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THE ENVIRONMENTAL EFFECTS OF TOURISM: ANALYZING THE IMPACT OF TOURISM, GLOBAL TRADE, CONSUMPTION EXPENDITURE, ELECTRICITY, AND POPULATION ON ENVIRONMENT IN LEADING GLOBAL TOURIST DESTINATIONS

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Abstract: The study analysed the impact of tourism, trade, consumption expenditure, electricity usage, and population on carbon dioxide emissions (CO_2) in leading tourist destinations. The study uses a panel dataset of 32 countries from different continents between 2001 and 2020 and applies the generalized method of moments (GMM) and Quantile Regression approaches. The results suggest that tourism (arrivals and revenues) can reduce environmental degradation, and that CO_2 emissions increase due to factors such as GDP per capita, electricity consumption, and population growth. Trade openness can reduce CO_2 emissions, and controlling for final consumption also indicates a decrease in CO2 emissions. The study suggests that sustainable tourism practices, responsible consumption, and larger international integration may play a role in mitigating CO_2 emissions. Leading tourist destinations should develop sustainable urban areas to accommodate population growth, and embrace eco-friendly technologies, infrastructure, and consumption patterns to promote sustainable economic growth while reducing CO_2 emissions.

Key words: CO2 Emissions, Tourist Destinations, Quantile Regression, Tourism, Sustainable Development

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INTRODUCTION

Tourism, which encompasses activities such as travel, leisure, relaxation, and exploration over a short period, plays a substantial role in global Gross Domestic Product (GDP) (Rahman et al., 2023). It brings a multitude of benefits to host nations, spanning social, economic, cultural, and environmental aspects, which is widely recognized by scholars (Uzuner et al., 2020). Tourism creates jobs, attracts foreign direct investment (FDI), enhances infrastructure development, and elevates service sector standards (Zuo and Huang, 2018). According to the World Tourism Organization (WTO), tourism contributes to 10% of global GDP and 7% of global trade, and supports one in ten jobs, with the potential to align with 17 Sustainable Development Goals (UNWTO, 2018; Shi et al., 2019). Given its profound influence on economic growth, numerous countries have shifted their focus toward the tourism sector, seeking to harness new avenues of economic expansion, foreign exchange income, job generation, and enhanced living standards. The global reach of the tourism industry is extensive, bolstering tax revenues, income streams, and employment prospects (Shi et al., 2019). However, the surge in tourist numbers in recent decades has raised concerns regarding environmental degradation (Adedoyin et al., 2021), which occurs in tandem with the industry's economic benefits. Tourism is recognized as a significant factor that can influence both the environmental and economic conditions of an economy (Ozturk et al., 2023).

The global temperature is rising, which is a cause for concern and is influenced by various factors, such as greenhouse gases, unplanned infrastructure, climate change, trade, and overpopulation (Alola et al., 2019). These factors are interconnected and

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contribute to carbon emissions, which can be exacerbated by tourism. Some studies suggest that tourism promotes trade and increases human mobility, leading to increased consumption and GDP growth, which, in turn, raises CO_2 emissions (Akadiri et al., 2020; Pata et al., 2023). This indicates that tourism operations consume substantial energy, drive economic growth, and result in higher CO_2 emissions, posing challenges to achieving sustainable development goals. Nosheen et al., (2021) stated that CO_2 has a detrimental effect on sustainable economic growth and harms human health and the environment. Tourism has emerged as a sector with potential to contribute to GDP growth in both developed and developing countries (Ozturk et al., 2023; Durani et al., 2023). However, this potential varies, with some cases yielding both economic and environmental benefits (Sun et al., 2023), whereas in other instances, economic gains may come at the expense of significant environmental costs (Irfan et al., 2023). This highlights the importance of identifying sustainable strategies that support the expansion of global tourism and transportation (Onifade and Haouas, 2023; Zaman et al., 2017) while preserving the environment.

The study examined the linkages between tourism, trade, population growth, consumption, and CO_2 emissions in the top 32 tourist arrival countries from six world regions. In 2019, tourism accounted for nearly 9.1% of the GDP in Europe, 8.8% in North America, 8.1% in Latin America, 8.4% in Asia, 7.5% in Africa, and 11.7% in Oceania. France, with over 90 million visitors in 2019, was the most popular travel destination, followed by Spain, the US, China, Italy, Turkey, Mexico, Thailand, Germany, and the UK (CEPAL, 2022). In the past, Europe and the US dominated global carbon emissions, but in the second half of the 20th century, Asia became the leading emitter. In 2019, Europe emitted 2.52 billion tons of CO_2, North America excluding the US emitted 1.24 billion tons, Latin America emitted 1.07 billion tons, Asia excluding India and China emitted 7.53 billion tons, Africa emitted 1.47 billion tons, and Oceania emitted 470.36 million tons (Dohlman et al., 2022). Notably, several of the top 32 tourist destinations are among the leading CO_2-emitting nations, indicating the need to assess the impact of tourism on the environmental quality of these countries, whether positive or negative. China is the largest source of CO_2 emissions, contributing 10.74 billion tons, followed by the US with 5.26 billion tons, and India with 2.63 billion.

