IJEEP
INTERNATIONAL JOURNAL OF ENERGY ECONOMICS AND POLICY
EconJournals
ISSN: 2146-4553

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2026, 16(4), 60-68.

Does Financial Development Promote Environmental Sustainability? Evidence from the MENA Region Using Panel Data Analysis

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Received: 05 October 2025 **Accepted:** 03 June 2026 **DOI:** https://doi.org/10.32479/ijeep.21511

ABSTRACT

The purpose of this study is to examine whether financial development can promote environmental sustainability in the MENA region. In particular, the study investigates the potential of green finance mechanisms as channels through which financial systems may contribute to ecological preservation and reduced environmental degradation. It also assesses the current state of green finance adoption and the broader institutional conditions that shape its effectiveness. To achieve the set of research objectives, four Pooled OLS (Panel Regression) Analysis have been conducted for assessing the impact of financial development under the adoption of green policy trends and institutional quality on the environmental degradation- through its four proxies- in the MENA region, since saving the ecological system is one of the major requirements needed for achieving economic sustainability. Nine countries in the MENA region have been incorporated in the analysis; namely Egypt- Israel- Jordon- Lebanon- Saudi Arabia-Turkey- Qatar- Algeria- and UAE., with the variables throughout the period from 1999 to 2021. The dataset includes various metrics of environmental deterioration and financial development, as well as a thorough set of control variables to account for cofounding influences. The key findings indicate that financial development indicators—namely, private sector credit as a percentage of *GDP* (*PCGDP*) and *FDI* net inflows (% of *GDP*) (*FDINI*)—exhibit a statistically significant negative relationship with environmental degradation, as measured by carbon dioxide emissions, natural resource depletion, greenhouse gas emissions, and energy use.

Keywords: Financial Development, Environmental Sustainability, MENA Region, Foreign Direct Investment, Carbon Emissions, Sustainable Development
JEL Classifications: C23, G20, O16, Q56

1. INTRODUCTION

1.1. Background

Global interest in sustainable development has intensified in recent years, driven by growing concerns over climate change, ecological degradation, and the unsustainable reliance on non-renewable energy sources (Jie et al., 2023). The Middle East and North Africa (MENA) region, home to some of the world's largest oil and natural gas reserves, faces a unique sustainability challenge. While hydrocarbon exports have long been central to economic development, this dependence has rendered the region vulnerable to environmental degradation and external shocks such as oil price volatility (Matallah, 2022).

In response, many MENA countries have initiated economic diversification strategies aimed at reducing their carbon footprints and enhancing long-term resilience. Among these efforts, the concept of green finance—financial instruments and investments supporting environmentally beneficial outcomes—has gained some momentum. For example, Saudi Arabia has issued "green

sukuk" bonds worth $650 million, Egypt has launched $750 million in sovereign green bonds, and Qatar National Bank has introduced the region's largest green bond offering (Moneer, 2023). These instruments have been used to finance renewable energy, waste management, water efficiency, and clean transportation projects.

However, despite these promising developments, green finance adoption remains limited. The MENA region accounted for only 1% of the $228 billion in global green financing issued in 2020, indicating significant untapped potential (Moneer, 2023). While direct green finance remains nascent, broader financial development—particularly through private sector credit and foreign direct investment (FDI)—can play an important role in enabling sustainable development. When directed appropriately, these financial flows may help reduce environmental degradation and support a low-carbon economic transition.

Accordingly, this study investigates the relationship between financial development and environmental sustainability in the MENA region, exploring whether credit provision and FDI inflows are associated with improvements in key environmental indicators.

1.2. Problem Statement

The MENA region faces a dual challenge: sustaining economic growth while mitigating long-term environmental degradation. Although the region's economies have historically relied on oil and gas exports, this model has led to significant ecological pressures and increased vulnerability to global market volatility (Ben Cheikh and Ben Zaied, 2021). As a response, economic diversification efforts have gained traction, with growing interest in steering financial resources toward more sustainable development paths (Matallah, 2020).

While the concept of green finance has received increasing attention globally, many MENA countries still operate within broader financial systems that are not explicitly designed around environmental objectives. Nevertheless, general financial development indicators—such as private sector credit and foreign direct investment (FDI)—can potentially influence environmental outcomes, especially when supported by appropriate institutional frameworks. However, empirical evidence on this relationship within the MENA region remains limited and mixed. For instance, some studies suggest that financial flows can contribute to greener growth (Puschmann et al., 2020), while others point to weak adoption and institutional fragmentation that hinder effective alignment with sustainability goals (Liu et al., 2022).

This lack of consensus underscores the need for a clearer understanding of how financial development interacts with environmental sustainability in MENA. Specifically, there is a research gap in assessing whether and how traditional financial flows are associated with reductions in environmental degradation. Addressing this gap is critical for informing policy frameworks that aim to align financial sector development with sustainable outcomes.

1.3. Research Objectives

To examine the impact of financial development—through private credit and foreign direct investment—on environmental sustainability in the MENA region. To pursuit this goal, the research objectives encompass the following:

1. To assess the current state of financial development in the MENA region, with a focus on private credit and FDI trends
2. To identify the key macro-financial and institutional factors influencing the relationship between financial development and environmental degradation
3. To analyze the extent to which financial development indicators (private credit and FDI), alongside institutional quality, are associated with reductions in carbon emissions, resource depletion, energy use, and greenhouse gas emissions.

