Tourism, Economic Growth, and Carbon Dioxide Emissions: Granger Evidence across Ten MENA Countries for a Sustainable Tomorrow

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Abstract *- Tourism serves a dual function in the Middle East and North Africa (MENA) area, functioning as a catalyst for economic expansion while also increasing environmental challenges through increased carbon emissions. This region is still understudied in the relationship between tourism, economic growth, and environmental factors. The objective of this paper is to investigate the causal linkages between international tourist arrivals, per capita gross domestic product, and carbon dioxide emissions in MENA countries. The study encompasses ten MENA countries over the period 2010 to 2023, selected based on data availability. The Granger Causality test is used to indicate the direction and nature of causation of different variables. The findings reveal three distinct patterns in MENA countries: bidirectional relationships, unidirectional causation from one variable to another, and no causation relationship exists among international tourist arrivals, per capita gross domestic product, and carbon dioxide emissions. These variances are due to different economic structures, environmental challenges, and policy regimes in the countries. The evidence suggests regionally specific strategies (such as green infrastructure, clean energy technologies, and policies to protect the environment) are required to build sustainability in tourism development and achieve the Sustainable Development Goals (SDGs).*

Keywords: Carbon Dioxide Emissions, Granger causality, International Tourist Arrivals, Per Capita Gross Domestic Product, Sustainable Development.

I. INTRODUCTION

Tourism is one of the fastest growing industries around the world with an impressive contribution to economic growth, job creation, and infrastructure (Sequeira & Maçãs, 2008; World Travel & Tourism Council, 2025). At the same time, it is also linked to broader environmental issues, such as transport emissions, energy consumption, and large-scale infrastructure, which are all contributing to carbon dioxide emissions (CO_2) (Chowdhury et al., 2024; Lenzen et al., 2018). As a result, finding a balance between the economic advantages of tourism and its environmental impact has become a crucial challenge for sustainable development.

In Middle East and North Africa (MENA) nations, tourism offers both opportunities and challenges. Historically dependent on oil and gas revenues, many MENA economies are now looking to tourism as a vital sector for diversification and long-term development (Luciani & Moerenhout, 2019; Times Aerospace). Prior to the COVID-19 pandemic, international tourist arrivals in the MENA region had a steady increase; yet the industry has also increased CO_2 emissions from energy-consuming hotels, air travel, and carbon-intensive infrastructure (Al-Mulali & Ozturk, 2015; Geoffrey & Kollwitz, 2024). As with other regions with heavy reliance on tourism such as Small Island Developing States , Southeast Asia, and Southern Europe (Prakash, 2018; Seetanah & Fauzel, 2018; Waaje et al., 2025), the MENA region stands out with its high tourism activity and extreme climate vulnerability (Abdouli & Hammami, 2017; Ben Cheikh et al., 2021; Gorus & Aydin, 2019), making it a compelling case for studying the causal relationships among tourism, economic growth, and environmental outcomes in MENA region.

Even with a global focus on sustainable tourism, limited empirical studies have investigated the connections between tourism, growth, and the environment in the MENA region. Knowing about these relationships is essential because a lot of these countries are going through the process of changing their economies from oil-dependent ones to diversified ones where tourism is the main contributor. The importance of this research is the offering of region-specific causal proof that adds to theoretical understanding of the tourism–environment–growth nexus and applied policy planning for sustainable development appropriate to the particular economic and environmental circumstances of MENA.

Given this context, it is important to understand how tourism, economic growth, and environmental outcomes are intertwined within the MENA region. To address this, the paper analyzed ten countries within the MENA region - Egypt, Iran, Israel, Jordan, Lebanon, Oman, Saudi Arabia, Algeria, Morocco, and Tunisia. The rationale for including these ten countries was based on credible data availability from 2010-2023. The study employs the Granger causality test for verifying patterns of bidirectional, unidirectional, or non-causality among international tourist arrivals, per capita gross domestic product (PGDP), and CO_2 emissions. Thus, the study can help policymakers make informed choices about sustainable tourism policies, such as implementing green infrastructure policies, renewable energy, or low-carbon development strategies that align with the Sustainable Development Goals (SDGs).

II. LITERATURE REVIEW

A. Theoretical framework

Guided by the Environmental Kuznets Curve (EKC) and Tourism-led Growth Hypothesis (TLGH), this study investigates the interrelationships between tourism, economic growth, and CO_2 emissions. The environmental Kuznets curve states that economic growth puts pressure on the environment and industrialization negatively impacts the environment but this trend is reversed and the impact on the environment becomes positive once the economy reaches a certain level of growth and technological advancement occurs and policies improve cleaner production and production of eco-friendly (Kaika & Zervas, 2013a, 2013b; Panayotou, 1993). In addition, the TLGH explains the growth of tourism economically with respect to the multiplier effects tourism has on the economy through employment, income, and investments(Balaguer & Cantavella, 2002). This perspective examines whether growth in tourism induces tourism growth in the MENA region, which has tourism sector growth and rapid economic development but sustainability challenges. This research employs Granger Causality to see if the relationships between tourism, economic growth and CO_2 emissions, confirm or deviate from the expectations of the underlying theories.

