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Impact of Income and Renewable Energy on Carbon Emissions: Evidence from Middle East Countries

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ABSTRACT

Most Middle East countries mainly depend on natural resources and energy sector is almost responsible for one-third of its environmental degradation. Most Middle East countries are going for greener energy and at the same time maintaining their economic growth. Henceforth, this study examines the effects of income and renewable energy on degradation of environment. Furthermore, total natural rent, trade openness, and urbanization are control variables in this panel study. The main aim of the study is to investigate in the Middle East the influence of several elements like total natural resource rents, urbanization, trade openness, and renewable energy and income on CO2 emissions. Panel techniques and tests such as cross-sectional dependency, panel unit root test, Westerlund panel cointegration test and FMOLS. This study finds that urbanization, trade openness, income, and total natural rent degrade environmental quality, whereas renewable energy improves environmental quality in Middle East Countries. It is recommended that policymakers incorporate environmental considerations into development plans. It is also recommended that Middle East countries enhance the share of renewable energy sources and improvement in natural resource management as most middle countries rely largely on natural resource revenues.

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1. Introduction

Global warming and climate change have been trendy recently. Human actions like burning fossil fuels and deforestation promote increased atmospheric greenhouse gases, specifically carbon dioxide (CO2). There's a strong chance that carbon emissions will negatively affect the Earth's climate (Begum, Raihan, & Said, 2020; Raihan, Begum, Mohd Said, & Abdullah, 2019). Climate change and sustainable development have become paramount globally, requiring decreased carbon emissions and improved environmental conditions

(Begum, Abdullah, & Sarkar, 2017; Raihan & Said, 2022). Nevertheless, the Middle East encounters distinct obstacles to environmental sustainability. The significant reliance on fossil fuels has led to increased emissions of greenhouse gases, which in turn has contributed to fluctuations in the global climate (Bank, 2021). Deforestation and water scarcity are just two of the many effects of global climate change (UNEP, 2019).

The Middle East was a source of energy consumption, in 2014 with nearly a quarter coming from this region as noted by the International Energy Agency in 2015 (Birol, 2017). Throughout the years the population and GDP of the Middle East region have grown substantially. Household energy usage saw an increase from 1971 to 2010 rising from 4% to 24% according to Farzaneh et al, in 2016. Countries like Iran, Kuwait Saudi Arabia and the UAE play a role in energy use due to their rising demands despite having fossil fuel reserves. However, some nations in the region still require assistance in managing their escalating energy needs effectively. Between 1980 and 2014 countries like Iran and Saudi Arabia witnessed a rise of around 62.5% in energy demand as reported by IEA in 2015. As per the World Banks findings in 2021 only a small portion (7%) of greenhouse gas can be attributed to the Middle East. It is crucial to acknowledge that a considerable share (38%) of these emissions stems from heat and electricity production within the region itself. Together Iran, Kuwait, Saudi Arabia and UAE contribute pointedly to emissions. Accounting for 60% and an even higher percentage (76%) specifically related to CO2 emissions, from electricity generation based on IEAs report in 2016.

Large oil and gas deposits in the Middle East, which make up roughly 48% of global reserves and 38% of natural gas reserves, have had a major impact on the region's economies (OPEC, 2020). Saudi Arabia, Iran, and the United Arab Emirates are just a few of the prominent players in this region that have increased their greenhouse gas emissions significantly. Saudi Arabia is ranked sixth in the world’s carbon emissions in 2021, according to the EIA. Based on estimations from the World Bank in 2021, the energy sector in the Middle East countries for nearly 38% of the region's emissions of greenhouse gases.