1.4. Significance of Study

This study provides valuable insights for both policymakers and researchers interested in the intersection of finance and environmental sustainability in the MENA region. While direct measures of green finance remain limited, the analysis focuses on broader financial development indicators—namely private sector credit and foreign direct investment (FDI)—to explore their association with environmental degradation. These findings can inform strategies aimed at leveraging existing financial systems to support sustainable development.

For policymakers, the results highlight the potential of redirecting financial flows toward environmentally responsible investments. By demonstrating that higher levels of credit and FDI are associated with lower levels of environmental degradation, the study supports the case for integrating sustainability criteria into financial and investment policies. This has practical implications for designing regulatory frameworks and incentives that align financial development with ecological goals.

From an academic perspective, the study contributes to the literature by providing new empirical evidence on the financial development–environment nexus in a region that is both underrepresented in sustainability research and highly vulnerable to ecological risks. It opens new avenues for future research exploring how institutional quality, policy interventions, and sectoral targeting can transform general financial flows into more explicitly green outcomes.

1.5. Study Rationale

The MENA region has been selected for this study due to its urgent environmental challenges and its strategic importance in the global transition toward sustainable development (Ben Cheikh and Ben Zaied, 2021). The region remains heavily reliant on oil and gas exports, making its economies vulnerable to environmental degradation and global energy market volatility. In response, several MENA countries have begun pursuing economic diversification strategies, including the adoption of green finance initiatives aimed at supporting low-carbon development (Alshaikh et al., 2020).

Although direct green finance indicators remain limited across much of the region, this study focuses on broader financial development measures—namely, private sector credit and foreign direct investment (FDI)—to assess their potential alignment with environmental sustainability objectives. These variables serve as

proxies for financial flows which, under appropriate institutional and policy frameworks, may support environmentally beneficial investments. Given the heterogeneity of MENA countries in terms of economic development, institutional strength, and environmental governance, the region provides a compelling context to explore how financial mechanisms relate to environmental outcomes.

2. LITERATURE REVIEW

In this section, a review of past literature on the topic of study has been presented. The section compares and contrasts the evidence available to draw research gaps that the study will fill.

2.1. Current State of Green Finance in the MENA Region

Green finance in the MENA region includes various funding options adopted to accelerate sustainable development. According to Beyer and Bayoumi (2022), green financing has been adopted in MENA countries aimed at facilitating the implementation of a National Renewable Energy Action Plan and a National Energy Efficiency Action Plan in various countries by creating an enabling environment for their adoption. Similarly, Assadiki et al. (2022) indicated that renewable energy investments in the MENA account for around 1.2% of the global total. Most of these investments are concentrated in a subset of countries, including the United Arab Emirates (UAE), Egypt, and Morocco, with limited investment in other countries. The assertions by the researchers imply the need to encourage green financing in the MENA region to accelerate sustainable development.

Further assertions by Aassouli (2021) indicate that there have been recent developments in the MENA region, such as the introduction of green bonds, which are aligned with the facilitation of sustainable investments. However, the researcher indicates that the availability of green projects is still considerably limited in the MENA region. Similarly, according to Nfaoui and Sayigh (2020), the limited investments in green projects in the MENA region can be attributed to cultural factors that still prefer traditional investments, such as real estate and gold which are perceived as more stable investments. In other words, the assertions by the researchers point to the need to improve awareness and create enabling environments to promote green financing. Generally, concerted efforts are necessary to encourage the adoption of sustainable financing projects through leveraging green financing by promoting factors that will enhance awareness, creating preference for such funding.

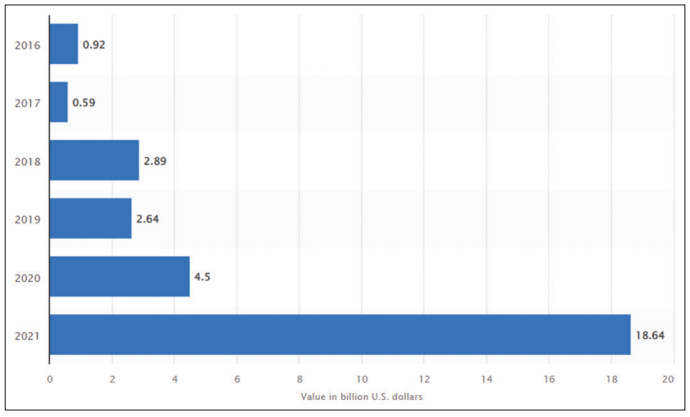
2.2. Green Finance and Sustainable Development in the MENA Region

Various successful green finance projects in the MENA region have been achieved through green financing. For example, according to the study by Nfaoui and Sayigh (2020), the Moroccan Agency for Solar Energy has applied green bonds through which funds have been successfully raised to fund the Noor-Ouarzazate solar power plant with a capacity of 580MW, considered one of the largest solar power plants globally. Through the project, Morocco has made significant strides toward achieving the goal of generating 52% of its power from renewable sources (Nfaoui and Sayigh, 2020). In addition, according to Koch (2022), Masdar City in Abu Dhabi is a crucial sustainable urban development financed through green financing. The project is aimed at achieving a zero-waste and carbon-neutral community (Koch, 2022). The project presents significant growth in sustainable development in the region by reducing overreliance on oil, thus reducing greenhouse gas emissions and decelerating global warming. The studies imply a considerable level of green finance adoption in the MENA region, with an observed increase in adopting sustainable development projects.