The annual trends of the various study variables are displayed in panels (a) – (d) in Figure 1 below. The graph illustrates the significant increase in GDP per capita and CO_2 emissions. Conversely, there are fluctuations observed in tourist arrivals, tourist receipts, and trade openness. During the period in question, CO_2 emissions increased by nearly 60%, with Asia experiencing the most significant expansion. Both Europe and Asia saw substantial growth in tourism arrivals. Between 2000 and 2020, GDP per capita nearly doubled, with Asian countries recording the most significant gains.

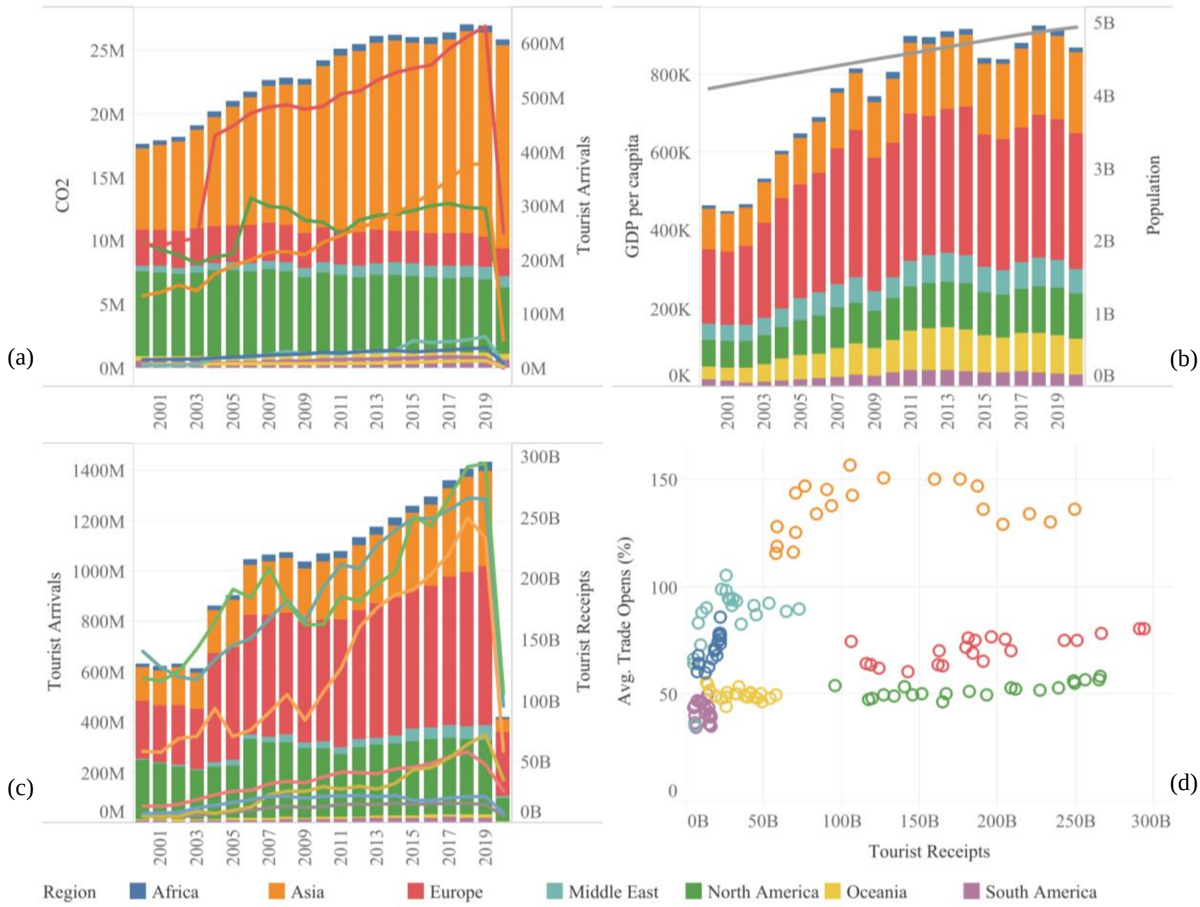

Figure 1. Annual trends of the study variables (a) CO_2 emission (CO2 emissions, kt) and Tourism Arrivals (number of Arrivals Millions) (b) GDP per capita (current US$) and Total Population (Million) (c) Tourist Arrivals (Millions) and Tourists receipts (US Billion, Current) (d) Trade openness and Tourism Receipts

In terms of tourism receipts, Asian, European, and North American countries experienced the largest growth. Interestingly, Europe and North America have relatively lower levels of trade openness compared to other regions, despite experiencing the highest growth in receipts. In contrast, Asian countries are highly open to trade and have rapidly expanded their tourism receipts, suggesting a different approach to tourism growth compared to Western countries.