B. Tourism and Economy

Recent studies on Egypt highlight diverse intersections between tourism and economy. Studies emphasise the potential of intangible cultural heritage and geo tourism (AbdelMaksoud et al., 2021) to diversify the sector and benefit local communities, while others stress the vulnerability of Egyptian tourism to crises and the impacts of economic, political, and social impacts (El Atiek & Goutte, 2023) particularly in the case of Red Sea ecosystems where natural capital loss directly minimize tourism flows and GDP (Gallegati et al., 2025). Economic and policy dimensions are also central: air transport reforms (Tchouamou Njoya, 2020) and agricultural productivity alongside renewable

energy use (Raihan et al., 2023) are shown to significantly affect both tourism competitiveness and carbon emissions. Moreover, resilience strategies such as mangrove-based climate solutions (Omar et al., 2025) and food security policies connect environmental sustainability to economic stability (Abd El-Ghani et al., 2025). In examining these studies, tourism development, environmental sustainability, and economic growth have been considered in isolation, which largely misses examining the causal interlinkages among GDP, CO_2 emissions, and tourism flows directly addressing the significance of understanding their impact on each variable.

Moreover, literature findings in the MENA region reveals diverse connections but also significant gaps. Several studies conducted in Iran show the structural dynamics of tourism's contribution to economic development, unemployment drivers, and green growth (Habibi et al., 2018; Mozaffaripour et al., 2025; Rafiee et al., 2024). Collectively, these studies highlight tourism's positive but different economic systems in variety of accepts, especially on provincial disparities, labour market rigidity, and environmental trade-offs. Complementing this, MICMAC-based analyses of Iran's tourism market and studies on entrepreneurship barriers demonstrates systemic weaknesses in planning and institutional resilience for future years (Hashemi et al., 2022; Nematpour et al., 2020). On the other hand, several studies on Israel, Jordan, and Lebanon nations discuss tourism within the context of socio and politically. For Instance, Israel's macroeconomic consequences (Eckstein & Tsiddon, 2004) and discussion of tourism-led vulnerability (Wang et al., 2022) underline security and structural constraints. Jordan's case studies (Kreishan, 2014) illustrates tourism's long-run GDP contribution with efficiency gains, while significantly empathising gender-based assessments (Alrwajfah et al., 2020). Additionally, Lebanon adds the dimension of geo-tourism in the literature (Abou Arrage & Chamra, 2022) and crisis management (Jallat & Shultz, 2011), stressing both natural and institutional fragility. Meanwhile, Gulf economies which are Oman and Saudi Arabia frame tourism as a diversification lever in the context: Oman discuses on food ,tourism and hotel efficiency (Enzenbacher, 2020), and Saudi Arabia via non-oil exports and renewable energy integration (Waheed et al., 2020). Morocco's heritage-based tourism (Ksissou et al., 2024) further broadens the cultural-development nexus. However, even though these studies main focus is connecting tourism to energy, gender, unemployment, or GDP growth, they are still dispersed across disciplines and frequently take a static approach. Few make an effort to concurrently integrate economic instability, tourist, and climate factors, and nearly none look at the directional causation between GDP, emissions, and tourism. Thereby a significant gap of identifying temporal and causal ordering of these variables highlights the need for a closer look that examines revealing proper causality.

C. Tourism and Climate

The discussion of tourism and climate in the MENA region highlights the diverse yet interlinked nature. In Egypt, (Omar et al., 2025) demonstrate the ecological consequences of tourism-driven pressures on mangroves, with a focus along the Red Sea coast. Conversely, the ecological perspective (Raihan et al., 2023) findings emphasise that tourism alongside fossil fuel use increases CO_2 emissions, while renewable energy and agriculture mitigate environmental degradation. While both studies situate tourism as a driver of climate stress, focus on local ecosystem vulnerability, whereas (Omar et al., 2025) stress structural energy and economic dynamics. However, both studies remain limited to an ecological scale and to an economic scale; the studies do not take into

consideration a unified causal framework of the variables, leaving a clear research gap in Egypt.

Further Egypt studies El Atiek and Goutte (2023) reveal how political crises (the 2015 plane crash) worsen vulnerabilities in the tourism industry, emphasising the intersection between non-climatic shocks and tourism sustainability. For instance, by showing how climate-sensitive health outcomes (Jalali et al., 2025) in Iran indirectly connect climate change to tourism risk through an increase in vector-borne diseases.