Further views given by Ibrahiem and Sameh (2022) have pointed out that green finance has played a significant role in sustainable development in Egypt. According to the researchers, by September 2020, Egypt had $750 million listed in sovereign green bonds on the London Stock Exchange, which was five times oversubscribed. The result was an observed robust investment in renewable energy in the country. Overall, investments such as the sovereign green bonds issued in Egypt have led to a surge in green financing in the MENA region by 38% by the first half of 2021 (Ibrahiem and Sameh, 2022). The assertions imply that green financing in the MENA region has been crucial in achieving sustainable development, with indications pointing to a growing trend. However, there are inconsistent views on the actual influence of green financing on sustainable development in the MENA region. Rasoulinezhad and Taghizadeh-Hesary (2022) argued that green finance in the MENA region is still in its early stages, with the region still lagging in terms of adoption as compared to other areas, such as Europe. The assertions imply that the lack of a comprehensive regulatory framework in the MENA region still limits the influence of green financing on sustainable development.

The observations from the literature reviewed imply that despite being a novel strategy, green financing in the MENA region has achieved considerable progress toward influencing sustainable development. For example, the trend can be observed in Figure 1 below, indicating an increase in green finance adoption, thus pointing to the continued trend of green finance in promoting accelerated sustainable development. The figure indicates

Figure 1: Trends in green and sustainable finance in the MENA region (Ibrahiem and Sameh, 2022)



a growing trend of sustainable finance in the region. The trend implies the ability of the area to achieve its sustainable development goals and economic diversification if the trend is sustained and increased progressively.

2.3. Factors Affecting the Adoption of Green Finance in the MENA Region

Various factors that affect the adoption of green finance in the MENA region have attracted the attention of multiple researchers. One of the factors has been identified to be regulatory frameworks. According to Moneer (2023), among the intricacies of green finance in the MENA region is the lack of a clear regulatory framework which has led to a relatively low adoption. Specifically, the researcher asserts that frameworks for disclosure and transparency, which aid in risk assessment and improved strategic planning of green investments, are still weak in countries like Bahrain, Oman, and Iraq which have limited the uptake of green financing by investors. In addition, Griffin and Jaffe (2022) indicate that there is an underutilization of the Taskforce on Climate-related Financial Disclosures in the MENA region. As a result, the understanding of concentrations of carbon-related assets in the financial sector and the exposure of economic systems to climate-related risks limits green finance uptakes. However, there are instances such as UAE, Morocco, and Jordan where policies and regulations such as feed-in-tariffs, incentives, and net metering have been introduced, which have promoted the uptake of green financing (Griffin and Jaffe, 2022). The views from the studies suggest that there is still a considerable need to improve regulations in the MENA region. The improved regulatory framework will enhance understanding of green financing and enable investors to make informed decisions, hence improving the uptake of the concept.

Some researchers have explored the influence of financial systems as a factor influencing green finance adoption in the MENA region. Ren et al. (2020) have noted that the presence of financial systems such as green bonds in the MENA region promotes the adoption of green finance, hence accelerating its uptake. Generally, the researchers' assertions suggest an effective financial design that promotes green financing is a crucial contributor toward the positive uptake of green finance. The trend is likely due to the influence of such financial systems in promoting an understanding of green finance, hence improving uptake. However, according to Elhoushy and Lanzini (2021), the lack of specialized financial institutions in the MENA region that can support green investments still limits the creation of suitable financial systems, hence green finance adoption. Each country in the MENA region has specific financial systems that can be developed further to promote the adoption of green financing initiatives. The factors specific to each country are as detailed in Figure 2 below. Figure 2 indicates the necessary investments per country, thereby revealing the unique needs of various MENA countries toward improving the adoption of green financing.

2.4. Impact of Green Finance on Environmental Degradation

The use of green finance has been noted to reduce environmental degradation. Chin et al. (2022) revealed a significant and negative relationship between green finance and environmental degradation. The authors noticed that allocating higher green finance reduced the deterioration of environmental quality by minimizing pollution. The study recommended several incentives, including reduction of corporate tax, subsidizing interest rates on green loans, and creating a green credit guarantee scheme to promote green financing and promote sustainability. Additionally, Ayad et al. (2023) showed that economic development that failed to monitor energy consumption was disastrous to the environment. The authors recommended that MENA countries finance renewable energies to reduce the rate of environmental degradation. The findings implied that green finance was essential for environmental and economic development sustainability. Similarly, Ibrahim and Vo (2021) acknowledged that failure to focus financial development toward clean energy consumption resulted into increased level of greenhouse gases, especially in the event of increased manufacturing activities. Therefore, a positive relationship was noted between financing green energy and environmental conservation which was a leading path to sustainable innovation. Essentially, the three studies concur on the point that green finance in MENA countries is a tool for reducing and preventing environmental degradation. Saadaoui (2022) noted that financial development on renewable energy development was responsible for decarbonization of the energy sector and economy, hence cleaner environment in MENA region. The finding proved that the structure of financial development must be inclined toward green practices to save the environment from degradation. Furthermore, Zhang et al. (2021) found out that green finance was the major mediating factor green economic growth and public spending. Specifically, the research revealed that research on green energy technologies financed by public funds contributed to sustainable green economy. The trend translates to reduction in environmental degradation to a significant scale. Consequently, green finance plays a key role in facilitating and promoting environmental sustainability for MENA countries.