Previous researchers from different countries have focused severely on the influences causing to environmental degradation. Arouri, Youssef, M'henni, and Rault (2012) observed the impact of energy use and per capita income on CO2 emissions in countries located in the MENA region. A study conducted by Alkasasbeh, Alassuli, and Alzghoul (2023) studied the association among income, energy use, and emissions of carbon in Middle Eastern nations. There is a considerable gap in previous research when it comes to studying the correlation among the assumption of renewable resources-based energy and carbon emissions in Middle Eastern countries. Furthermore, it is worth mentioning that numerous nations in the Middle East possess significant reserves of natural resources. The development of these nations is greatly affected by trade openness and urbanization. Therefore, the main aim of the study is to investigate in the Middle East the influence of several elements like total natural resource rents, urbanization, trade openness, and renewable energy and income on CO2 emissions. Previous studies conducted by Gyamfi, Adedoyin, Bein, Bekun, and Agozie (2021); Khalid, Ul Haq, Khan, and Abbas (2022); Sun, Li, Andlib, and Genie (2022) who investigated these factors as noteworthy markers of carbon emissions have shaped the approach.

The current research article is ordered as follows: the next part provides a thorough analysis of important academic literature and earlier empirical research. A thorough kind of research methodology used in this study may be obtained in the third part. Section four of the research represents an inclusive analysis of the findings and subsequent discussion. At the end of the paper, the study's conclusion is summarized, and recommendations are offered.

2. Literature Review

Several previous studies have examined the influence of various factors on environmental degradation, specifically income, renewable resources-based energy usage, trade openness, total natural rent, and urbanization (Gasimli et al., 2022; Gyamfi et al., 2021; He, Xu, Shen, Long, & Chen, 2017; Kirikkaleli, Güngör, & Adebayo, 2022). Based on the existing academic literature, we have divided it into sections that examine how different variables influence the environment. The following sections are delineated as follows:

2.1. Income and Carbon Emissions

Prior research efforts have examined the complex association between economic performance, macroeconomic indicators, and environmental outcomes, following Grossman and Roberts and Grimes (1997) seminal research that raised the issue of environmental degradation as a major concern. These inquiries have primarily focused on the non-linear correlation linking income expansion and greenhouse gas emissions. In the initial phases of economic development, economies tend to switch from agricultural pursuits to industrialization, primarily emphasizing economic progress rather than environmental protection (Sadik-Zada & Gatto, 2023). In this stage, Dasgupta, Laplante, Wang, and Wheeler (2002) stress the value of economic expansion and employment creation over environmental concerns. This line of action, as per Grossman and Krueger (1991), results in the easing of trade and environmental regulations, which in turn causes economic growth, changes to the economic structure, and adjustments to industrial techniques—often at the price of the environment. The desire of individuals for better living conditions has made environmental quality more and more significant as nations have developed (Selden & Song, 1994). To minimize pollution, governments must enact environmental laws and support greener energy and technology (Arrow et al., 1995). Furthermore, putting research and development plans into practice can result in the replacement of ecologically hazardous technologies with less damaging options, which will greatly improve the environment (Komen, Gerking, & Folmer, 1997). As economies grow, different considers and compositional components can lead to environmentally positive effects (Miah, Masum, Koike, & Akther, 2011).

2.2. Renewable energy and carbon emissions

Numerous empirical studies have been carried out to investigate how well renewable energy sources can lower greenhouse gas emissions. Exploitation of renewable resources based energy and the decrease in carbon emissions are positively correlated, according to the empirical evidence that is at present accessible. In their study, Kirikkaleli et al. (2022) analyze the situation of Chile to give an illustration of this. Their study's inferences show a strong link linking cutting carbon emissions and using renewable energy sources. Examining countries in North Africa, Ben Jebli, Ben Youssef, and Ozturk (2015) got a short term, one-sided causal nexus among CO2 emissions and the implementation of renewable energy. Bilgili, Koçak, and Bulut (2016) found an inverse link among carbon releases and the utilization of renewable energy. Establishing a strong inverse link among Turkey's greenhouse gases emissions and the output of renewable energy, Bölük and Mert (2015) came to a long-term association.