Moreover, the policy-making insights emerge from Jordan and Lebanon, where (Abu-Hamatteh et al., 2025) call for renewable energy-driven mitigation, while studies (Abou Arrage & Chamra, 2022) highlight geo tourism as a pathway for resilience. Oman's case reflects how emerging tourism industries must align with sustainability from the outset (Enzenbacher, 2020). Importantly, none of these studies properly integrates tourism, economic growth, and climate dynamics within a causal framework; instead, they show fragmented methods, spanning from ecosystem-specific, health-related, and energy-economic viewpoints. This highlights a need to apply causality to investigate bidirectional causal relationships between GDP, tourism arrivals, and CO_2 emissions.

D. Economy and Climate

Egypt plays a major role in its reliance on trade infrastructure, agriculture, and water resources, revealing an economic-climate nexus in the MENA area. Studies evaluate the impacts of sea level rise (SLR) on Alexandria and Damietta ports, emphasising the importance of adaptation and development plans for sustaining economic activity while climate hazards pose significant risks to maritime trade (Romya et al., 2025). Further, literature shows how the water-energy-food (WEF) nexus in MENA is increasingly strained by climate occurrences, with Egypt facing heightened risks of drought and food insecurity. Similarly, highlight the persistence of wheat yield gaps in MENA, where Egypt is one of the most prominent producers due to climatic variability and water scarcity (Mohammed Qasem & Scholz, 2025; Tita et al., 2025). Together, these studies demonstrate how Egypt's agricultural sector is both an economic pillar and a climate hotspot.

In considering regional finance and innovation research, complementary insights were found in the findings. For instance, findings show that climate legislation reduces bank lending, indirectly affecting investment opportunities, while stressing the urgency of taking steps in protecting natural capital in economies like Egypt's, where nations depend on resource-oriented oriented (Ferreira et al., 2024; Ghosh, 2023). In addition, the studies emphasise the fact that investment, emerging technology and oil rents interact with environmental sustainability in complex ways, highlighting policy trade-offs for the region. Although literature provides a deeper understanding of ports, agriculture, and water resources, with the other remaining sectors, none explicitly examine the causal dynamics which may lead to building an economy and climate framework that is more enriched across the multiple sectors across MENA.

In the found studies, Saudi Arabia's economy and climate have been thoroughly studied due to its heavy dependency on fossil fuels and the Vision 2030 reforms. Several dimensions are highlighted by research, such as farm size, knowledge, and inadequate extension services, which limit farmers' ability to adjust to climate disasters (Alotaibi et al., 2025), while renewable energy development faces institutional, financial, and skills barriers despite strong circular economy potential (Solangi et al., 2025). Moreover, literature shows carbon pricing simulations demonstrate emission reduction potential but highlight non-linear responses and the need for sector-specific strategies (Hasanov et al.,

2025). Additionally, complementary research highlights carbon removal technology and the long-term connection between urbanisation, oil-driven growth, and CO_2 emissions (Tlili et al., 2025). These findings have limited integration of the policy, socio-economic, and technological factors in a comprehensive framework, making them relevant but fragmented.

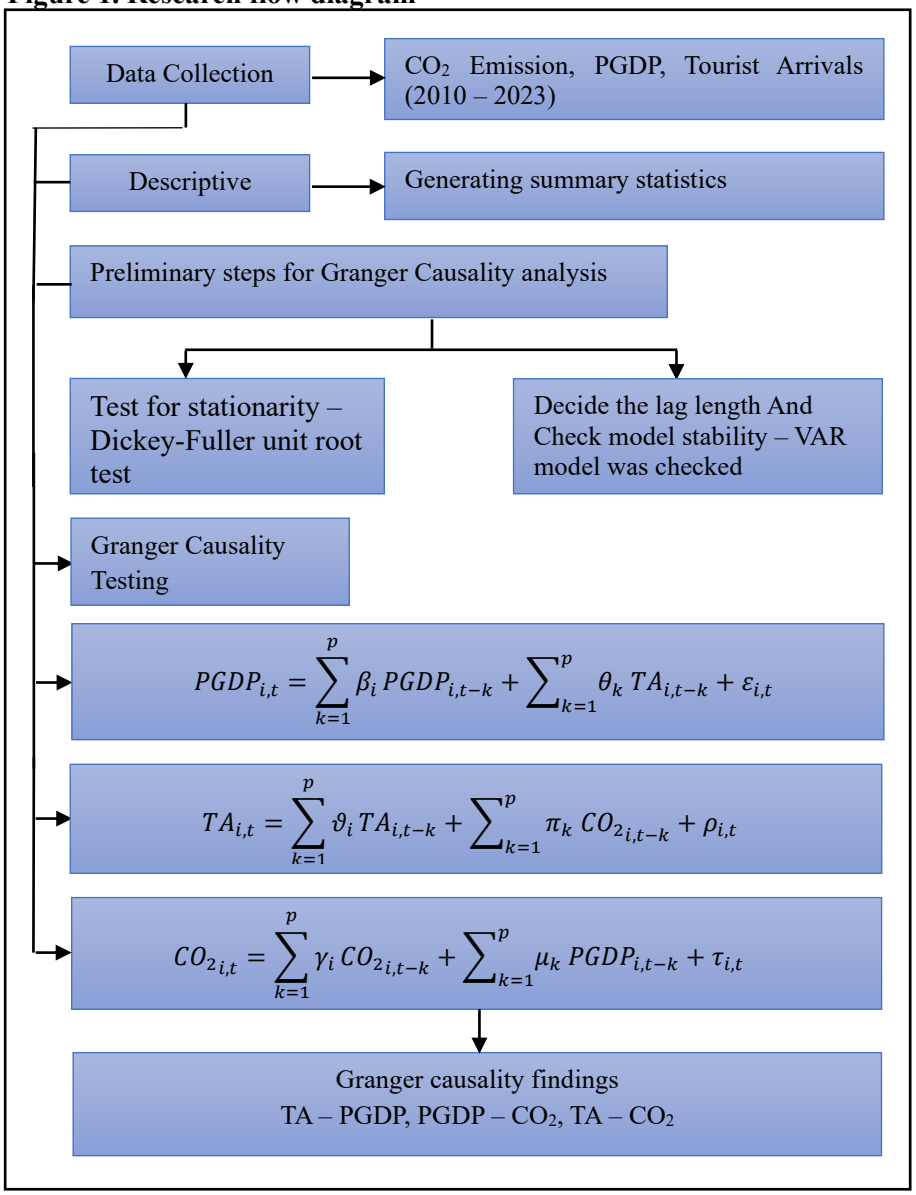
Morocco's findings highlight the vulnerability of resource-dependent economies by indicating that by 2050, climate-related disasters, particularly floods and water scarcity, could endanger up to 6.5% of GDP (El Asli & Azeroual, 2025). However, the analysis remains largely descriptive, lacking deeper causal exploration of how economic diversification or international cooperation could mitigate these losses.