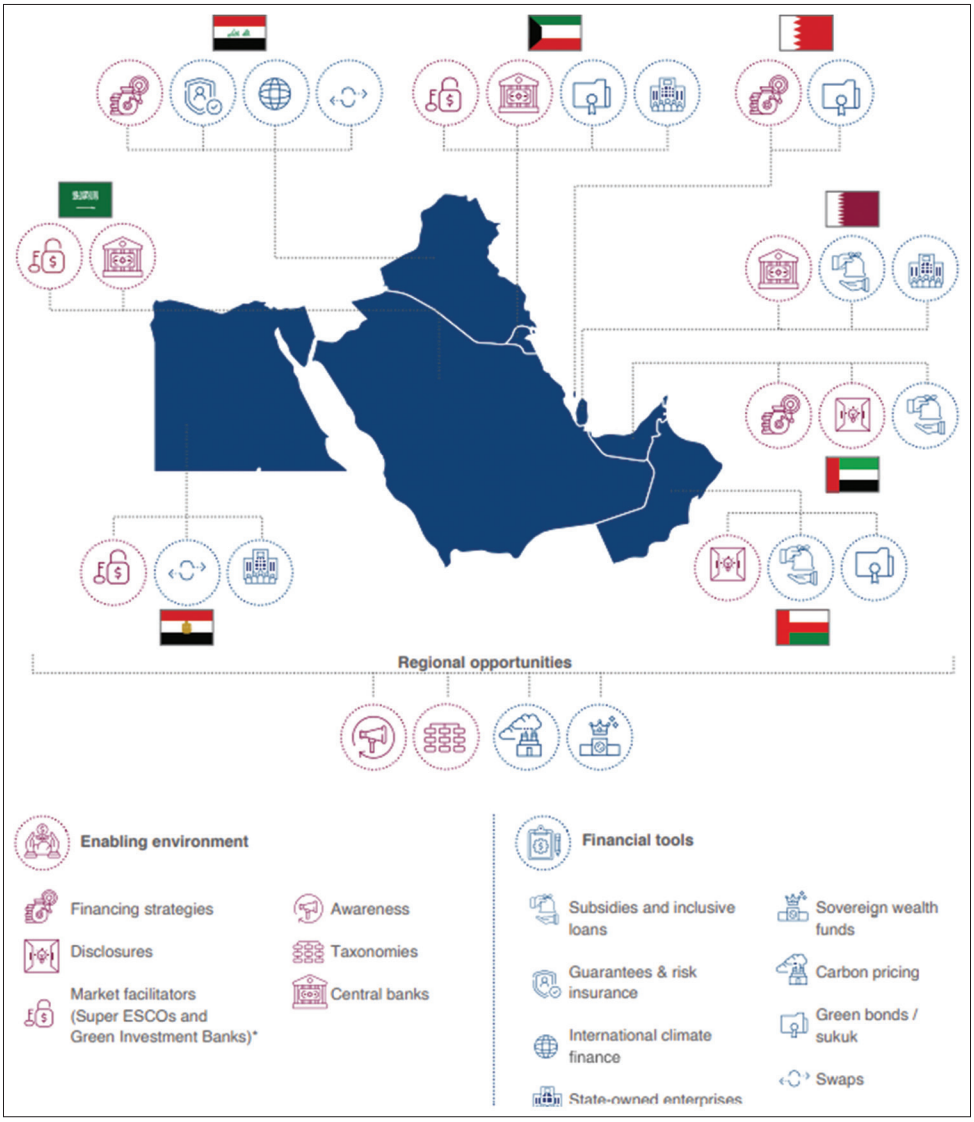
3. METHODOLOGY AND RESULTS

3.1. Variables Description and Statistical Analysis

3.1.1. Variables Description

In the current study, the researchers have meticulously measured and precisely identified the variables that signify the factors influencing financial development, investment inflows, and Institutional frameworks. It is anticipated that these variables will exert substantial influences on environmental sustainability in the MENA region. Data was collected from a group of nine countries in the MENA region; Egypt- Saudi Arabia- Jordon- Lebanon- Israel- Turkey- Qatar- Algeria- and UAE, with the dataset covering the period from 1999 to 2021. The dataset includes various metrics of environmental deterioration and financial development, as well as a thorough set of control variables to account for cofounding influences. The assessment of Environmental deterioration involves the utilization of four indicators: CO_2 emissions, the exhaustion of Natural Resources, greenhouse gas emissions, and energy consumption. Financial development is measured using credit to the private sector, and FDI. The model controls for a set of variables: gross domestic product, governance standards and effectiveness, technology (mobile cellular subscriptions), population, urbanization, and education. All variables are listed comprehensively in Table 1.