2.3. Resource rent and Carbon emissions

The nexus among emissions of carbon and natural resource rents interests researchers. Many studies on both developed and underdeveloped nations have been conducted to investigate the link between economies Altinoz and Dogan (2021); Azra, Munir, Abbas, Khalid, and Ul Haq (2023); Badeeb, Lean, and Shahbaz (2020); Khan, Ju, Danish, Latif, and Khan (2021); Ulucak and Ozcan (2020); Umar, Ji, Kirikkaleli, Shahbaz, and Zhou (2020) found a noteworthy unidirectional causal association between carbon emissions in case of OECD countries and natural resource rents. Relatively consistent evidence of the link has come from

current investigations conducted over several countries and regions. Nwani and Adams (2021) examined the association among resources rent, energy intensity and emissions of carbon using data from 1995 to 2017 for 93 nations. And found the positive and significant association among natural rent and emissions of carbon in upper quality of governance countries and while inverse association among variables in case of lower quality of governance countries.

2.4. Trade openness and carbon emissions

Critics of trade liberalization have lately focused on how it affects greenhouse gas emissions. In 105 different nations, trade openness and environmental quality have a negative association, claims (Shahbaz, Nasreen, Ahmed, & Hammoudeh, 2017). In another Pakistani study, Khalid et al. (2022) got a negative correspondence among trade openness and emissions of carbon. In their most recent study, Ertugrul, Cetin, Seker, and Dogan (2016) analyzed the link among degradation of environment, trade openness, and energy use in several nations and noted variations in the effect of trade openness on CO2 emissions. Wang and Zhang (2021a) look at how trade openness affects CO2 emissions and finds that it lowers in upper-middle-income and high-income countries but not in lower-middle-income ones. It implies policy consequences to separate for various income levels decoupling CO2 emissions from economic growth.

2.5. Urbanization and Carbon Emissions

About urbanization and CO2 emissions, several empirical studies conducted over different historical eras and geographical areas have shown contradicting results. Wang, Liu, Zhou, Hu, and Ou (2017); Wang, Chen, and Kubota (2016) both assert that between urbanization and emissions there exist several relationships, both positive and negative as well as non-linear ones. Chen, Wang, and Li (2020) investigated how urbanization and CO2 emissions are linked in several Chinese provinces. He et al. (2017) investigated and found in many Chinese provinces an inverted U-shaped curvilinear relationship. Urbanisation in Turkey has reportedly caused environmental damage, according to (Katircioğlu & Katircioğlu, 2018). The effects of different economies, particularly industrialized economies on urbanization have not yet been well studied.

3. Theoretical Framework

This study's theoretical approach examines how the Middle easy countries' income and use of renewable energy affect their carbon emissions. Use of renewable resources-based energy is proposed as a way to mitigate environmental degradation by lowering carbon emissions through the auxiliary of fossil fuels with cleaner energy sources. Evidence that the countries have made large investments in renewable energy, supporting international efforts to lower carbon emissions, lends credence to this association (Sebri & Ben-Salha, 2014). The Environmental Kuznets Curve hypothesis, which contends that as income levels rise, carbon emissions first rise but eventually drop as economies shift toward cleaner technology and more efficient energy use, is also incorporated into the framework. But in developing nations such as the BRICS, where economic expansion frequently accompanies rising energy use and emissions, this relationship can be different (Grossman & Krueger, 1995).In order to improvement sustainable economic growth while limiting environmental impacts, the study intends to provide insights into how technical advancements and renewable energy efforts might be integrated into regulatory frameworks.

4. Methodology

4.1. Data

This study examines panel data for Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Turkey, and the United Arab Emirates using a panel data set that spans Middle Eastern nations between 2000 and 2020. adopting CO2 emissions, the consequences of adopting renewable energy sources, and economic growth, a thorough assessment of environmental degradation was carried out to determine the extent of the degradation. Several control variables, including trade openness, urban population, and natural rent, are included in this model. Table 1 provides a thorough summary of these variables.