Overall, the majority of studies are case-specific, concentrate on sectoral policy, or continue to be predictive rather than causative, even though the literature acknowledges climate change as an economic concern in the MENA region. This identifies a research need for cross-national comparative studies that look at the long-term causal relationships between emissions, climate resilience, and economic growth.

III. METHODOLOGY

The overview of the research methodology employed in this study is presented in Figure 1. First, data were collected from reliable sources over a standard period. The analysis included 10 countries, excluding any records with missing values for one or more variables. The study examines the causal relationship between tourist arrivals, CO_2 emissions, and PGDP across these countries using the Granger causality test.

Figure 1. Research flow diagram

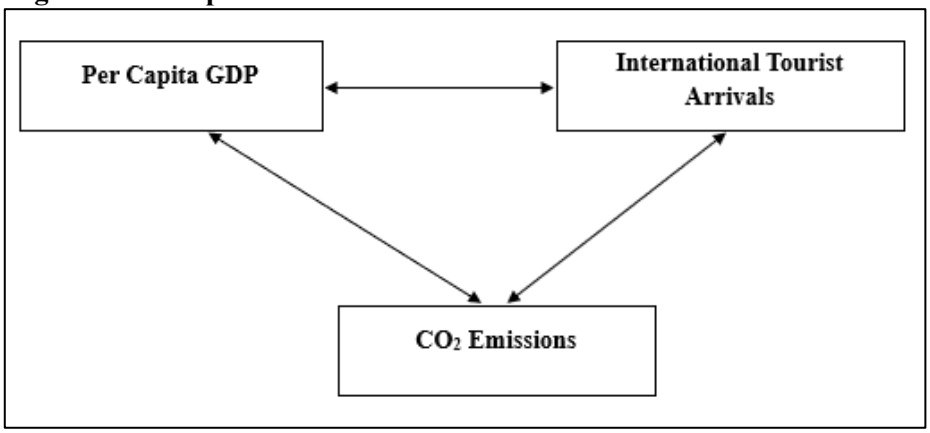


Source: Authors' compilation.

A. Conceptual Model

Figure 2 shows the bidirectional relationship between PGDP to International Tourist Arrivals, International Tourist Arrivals to PGDP, CO_2 emissions to PGDP, PGDP to CO_2 emissions, CO_2 Emissions to International Tourist Arrivals and International Tourist Arrivals to CO_2 Emissions, where each element both influences and is influenced by the others.

Figure 2. Conceptual framework



Source: Authors' compilation.