Figure 2: Regional and national recommendations for green financing adoption in the MENA region (Beyer and Bayoumi, 2022)



3.1.2. The Descriptive Analysis

Prior to the provision of the detailed methodology and analysis, an overview of the statistical findings are provided in Table 2. An overview of the Statistical Measurements is provided to illustrate the descriptive analysis of the set of independent variables.

3.2. Stationarity Tests

One method that could be provided to test non-stationarity is performing the Panel Unit Root Test, with the utilization of the provided tests in Table 3:

As shown in Table 3 the variables incorporated in the study exhibit non-stationarity in the original form according to most tests. Consequently, it was necessary to take the first differences in order to transform them in the stationary form. The findings resulted in the rejection of the null hypothesis in favor of the alternative hypothesis, affirming that the time series of the variables incorporated in the study are stationary after running the test with the first differences. Conversely, the opposite will be convenient for the Hadri Test.

The incorporation of the unit root test in this study can be supported by Lee and Strazicich's (2013) description of the test as a tool for identifying a stochastic trend that reveals an unpredictable systematic pattern. The fundamental test is essential in validating or invalidating the existence of stationarity. Additionally, Enders and Lee (2012) emphasize that although running arguments about the effectiveness of unit root tests, the prevailing consensus is that the majority of such series exhibit non-stationarity. Consequently, this measurement plays a significant role in macroeconomic analysis by influencing the correlation outcomes among the variables under investigation in this study. In essence, the economic metric primarily assesses changes in the variance and the mean across time.

Pesaran's (2012) discovered that a time series is deemed stationary when the statistical characteristics remain consistent across time. This identification is valuable as it enables the study to pinpoint the source of non-stationarity. To accurately assess correlations, data generation must involve a random normal sample. Essentially, the unit root test plays a pivotal role in enhancing the understanding of

Table 1: The dependent, explanatory, and control variables incorporated in the utilized econometric models

Variable	The variable term	Source
$LNCOE_{it}$	Natural Logarithm of Carbon dioxide emissions	World Bank
NRD_{it}	Natural Resource Depletion (%GNI)	World Bank
$LNGHGE_{it}$	Natural Logarithm of Greenhouse gas emissions per capita	Climate watch Data
$LNEUPP_{it}$	Natural Logarithm of Energy Use	International Energy Agency
Independent (Explanatory) variables		
Financial Development Indicators		
$PCGDP_{it}$	The percentage of private sector credit to GDP (%)	World Bank
$FDINI_{it}$	FDI, net inflows (%of GDP)	World Bank
Control variables		
$GDPPC_{it}$	GDP per capita (In Current US$) in thousands	World Bank
GEI_{it}	Government effectiveness Index	Our World in Data
$MPCS_{it}$	Mobile Cellular Subscriptions (per 100 people) (Technology)	Our World in Data
$LNPOP_{it}$	Natural Logarithm of Population size in million	Our World in Data
$UPPT_{it}$	Urban population (% of total Population)	World Bank
$SEPG_{it}$	School Enrollment, Secondary (%gross)	World Bank

Table 2: Utilizing various statistical metrics to demonstrate the descriptive analysis of the independent variables in various countries

Variables	Descriptive statistics					Range
	Mean	Median	Standard deviation	Maximum	Minimum	
$LNCOE_{it}$	11.45	11.50	1.04	13.28	9.59	3.69
NRD_{it}	5.82	3.90	6.84	33.50	0.00	33.50
$LNGHGE_{it}$	11.74	12.00	1.06	13.51	9.85	3.67
$LNEUPP_{it}$	10.37	9.81	1.10	12.48	8.95	3.53
$PCGDP_{it}$	53.85	54.66	26.52	140.00	5.40	134.60
$FDINI_{it}$	3.45	2.30	3.70	23.50	−1.70	24.7
$GDPPC_{it}$	19445.84	8989.50	21498.59	98041.00	1016.30	97024.70
GEI_{it}	0.26	0.10	0.68	2.26	−1.16	3.42
$MPCS_{it}$	87.55	92.00	51.09	221.00	0.00	221.00
$LNPOP_{it}$	16.44	16.07	1.32	18.51	13.25	5.26
$UPPT_{it}$	77.07	83.00	17.75	99.00	43.00	56.00
$SEPG_{it}$	90.05	91.00	14.75	116.30	49.00	67.3

