct investment (FDI). The findings reveal a heterogeneous relationship between green finance and environmental outcomes in the MENA region: **In high-income MENA countries**, green finance significantly enhances environmental performance, especially under robust institutional quality. The ND-Gain Index, when moderated by effective COC and better regulatory quality, contributes to a significant reduction in CO_2 emissions. However, FDI inflows and industrialization are positively correlated with CO2 emissions, indicating that openness and economic growth driven by carbon-intensive industries and technology adoption in the GCC can potentially offset environmental gains if not carefully managed. GDP per capita growth demonstrated a negative correlation with emissions, suggesting that economic prosperity, coupled with increased awareness and good governance, encourages a shift towards eco-friendly alternatives. **In low- and middle-income MENA countries**, Green finance deteriorates environmental performance, reflecting the inefficiencies of such countries to adopt adequate policies, underscoring the insufficiency of green finance alone in the absence of robust institutional frameworks. Here, ND-Gain, COC were found to significantly increase CO_2 emissions. Additionally, industrialization logically generates more CO2 emissions. While regulatory quality exerted a mitigating effect, it reduced per capita emissions by efficiently implementing mitigation initiatives. FDI also reduced emissions, but to a lesser extent, by introducing cleaner, innovative technologies. Lastly, Urban population growth reduced CO2 emissions through infrastructure enhancement. The findings underscore that green finance is a powerful tool for environmental sustainability but its success highly contingent on institutional quality and governance frameworks.

12. Recommendations

Scaling green finance in the MENA region requires a coordinated and comprehensive effort involving governments, financial institutions, and individuals. **Governments** should focus on strengthening institutions by adopting anti-corruption measures, enhancing regulatory transparency, and developing robust legal systems to support green finance. Tailoring green finance policies to national socio-economic factors. **Organizations and financial institutions** need to integrate environmental, social, and governance (ESG) criteria into investment and lending decisions. globally. They should develop tailored, innovative green financial mechanisms while ensuring transparent reporting and third-party verification to build trust. **Individuals** play a crucial role in advancing sustainability; by adopting sustainable behaviors in consumption, investment, and community engagement, they can significantly contribute to the region's environmental goals of a low-carbon future for the MENA region.

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