Table 1
Description of the Variables

Variables	Symbol	Description	Source
Carbon emissions	CO2	Measured in metric tons per capita	WDI (2023)
GDP per capita	GDPP	Measured in constant 2015 US$	WDI (2023)
Renewable Energy Consumption	REC	Measured in % total energy consumption	WDI (2021)
Total Natural Resources Rent	TNR	Measured in % of GDP	WDI (2023)
Trade Openness	TR	Measured in % of GDP)	WDI (2023)
Urban Population	UR	Measured in % of total population	WDI (2021)

Prior to conducting unit root tests, the cross-sectional dependency (CD) is assessed. CD arises from factors like economic integration and residual interdependency. The Pesaran CD test is employed to determine the presence of CD. Addressing CD is crucial, as it impacts the reliability of unit root and cointegration results. The study applies unit root tests to panel data after CD assessment.

4.2. Panel Cointegration

To predict long-run values, panel cointegration of underlying variables is assessed. Traditional cointegration methods may yield inaccurate results in the presence of CD and heteroscedasticity. Based on a panel cointegration test proposed by Westerlund and Edgerton (2008), the present study takes into account CD, autocorrelation, and structural breakdowns in its analysis.

4.3. Long Run Analysis

Panel FMOLS tests are conducted to measure the impact of income and renewable energy consumption on CO2 in Middle East countries. The model used for the study is presented as follows:

$$lnCO_{2it} = \beta_{1i} + \beta_{2i} lnGDPP_{it} + \beta_{3i} lnTNR_{it} + \beta_{4i} lnTR_{it} + \beta_{5i} lnUR_{it} + \beta_{6i} lnREC_{it} \in_{it} \quad (1)$$

In equation 1, i shows cross-sectional parts, t shows time period and β_{1i}, β_{2i}, β_{3i}, β_{4i}, β_{5i}, β_{6i} $\in_{it}$ are intercept, slopes and error term respectively. Similarly, CO2 stands for Carbon Dioxide, GDPP for Gross Domestic Product per Capita, TNR for Total Natural Resource Rent, TR for Trade Openness, UR for Urban Population, and REC for Renewable Energy Consumption.

5. Results and Discussion

Descriptive statistics present several measures, such as the median, mean, maximum, minimum values, and standard deviation. Carbon dioxide emissions are typically measured in metric tons per capita. The mean value for carbon dioxide emissions is 12.64 USD, while the

median value is 7.53 USD. The maximum and smallest carbon emissions per capita values are 47.70 and 1.64 metric tons, respectively. The mean GDP per capita is $20,287.32, with a maximum value of $69,679.40 and a minimum of $1,981.83. The maximum value of total natural rent is 176.75% of GDP, while the least value is 30.25%. The average percentage of GDP attributed to trade openness is 83.31%, whereas urbanization accounts for an average of 78.78%.

Table 3 contains the correlation matrix, which provides a clear insight into and a generalized view of the dataset utilized in this study. The results indicated that CO2 is strongly correlated with GDPP and negatively correlated with renewable energy use. There is a mixed association between CO2 and the other variables. Matrix results indicate mixed correlations, though no strong correlations are observed. Natural resources and trade are also positively correlated with GDPP. Trade and urbanization are also positively correlated with total natural resources. Furthermore, renewable energy consumption negatively associated with GDPP, natural resources, trade, and urbanization.

Table 2:
Descriptive Statistics

	CO2	GDPP	TNR	TR	UR	REC	
Mean	12.64	20287.32	23.17	83.31	78.78	4.28	
Median	7.53	11935.39		23.44	86.12	81.20	1.53
Maximum	47.70	69679.40		66.69	176.75	100	23.08
Minimum	1.64	1981.83		0.01	30.25	42	0.01
Std. Dev.	11	20061.22		18.33	32	15.33	5.71