Variable	Descriptive statistics				
	Skewness	Kurtosis	Jarque-Bera	Prob.	Comments
$LNCOE_{it}$	−0.17	1.91	11.29	0.00	Normal Skewness: 0 and platykurtic, with rejection of normal distribution.
NRD_{it}	1.14	3.73	49.77	0.00	Positive Skewness and Leptokurtic, with rejection of normal distribution.
$LNGHGE_{it}$	−0.27	1.86	13.76	0.00	Normal Skewness: 0 and platykurtic, with rejection of normal distribution.
$LNEUPP_{it}$	0.58	1.80	23.93	0.00	Normal Skewness: 0 and platykurtic, with rejection of normal distribution.
$PCGDP_{it}$	0.28	2.70	3.48	0.18*	Normal Skewness: 0 and platykurtic, with acceptance of normal distribution.
$FDINI_{it}$	1.92	8.02	344.39	0.00	Positive Skewness, and Leptokurtic, with rejection of normal distribution.
$GDPPC_{it}$	1.54	5.02	116.99	0.00	Positive Skewness and Leptokurtic, with rejection of normal distribution.
GEI_{it}	0.48	2.19	13.50	0.00	Normal Skewness: 0 and platykurtic, with rejection of normal distribution.
$MPCS_{it}$	0.20	2.68	2.22	0.33*	Normal Skewness: 0 and platykurtic, with acceptance of normal distribution.
$LNPOP_{it}$	−0.17	2.21	9.39	0.04	Normal Skewness: 0 and platykurtic with rejection of normal distribution.
$UPPT_{it}$	−0.84	2.37	27.74	0.00	Normal Skewness: 0 and platykurtic with rejection of normal distribution.
$SEPG_{it}$	−0.40	2.40	8.61	0.013***	Normal Skewness: 0 and platykurtic. The existence of a prob. value that is >10% would result in accepting the hypothesis of normality distribution.

*, **, and ***indicate significance at α=1%, 5%, and 10% respectively

the determinants' financial performance. Furthermore, according to Hadri and Kurozumi' (2012), the stationarity test serves as a significant tool utilized by researchers to validate or invalidate the hypotheses of the study. To achieve this, a higher test statistic value should surpass the specified critical values. Hence, it serves as an essential measure in achieving the research objectives.

3.3. The Methodology

Four Pooled OLS- Panel Regression Analysis - have been conducted for assessing the impact of financial development and institutional quality on the environmental deterioration- through its four proxies- in the MENA region.

$$LNCOE_{it} = \beta_0 + \beta_1 PCGDP_{it} + \beta_2 FDINI_{it} + \beta_3 GDPPC_{it} + \beta_4 GEI_{it} + \beta_5 MPCS_{it} + \beta_6 LNPOP_{it} + \beta_7 UPPT_{it} + \beta_8 SEPG_{it} + \varepsilon_{it} \quad (1)$$

$$NRD_{it} = \beta_0 + \beta_1 PCGDP_{it} + \beta_2 FDINI_{it} + \beta_3 GDPPC_{it} + \beta_4 GEI_{it} + \beta_5 MPCS_{it} + \beta_6 LNPOP_{it} + \beta_7 UPPT_{it} + \beta_8 SEPG_{it} + \varepsilon_{it} \quad (2)$$

$$LNGHGE_{it} = \beta_0 + \beta_1 PCGDP_{it} + \beta_2 FDINI_{it} + \beta_3 GDPPC_{it} + \beta_4 GEI_{it} + \beta_5 MPCS_{it} + \beta_6 POP_{it} + \beta_7 UPPT_{it} + \beta_8 SEPG_{it} + \varepsilon_{it} \quad (3)$$

$$LNEUPP_{it} = \beta_0 + \beta_1 PCGDP_{it} + \beta_2 FDINI_{it} + \beta_3 GDPPC_{it} + \beta_4 GEI_{it} + \beta_5 MPCS_{it} + \beta_6 LNPOP_{it} + \beta_7 UPPT_{it} + \beta_8 SEPG_{it} + \varepsilon_{it} \quad (4)$$