B. Granger Causality Test

The Granger causality test was applied separately to each country to examine the relationships between tourist arrivals, PGDP, and CO_2 emissions. A variable X is said to Granger-cause Y if past values of X provide significant predictive information for Y beyond Y's own past values. Wald tests within the VAR framework were used to determine the existence and direction of causality. All analyses were carried out in STATA.

$$PGDP_{i,t} = \sum_{k=1}^{p} \beta_i \, PGDP_{i,t-k} + \sum_{k=1}^{p} \theta_k \, TA_{i,t-k} + \varepsilon_{i,t} \quad (1)$$

$$TA_{i,t} = \sum_{k=1}^{p} \vartheta_i \, TA_{i,t-k} + \sum_{k=1}^{p} \pi_k \, CO_{2_{i,t-k}} + \rho_{i,t} \quad (2)$$

$$CO_{2_{i,t}} = \sum_{k=1}^{p} \gamma_i \, CO_{2_{i,t-k}} + \sum_{k=1}^{p} \mu_k \, PGDP_{i,t-k} + \tau_{i,t} \quad (3)$$

Here, i and t represent the country and the time period (2010–2023), respectively. p is the number of lags, k is the lag frequency, and $\varepsilon_{i,t}$, $\rho_{i,t}$ and $\tau_{i,t}$ are the error terms for the two equations. This study examined pairwise relationships between PGDP and tourist arrivals, tourist arrivals and CO_2 emissions, and CO_2 emissions and PGDP. Each relationship was analysed in both directions to determine whether one variable causes the other using the Granger causality test.

The Granger causality test was chosen for this study as it effectively identifies the direction of relationships between time-series variables. It determines whether past changes in one variable can predict future changes in another. This method is appropriate for examining the dynamic interactions between tourist arrivals, PGDP, and CO_2 emissions over time. Its pairwise approach also helps detect both unidirectional and bidirectional causal effects. Granger causality is widely applied in economic and environmental research, offering clear and reliable insights.

IV. DATA ANALYSIS AND DISCUSSION

A. Data

A panel data collection, spanning the years 2010 to 2023, will be used for this investigation. Under the variables of PGDP, Tourist Arrivals and CO_2 emission globally data are gathered and displayed. The information for this study is reliable international databases such as the World Bank and UNWTO. Data sources and variables are shown in Table 1.

Table 1: Data sources and variables

Variables	Measure	Source and link
Per Capita Gross Domestic Product	Current US$	(World Bank, 2024)
CO_2 Emissions	Metric Tons	(Our World in Data, 2024)
International Tourist Arrivals	Per Person	(World Tourism Organization (UN Tourism), 2024)

Source: Authors' compilation.

B. Descriptive Statistics

The section demonstrates the comprehensive view on descriptive statistics obtain for 10 nations particularly to the MENA region. Accordingly, Table 2 presents statistical values of mean, standard deviation, Minimum and Maximum values to capture both central tendencies and variations.

Table 2: Descriptive Statistics results

Country	Variables	Mean	Std. dev	Min	Max
Algeria	PGDP	4997.222	763.5619	3743.542	6094.694
	TA	1965643	791241.1	125238	2732731
	CO_2	158429.4	21348.33	118353.3	184558.1
Egypt	PGDP	3117.882	538.1426	2395.103	4233.308
	TA	9880305	3122182	3618633	14905000
	CO_2	238681.5	23019.98	203607.6	271168.5
Iran	PGDP	5369.002	1467.216	2988.781	8114.081
	TA	4559059	2101381	989430	9107261
	CO_2	682419	84595.12	561496.1	817879.9
I s	PGDP	41409.3	7521.666	31338.56	54930.73

Country	Variables	Mean	Std. dev	Min	Max
	TA	2806861	1082913	396500	4551600
	CO_2	62516.71	4788.672	58655.66	74784.85
Jordan	PGDP	4124.37	183.1579	3718.47	4455.51
	TA	3769695	1048904	1067166	5345134
	CO_2	23170.26	2211.807	20254.5	25898.83
Lebanon	PGDP	7050.768	2012.919	3350.3	9174.537
	TA	1515554	456209.6	414168	2168000
	CO_2	23005.04	3060.226	18922.39	27824.08
Morocco	PGDP	3373.11	221.6507	3067.985	3785.936
	TA	9807657	3156194	2777802	14524727
	CO_2	61575.17	5757.776	54365.2	70245.23
Oman	PGDP	21017.39	2914.234	16784.86	25188.01
	TA	1721786	725439.2	464000	2849000
	CO_2	67344	7337.923	51177.63	78511.3
Saudi Arabia	PGDP	26636.29	3824.173	21515.66	34454.2
	TA	15148395.27	5976364	3477216	27423536
	CO_2	629907.7	58136.6	540578.9	736205.3
Tunisia	PGDP	3969.096	343.5251	3528.872	4458.979
	TA	6517590	2190114	2012371	9429049
	CO_2	30016.29	1798.261	26436.43	32792.88

Source: Authors' compilation.

Below Figure 3 represents the graphical illustrations of the values showing a clear discrepancy in the economy, tourism, and environment across the selected countries from the MENA region. The average PGDP values show Israel has the highest PGDP reflecting its advanced and diversified economy, while Egypt and Morocco as a low PGDP, which indicates their developing economic conditions.