Author's calculations

Table 3
Correlation Matrix

Variable	CO2	GDPP	TNR	TR	UR	REC
CO2	1.00					
GDPP	0.96	1.00				
TNR	0.49	0.38	1.00			
TR	0.35	0.38	0.17	1.00		
UR	0.66	0.64	0.25	0.50	1.00	
REC	-0.30	-0.28	-0.25	-0.29	-0.33	1.00

Author's calculations

Table 4 shows the Cross-sectional dependence (CD)test results, which validate the CD presence in our data set. We accept the alternative hypothesis of the CD test that of CD which guides our study. This suggests that our data set features CD. This suggests that lnCO2, lnGDPP, lnTNR, lnTR, lnUR, and lnREC suffer from cross-sectional dependency.

Table 4
Cross Sectional Dependency

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	254.26	55.00	0.00
Pesaran scaled LM	17.95		0.00
Pesaran CD	-1.34		0.18

Author's Calculations

According to Table 5, a statistically significant cointegration is observed at a 1% significance level between many variables, including GDP per capita, total natural rent, renewable energy, trade openness, urbanization, and carbon emissions.

It is obvious from Table 6 that GDP per capita has a optimistic impact on carbon emissions. According to Hasnisah, Azlina, and Taib (2019), economic development firstly

causes an expansion in environmental degradation, including carbon emissions, consistent with the findings. According to a study conducted in Xinjiang, per capita income also positively affects carbon emissions Ziyuan et al. (2022). Given the high GDP per capita in many Middle East countries, it is crucial to focus on sustainable economic growth. Investments in green technologies and eco-friendly practices can help mitigate the influence of GDP growth on CO2 emissions.

Table 5
Westerlund Co integration Test

Statistics	Value	Z-value	P-value	Robust P-value
Gt	-2.93	-4.44	0.00*	0.00*
Ga	-13.95	-3.52	0.00*	0.00*
Pt	-11.44	-3.48	0.00*	0.00*
Pa	-13.66	-6.40	0.00*	0.00*

* shows the 1% significance level

Renewable energy use has negative and significant impact on carbon emissions. Studies are similar with (Mukhtarov, Aliyev, Aliyev, & Ajayi, 2022; Sharma, Tiwari, Erkut, & Mundi, 2021; Xiang, Chau, Iqbal, Irfan, & Dagar, 2022). Mukhtarov et al. (2022) found that Dropping carbon emissions depends critically on renewable energy. The Middle East has abundant solar and wind resources. A study published in December 2022 shows that renewable energy consumption can helps to greatly lower greenhouse gases. The results suggest that investing in renewable energy sources like solar and wind can be a highly effective policy for reducing carbon emissions, especially given the region's abundant natural resources.

Natural resources rent has a progressive effect on carbon emissions. Several studies found consistent results, including (Nathaniel, Yalçiner, & Bekun, 2021; Ulucak & Ozcan, 2020; Zafar, Saeed, Zaidi, & Waheed, 2021). Countries highly dependent on natural resources, according to Huang, Sadiq, and Chien (2021), generally show fast industrialization, urbanization, and economic development. Rising energy use increases carbon emissions, mostly from sources with carbon intensity like fossil fuels. The Middle East possesses a large wealth of natural resources, particularly oil and gas, whose use is usually connected to major emissions. The results suggest that stricter environmental regulations on the usage of natural resources will help to reduce the carbon footprint related with various activities.

Carbon emissions clearly and undeniably depend on trade openness. The outcomes match earlier research (Wang & Zhang, 2021b; Wenlong et al., 2023). Especially in the oil industry, Middle Eastern nations are quite important for world trade. Trade operations sometimes involve transportation and manufacturing procedures that can contribute to emissions, even if there is no direct proof tying trade openness to carbon emissions. Middle Eastern countries can help to lower the environmental effects of trade by implementing ecologically friendly trade regulations and supporting the commerce of sustainable products.