Table 3: An overview of the panel unit root tests

Variables	Levin, Lin and Chu- test				Im, Pesaran and Shin- test				ADF-Fisher- test			
	Level		Diff		Level		Diff		Level		Diff	
LNCOE	C	−4.92	C	−9.45	C	−1.78	C	−8.41***	C	27.45	C	103.38**
LNCOE	C, t	0.28	C, t	−10.40*	C, t	0.89	C, t	−9.14*	C, t	19.22	C, t	100.45*
NRD	C	−1.86	C	−11.41***	C	−1.24	C	−10.68*	C	20.09	C	*117.68
NRD	C, t	−3.63	C, t	−7.97	C, t	−1.04	C, t	−8.41*	C, t	18.45	C, t	*86.56
LNGHGE	C	−3.96	C	−6.73	C	−1.95	C	−4.86***	C	34.13	C	***96.58
LNGHGE	C, t	3.91	C, t	−8.24	C, t	4.89	C, t	−7.92*	C, t	27.08	C, t	**119.56
LNEUPP	C	−2.57	C	−7.44	C	−1.56	C	−7.74**	C	28.29	C	**88.36
LNEUPP	C, t	0.22	C, t	−5.04*	C, t	−0.64	C, t	−6.11*	C, t	27.62	C, t	**65.64
PCGDP	C	−0.8	C	−9.93*	c	2.84	C	−8.48*	c	8.55	C	97.25*
PCGDP	C, t	0.78	C, t	−8.89*	C, t	−0.18	C, t	−7.14*	C, t	22.43	C, t	77.47*
FDINI	C	−3.09	C	−8.43	C	−4.31	C	−9.54	C	57.7	C	110.27
FDINI	C, t	−3.69	C, t	−6.59	C, t	−4.18	C, t	−8.01	C, t	49.59	C, t	84.43
GDPPC	C	−0.8	C	−10.21*	C	−0.19	C	−8.75*	C	24.52	C	*99.93
GDPPC	C, t	−0.29	C, t	−9.18*	C, t	0.8	C, t	−7.53*	C, t	18.62	C, t	*79.58
GEI	C	−1.29	C	−11.63**	C	−3.79	C	−11.91	C	50.2	C	140.21
GEI	C, t	−1.03	C, t	−10.74*	C, t	−3.54	C, t	−11.42	C, t	42.83	C, t	119.5
MPCS	C	−4.49	C	−3.76	C	−2.23	C	−4.27***	C	31.45	C	52.15**
MPCS	C, t	0.42	C, t	−3.03*	C, t	3.34	C, t	−4.29*	C, t	5.92	C, t	*52.99
LNPOP	C	-2.89	C	2.45	C	−2.48	C	−0.0.9	C	40.24	C	26.75***
LNPOP	C, t	3.64	C, t	−5.04*	C, t	3.01	C, t	−0.59	C, t	30.97	C, t	45.41***
UPPT	C	−2.24	C	−9.27***	C	1.52	C	−13.87*	C	8	C	133.01*
UPPT	C, t	−3.27	C, t	−4.62	C, t	−6.43	C, t	−11.51	C, t	69.03	C, t	118.73
SEPG	C	−1.48	C	−7.15**	C	−0.49	C	−7.84*	C	19.76	C	90.51*
SEPG	C, t	−0.64	C, t	−6.59*	C, t	−1.62	C, t	−6.78***	C, t	29.99	C, t	72.87**

*, **, and *** indicate that the variable is stationary at α=1%, 5%, and 10% respectively. (c) is referring to Individual Intercept and (c, t) is referring to Individual intercept beside the trend

3.4. The Regression Outcomes:

3.4.1. Interpretation of the first regression equation results ($LNCOE_{it}$)

As shown in Table 4 that carbon dioxide emissions (*LNCOE*) have a highly significant inverse relationship with both private sector credit (*PCGDP*) and foreign direct investment (*FDINI*). This suggests that increased financial development and investment inflows are associated with reduced carbon emissions, possibly reflecting the role of finance in supporting cleaner production processes and improved environmental standards.

However, the relationship between carbon emissions and institutional quality is found to be statistically insignificant. This highlights a critical policy implication for the MENA region: the need to strengthen institutional frameworks and environmental governance to more effectively implement green initiatives that could translate financial gains into tangible environmental improvements.

In addition, the findings indicate that urbanization (*UPPT*) and population growth (*LNPOP*) are both positively and significantly associated with increased carbon emissions. These results are consistent with the positive relationship observed between economic growth (*GDPPC*) and emissions—likely due to the energy-intensive nature of growth in the region, which often relies on fossil fuels.

A significant direct relationship is also found between carbon emissions and technology use (MPCS). This suggests that current technological practices may still be contributing to environmental harm. To counter this, MENA countries are encouraged to adopt green and environmentally friendly technologies, which can enhance energy efficiency, reduce emissions, and limit ecological degradation. Innovations in green technology—ranging from clean energy to eco-efficient industrial processes—can significantly mitigate the environmental impact of growth and industrialization in the region.

Lastly, the positive association between secondary school enrollment and carbon emissions reveals a potential disconnect between educational attainment and environmental awareness. This underscores the importance of not only increasing access to education but also integrating climate literacy, sustainability education, and environmental stewardship into curricula. Doing so can empower future generations to contribute meaningfully to addressing environmental challenges.

3.4.2. Interpretation of the second regression equation results (NRD_{it})

The results for natural resource depletion (*NRD*) reveal a pattern that differs from carbon emissions in certain aspects. Notably, institutional quality demonstrates a strong and statistically significant inverse relationship with *NRD* at the 1% level, suggesting that effective institutions play a pivotal role in mitigating the depletion of natural resources. This supports the view that robust environmental governance can constrain unsustainable exploitation and promote policy enforcement, thereby enhancing long-term ecological preservation.

Similar to carbon emissions, NRD also shows a significant inverse relationship with the financial development indicators—private credit (PCGDP) and foreign direct investment (FDINI). This

Table 4: The regression outcomes

Variables	(1)	(2)	(3)	(4)
	$LNCOE_{it}$	NRD_{it}	$LNGHGE_{it}$	$LNEUPP_{it}$
$PCGDP_{it}$	−0.004984* (0.001689)	−0.128515* (0.016583)	−0.007095* (0.001700)	−0.005790* (0.001900)
$FDINI_{it}$	−0.041586* (0.098898)	−0.240173** (0.097534)	−0.044955* (0.009997)	−0.048632* (0.011176)
$GDPPC_{it}$	1.57E-05* (2.55E-06)	7.72E-05* (2.50E-05)	1.38E-05* (2.56E-06)	2.01E-05* (2.86E-06)
GEI_{it}	−0.057160 (0.076934)	−4.828408* (0.755255)	−0.070318 (0.077411)	−0.058084 (0.086540)
$MPCS_{it}$	0.001650*** (0.000891)	0.030354* (0.008742)	0.002508* (0.000896)	0.002607** (0.001002)
$LNPOP_{it}$	0.719981* (0.048143)	−3.710371* (0.472622)	0.620460* (0.048442)	−0.281101* (0.054155)
$UPPT_{it}$	0.013058* (0.003745)	−0.153544* (0.036763)	0.004686 (0.003768)	0.012914* (0.004212)
$SEPG_{it}$	0.016026* (0.002719)	0.071186* (0.026924)	0.015405* (0.002736)	0.016843* (0.003059)
No. of Observations		207		
R^2	0.822	0.600	0.824	0.798