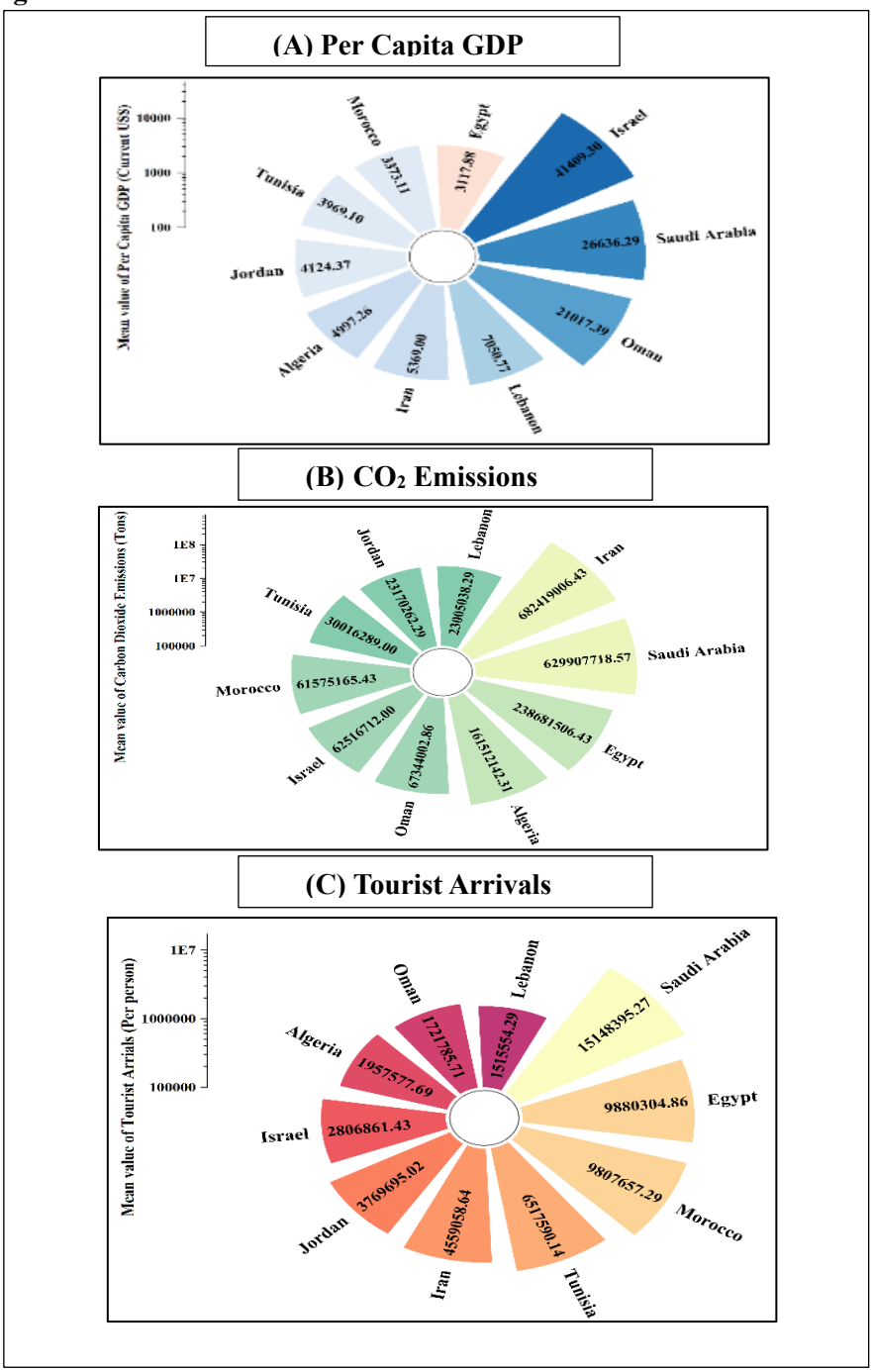
In regard to Tourism Industry, Saudi Arabia leads the way with an average of over 15 million Tourist Arrival while Egypt and Morocco also attract significant tourism based on cultural heritage and coastal tourism. Meanwhile Lebanon and Oman generated much lower tourist bases on the same time span.

In terms of Carbon emission, the highest averages were found in Iran and Saudi Arabia, which indicates the oil-dependent industries and energy consumption are significant contributors to total state-wide emissions from natural and mechanical energy

along the region. Conversely, smaller economies such as Jordan and Lebanon have much less emissions.

Overall, these means illustrate the distinct divides between resource rich and industrialised economy and those smaller or developing states in foreign income, tourist arrivals and environmental impacts.

Figure 3. Mean value of variables



Source: Authors' compilation based on descriptive results.

C. Dickey-Fuller unit root test

The Dickey–Fuller unit root test was used to check whether the data are stationary as shown in Table 3. This method was chosen because it works well for detecting unit roots in time-series data for each entity over a set period.

$$Y_t = \alpha + \beta Y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta Y_{t-i} + \varepsilon_t \quad (4)$$

Equation (4) illustrates the formula applied in the unit root test. Here, α denotes the intercept β is the autoregressive coefficient, p indicates the number of lagged differences included in the model, and ε_t represents the error term.