Table 6
Fully Modified OLS

Regressors	Coefficient	Std. Dev.	Prob.
logGDPP	0.75	0.05	0.00*
logREC	-0.04	0.01	0.00*
logTNR	0.09	0.02	0.00*
logTR	0.47	0.05	0.00*
logUR	0.50	0.27	0.06**

*, **shows the 1 and 5% level of significance

Trade openness clearly and certainly affects carbon emissions. The outcomes line with earlier research (Ge et al., 2022; Wang & Zhang, 2021a; Wenlong et al., 2023). Especially in the oil industry, Middle Eastern nations are very important for world trade. Trade operations

sometimes involve transportation and manufacturing procedures that can contribute to emissions, even if there is no direct proof connecting trade openness to carbon emissions. Middle Eastern countries can help to lessen the negative effects of trade by putting environmentally friendly trade regulations into effect and supporting the trade of sustainable products.

6. Conclusion and Recommendations

Climate change and sustainable development have become paramount globally, requiring decreased carbon emissions and improved environmental conditions. Nevertheless, the Middle East encounters distinct obstacles to environmental sustainability. The significant reliance on fossil fuels has led to increased emissions of greenhouse gases, which in turn has contributed to fluctuations in the global climate. Deforestation and water scarcity are just two of the many effects of global climate change. Large oil and gas deposits in the Middle East, which have a huge reserve of oil and natural gas reserves, have had a major impact on the region's economies. Saudi Arabia, Iran, and the United Arab Emirates are just a few of the prominent players in this region that have increased their greenhouse gas emissions significantly. This paper looks at several elements' influence on Middle Eastern countries' carbon emissions. It looks at how income, consumption of renewable energy, overall natural rent, urbanization, and trade openness relate to one other. This study investigates, from 2000 to 2020, the link between carbon emissions and several variables using panel data analysis in Middle East nations. he main goal of this study is to investigate in the Middle East the influence of several elements like total natural resource rents, urbanization, trade openness, and renewable resources-based energy and income on carbon emissions. The study considers GDP per capita, renewable energy sources, total natural rent, trade openness, and urban population as independent variables. Confirming the presence of CD is necessary before conducting the unit root test. The Westerlund panel cointegration test was utilized in this investigation. Fully dynamic OLS is used in this study's long-term outcomes. To analyze the unit root problem, this study used CADF and CIPS. The study confirms cross-sectional dependence and utilizes Westerlund panel cointegration tests. The results shows that while renewable energy consumption negatively influences carbon emissions, GDP per capita income, total natural rent, trade openness, and urbanization have favorable and significant impacts.

Analyzing the environmental consequences of different economic and developmental indices in the Middle East reveals that, although economic growth—shown by GDP per capita—leads to rising carbon emissions; hence, there is a clear need to turn toward sustainable practices. The region's plenty of solar and wind resources offers a tremendous opportunity to buck this trend. Utilization of renewable energy has shown a good linkage with lowered carbon emissions. Still, the Middle East's significant participation in world trade—especially in the oil sector—along with its great reliance on natural resource rents—especially from oil and gas—raise its carbon footprint. Furthermore, although a symbol of development, the fast-paced urbanization trend causes environmental problems due of increased energy and waste management needs. These results imply that the Middle East ought to give sustainable economic development top priority by large investments in solar and wind energy sources. More strict rules on the utilization of natural resources will help to reduce the negative consequences for the surroundings. Furthermore, greatly reducing the carbon emissions in the area can be achieved by supporting and implementing sustainable trade policies. Furthermore, sustainability should be included in urban design; particular focus should go to the building of green areas and effective transportation. Following these recommendations will help the Middle East to create a harmonic mix of environmental awareness and economic development, acting as a model for other countries all around.

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Omar Ahmed Abdulraqeb: Writing Original Draft, Methodology, Literature Reviewing & Editing, Data Analysis & Interpretations.
Cao Erbao: Supervision and Conceptualization.
Abdullah Aloqab: Literature Reviewing,Data Curation, Methodology , Visualization ,Review and Editing.
Al-Dakhli Abdullah: Revising the Draft & Editing

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