*, ** and *** indicate that the variable is significant at α=1%, 5%, and 10% respectively

indicates that financial flows, when guided by appropriate policy frameworks, can contribute to more responsible resource use and sustainable investment practices.

Conversely, NRD exhibits a positive and significant association with both economic growth (GDPPC) and technology use (MPCS). This implies that while growth and technological advancement may boost productivity, they may also accelerate resource depletion unless accompanied by a shift toward green and energy-efficient technologies. These findings reinforce the need for MENA countries to invest in eco-friendly technological solutions that balance development with sustainability goals.

Interestingly, population size (LNPOP) is negatively associated with NRD. This may reflect the demographic distribution in many MENA countries, where a large share of the population resides in rural areas with relatively lower resource-intensive activities. Furthermore, urbanization (UPPT) also shows an inverse relationship with NRD, which may suggest that in certain MENA countries, urban development is being guided—at least partially—by greener urban planning policies aimed at conserving natural resources.

Together, these results highlight the multifaceted nature of natural resource depletion in the MENA region and underscore the importance of institutional strength, financial development, and green technology in promoting sustainable resource management.

3.4.3. Interpretation of the third regression equation results (LNGHGE)

Greenhouse gas emissions (*GHG*) exhibit a highly significant inverse relationship with financial development (*PCGDP*) and a significant inverse relationship with foreign direct investment (*FDINI*). These findings suggest that increased credit to the private sector and higher investment inflows may be associated with lower levels of *GHG* emissions, aligning with the patterns observed for carbon dioxide emissions in the first model. This may indicate that financial resources, when mobilized under suitable conditions, can contribute to more environmentally conscious production processes and investment in cleaner technologies.

3.4.4. Interpretation of the fourth regression equation results (LNEUPP)

The results for energy use (*LNEUPP*) show a similar pattern of significance to that of natural resource depletion (*NRD*), with one notable exception: the relationship with institutional quality is not statistically significant. This finding underscores the need for stronger and more effective policy frameworks to regulate energy consumption and promote efficiency in the MENA region.

As expected, urbanization (*UPPT*) demonstrates a significant positive relationship with energy use. This aligns with the notion that urbanization is typically accompanied by industrialization and economic expansion, which increase the demand for energy to support production, infrastructure, and services.

Most importantly, both private sector credit (*PCGDP*) and foreign direct investment (*FDINI*) exhibit significant inverse relationships with energy use. This suggests that higher levels of financial development may contribute to more efficient or cleaner energy usage patterns, potentially through the adoption of energy-saving technologies or shifts toward less energy-intensive industries.

4. CONCLUSION AND LIMITATIONS AND FUTURE STUDIES

The findings of this study indicate that key environmental degradation indicators—carbon dioxide emissions (*LNCOE*), natural resource depletion (*NRD*), greenhouse gas emissions (*LNGHGE*), and energy use (*LNEUPP*)—are negatively and significantly associated with financial development indicators, namely private sector credit (*PCGDP*) and foreign direct investment (*FDINI*). These results suggest that greater financial development may be associated with improved environmental outcomes in the MENA region, potentially through increased investment in cleaner technologies or more efficient resource use.

While the study does not directly measure green finance, the inverse relationships observed between financial indicators and environmental degradation proxies may imply that financial flows—under the right institutional and policy conditions—can contribute to environmental sustainability. This supports the broader argument that aligning financial development strategies with environmental objectives can be a viable pathway toward sustainable development in MENA countries.

However, the study also has several limitations. First, there is a lack of comprehensive and disaggregated data on explicit green finance

instruments in the region, making it difficult to directly assess the scale or effectiveness of green financing efforts. Second, empirical research on the finance–environment nexus in MENA remains limited, and country-level heterogeneity in institutional capacity, culture, and environmental policy may affect the generalizability of the findings. Third, the study relies on proxy variables and assumptions that require further validation.

Future research should aim to integrate more direct measures of green finance, such as green bonds, ESG indices, or sector-specific investment flows, to enhance accuracy and policy relevance. Comparative studies across individual MENA countries could uncover how national contexts shape the effectiveness of financial development in promoting sustainability. Additionally, the role of international actors—such as development banks and multilateral agencies—should be examined to assess their contribution to mobilizing sustainable finance in the region.

Overall, the study contributes to a growing body of literature suggesting that financial development, when supported by appropriate institutional and policy frameworks, can serve as a lever for achieving environmental and economic sustainability in the MENA region.

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