H_0: The series contains a unit root (non-stationary)

H_1: The series does not contain a unit root (stationary)

If the null hypothesis was accepted at the 1% significance level, the variable was differenced and marked with the prefix "D." If stationarity was still not achieved, further differencing was applied, and the test repeated until the null hypothesis was rejected at the 1% level.

Table 3: Dickey-Fuller unit root test results

Country	TA	dTA	ddTA	PGDP	dPGDP	ddPGDP	CO_2	dCO_2	$ddCO_2$
Egypt	-2.630*	-	-	-	-	-2.630*	-	-3.750***	-
Iran	-	-3.000**	-	-	-3.000**	-	-	-3.750***	-
Israel	-	-3.000**	-	-	-3.000**	-	-	-3.750***	-
Jordan	-	-3.000**	-	-	-	-3.000**	-	-3.000**	-
Lebanon	-2.63*	-	-	-	-	-3.000**	-	-	-3.750***
Oman	-	-2.630*	-	-	-3.000**	-	-	-3.000**	-
Saudi Arabia	-	-	-3.000**	-	-3.000**	-	-	-3.750***	-
Algeria	-	-	-2.630*	-	-3.000**	-	-	-3.750***	-
Morocco	-	-2.630*	-	-	-3.750***	-	-	-3.750***	-
Tunisia	-	-2.630*	-	-	-3.000**	-	-	-3.750***	-

Source: Authors' compilation. Note: * denotes significant at the 10% level, ** at the 5% level, and *** at the 1% level. dTourist Arrivals = first difference of Tourist Arrivals; ddTourist Arrivals = second difference of Tourist Arrivals; dPGDP = first difference of PGDP; dCO_2 Emissions = first difference of CO_2 Emissions.

Stability Test of the VAR Model

The stability of the VAR model was assessed. It ensures that shocks decrease over time rather than intensify. Stability is confirmed when all eigenvalues lie strictly inside the unit circle.

$$Y_T = A_1 Y_{t-1} + \cdots + A_p Y_{t-p} + u_t \quad (5)$$

Equation (5) represents the VAR model, where Y_T is a vector of endogenous variables, A_i are coefficient matrices, and u_t is the error term. Stability in this study was evaluated using Stata's "varstable" command. If any eigenvalue falls on or outside the unit circle, the VAR is unstable and requires adjustment. In this study, the model met the stability condition, confirming it is stationary and appropriate for the Granger causality tests.

E. Granger Causality Test

Table 4 represents the granger causality results of tourist arrivals, CO_2 emissions and PGDP. Morocco shows unidirectional relationships from PGDP to tourist arrivals while unidirectional relationships from tourist arrivals to PGDP are found in Iran, Oman and Algeria. A bidirectional relationship exists in Israel and Lebanon. No relationship is found in Egypt, Jordan, Saudi Arabia and Tunisia. Regarding tourist arrivals to CO_2 emissions, has a unidirectional influence in Egypt, Oman and Tunisia. A unidirectional relationship from CO_2 emissions to tourist arrivals is found in Morocco. No relationship is observed in Iran, Israel, Jordan, Lebanon, Saudi Arabia and Algeria. For PGDP and CO_2 emissions, a unidirectional relationship from PGDP is found in Israel, Lebanon, Oman and Tunisia a unidirectional effect from CO_2 emissions is seen in Algeria. A bidirectional relationship is observed in Morocco. No relationship is found in Egypt, Iran, Jordan and Saudi Arabia.

Table 4: ***Granger causality results***

Country	PGDP - TA	TA – CO_2	PGDP - CO_2
Egypt	ddPGDP ⟷ TA	TA → dCO_2	ddPGDP ⟷ dCO_2
Iran	dPGDP ← dTA	ddTA ⟷ dCO_2	dPGDP ⟷ dCO_2
Israel	dPGDP ↔ dTA	dTA ⟷ dCO_2	dPGDP → dCO_2
Jordan	ddPGDP ⟷ dTA	dTA ⟷ dCO_2	ddPGDP ⟷ dCO_2
Lebanon	ddPGDP ↔ TA	TA ⟷ $ddCO_2$	ddPGDP → $ddCO_2$
Oman	dPGDP ← dTA	dTA → dCO_2	dPGDP → dCO_2
Saudi Arabia	dPGDP ⟷ ddTA	ddTA ⟷ dCO_2	dPGDP ⟷ dCO_2
Algeria	dPGDP ← ddTA	ddTA ⟷ dCO_2	dPGDP ← dCO_2
Morocco	dPGDP → dTA	dTA ← dCO_2	dPGDP ↔ dCO_2
Tunisia	dPGDP ⟷ dTA	dTA → dCO_2	dPGDP → dCO_2

Source: Authors' compilation.

The arrows → and ← represents unidirectional relationship, and ↔ represents bidirectional and no relationship between variables respectively.

F. Discussion

The following discussion presents heterogeneous study results of Granger causal relationships between tourism, economic growth, and CO_2 emissions across MENA countries, offering both similarities and contrasts with the prior literature.

In the discussion of tourism growth nexus, the unidirectional causality relationship from tourism to PGDP in Iran, Oman, and Algeria supports the tourism-led growth hypothesis consistent with the past studies (Tang & Abosedra, 2014), which shows tourism as a significant driver of economic growth in the MENA region. Similarly, the bidirectional causality in Israel and Lebanon aligns with (Wijesuriya et al., 2025), who highlighted feedback effects between globalisation and growth in parts of Africa. However, the absence of causality in Egypt, Jordan, Saudi Arabia, and Tunisia contradicts (Tang & Abosedra, 2014) and may reflect the moderating role of political instability and structural dependence, which these authors also noted as barriers to economic growth. Morocco's reverse causality (PGDP → tourism) suggests an economy-driven tourism expansion, contrasting with the tourism-led pattern reported in much of the literature.

In the context of the relationship between tourism and the climate environment, the unidirectional effect emphasises the tourism industry's impact on emissions in Egypt, Oman, and Tunisia, confirming evidence from (Idroes et al., 2024), which shows that increasing emissions have resulted from the tourism industry in North Africa. Moreover, studies observed nonlinear and asymmetric environmental impacts of tourism in Tunisia, as justified by the present study's findings (Trabelsi, 2025). On the other hand, Morocco, which demonstrates unidirectional causality from CO_2 emissions to tourism, reflects environmental conditions influencing tourist arrival (Ghosh et al., 2024) for G7, BRICS, and CIVET economies emphasising the importance of geographically specific environmental policies with climate change strategies in the tourism sector.

Moreover, the studies investigated through the Environmental Kuznets Curve (EKC) evidence also brought valuable arguments. The bidirectional causality results demonstrate in Morocco align with similar results, which show validating the EKC in oil exporting MENA states. Similarly, unidirectional causality from PGDP to emissions in Israel, Lebanon, Oman, and Tunisia echoes (Daly et al., 2024), which emphasise that energy-driven growth patterns are linked to higher emissions in Saudi Arabia. However, Algeria's reverse causality from carbon emission to economic growth reflects energy-intensive industrial growth, diverging from studies reporting neutral or growth-led dynamics.

Overall, the results show a lack of consistency throughout MENA, supporting certain regional trends in literature but also exposing inconsistencies that emphasise the impact of institutional, political, and structural factors unique to each nation.

V. CONCLUSION AND POLICY RECOMMENDATIONS

This study analysed causal links between tourist arrivals, PGDP, and CO_2 emissions in 10 MENA countries (2010 - 2023). Granger causality revealed bidirectional, unidirectional, or no relationships, showing that tourism, economic growth, and environmental impact interact differently across regions due to variations in economic structure, environmental policies, and tourism development. These results are important because they provide new, region-specific evidence on how tourism and economic growth impact environmental outcomes. This information can guide policymakers and researchers who are looking for sustainable development strategies in the MENA region.

From a policy perspective, countries where tourism boosts growth should focus on sustainable practices like low-carbon infrastructure, renewable energy, and green

transport. Where growth increases emissions, strong environmental regulations are needed. In regions where environmental harm threatens tourism, protecting nature and promoting sustainable tourism is key to long-term economic and industry resilience.

The study shows that the links between tourism, economic growth, and environmental impact differ across regions and development stages. Countries should adopt context-specific strategies aligned with SDGs 8, 12, and 13, to use tourism for economic growth while minimising environmental harm, ensuring balanced and sustainable development.

Overall, the findings highlight the need for strategies that are specific to the context and align with the SDGs (SDGs 8, 12, and 13). These strategies should balance economic development with environmental protection. By applying these focused approaches, policymakers can boost tourism's economic advantages, reduce environmental damage, improve climate resilience, and promote sustainable growth in the MENA region.

VI. LIMITATIONS AND FUTURE WORK

A key limitation of this study is its reliance on Granger causality. This method identifies predictive relationships but does not capture true structural causation. It is also sensitive to lag selection, stationarity adjustments, and omitted variables. Secondly, the study is limited to three indicators, international tourist arrivals, PGDP and CO_2 emissions, and within the MENA region, which limits generalizability.

Future research can build upon this study by expanding the indicator set to include variables such as renewable energy use, impacts of infrastructure development, cultural impacts, and impacts on social wellbeing. Future work can also examine beyond the regional level, or measure how effective sustainable tourism plans, investments in green technology, and renewable energy initiatives have been. Techniques such as wavelet coherence can also be used to capture the short- and long-term dynamics, allowing a better, actionable picture of how tourism can promote GDP growth while preserving environmental sustainability.

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