The objective of this research is to examine the impact of various factors, including tourism, trade, consumption expenditure, electricity consumption, income, and population, on CO_2 emissions in top tourist nations. By analyzing these interrelationships, the study aims to provide insights into the sustainable environment of the tourism industry and the factors that contribute to environmental degradation. The research utilizes a panel dataset containing 32 countries from various continents spanning from 2001 to 2020. The measurement of tourism is based on both the number of tourist arrivals and corresponding revenue generated. The analysis employs the Generalized Methods of Moments (GMM) and Quantile Regression methodologies. To avoid potential biases, a two-step System GMM approach with differencing variables is implemented. Additionally, the study excludes five countries with the highest and lowest tourist arrivals to assess whether the primary findings are affected by the extreme observations in the sample.

This study makes a valuable contribution to the literature on CO_2 emissions in several ways. Firstly, it enhances our understanding of the factors that influence CO_2 emissions, particularly in the context of tourism-related activities such as trade, population, final consumption, electricity consumption, and GDP. Additionally, the research included two variables related to tourism activities: tourism revenue and foreign tourists' arrivals. This is important, as the literature has shown inconclusive results when either revenue or arrival is used as a proxy for tourism (Farooq et al., 2023; Ansari and Villanthenkodath, 2022). Secondly, our analysis broadens the scope of the study by incorporating data from 32 leading tourist countries across six distinct continents. This addresses a notable gap in the literature, as many studies tend to focus solely on individual top tourist destinations or specific regions, often overlooking multi-regional considerations. Thirdly, the paper employed advanced analytical techniques, including Quantile Regression and GMM, which enhance the robustness of the findings. The use of differencing variables and the two-step System GMM approach further minimized potential biases. Additionally, the paper used Quantile Regression, which can handle extreme values that are often encountered in diverse country samples and have the potential to exert a disproportionate influence on the results. Fourthly, there were two kinds of robustness tests used in this work. Quantile regression was used in the study to estimate robustness. However, in order to assess the research's robustness, the top five and bottom five tourist countries were excluded from the list of 32 tourist destinations. The structure of this paper is as follows. In Section 2, the paper will present a comprehensive literature review. In Section 3, the paper will provide an overview of the data and methodology used in this study. The results and findings will be described and discussed in Section 4. In Section 5, the paper will have a discussion on the study's findings. Finally, the conclusions and policy implications will be explained in Section 6. In Section 7, the paper will discuss the limitations and scope of this study. This paper has two appendices. The list of nations is in Table 9, while the list of abbreviations is in and Table 10.

LITERATURE REVIEW

Over the past two decades, the impact of travel and tourism on the economy has received significant attention, leading to a surge in theoretical and empirical research. This body of work has comprehensively examined the complex correlation between CO_2 emissions, economic growth, and energy consumption on a global scale. The relationship between tourism and CO_2 emissions has been thoroughly analyzed from various perspectives. International travel is one of the most energy-intensive aspects of tourism, with energy consumed across tourism destinations for activities such as transportation, shipping, waste management, and the importation of goods, making it an energy-demanding endeavour (Ali, 2023; Zaman et al., 2017). Additionally, amusement parks, ski resorts, entertainment, and shopping centers, which are largely automated, exhibit substantial energy consumption patterns (Zhao et al., 2023; Dwyer et al., 2010). It is worth noting that in regions with milder climates, CO_2 emissions can have disproportionate effects on tourism, as demonstrated by the adverse consequences observed in Buttke et al. (2023), Gössling et al. (2015), and Hamilton et al. (2005).

Prior research suggests that tourism can serve as an agent of environmental conservation when managed effectively by promoting the adoption of eco-friendly technologies and transportation methods (Ahmad et al., 2023c; Koçak et al., 2020; Leal Filho et al., 2023). This shift towards sustainability can involve measures such as reducing gasoline consumption, enhancing road infrastructure, expanding safer highways, and bolstering rail transportation, which can contribute to the reduction of CO_2 emissions (Ghosh et al., 2023; Polcyn et al., 2023; Umurvzako et al., 2023). Constructing eco-friendly infrastructure to support the tourism sector, including airports, railways, roads, and telecommunications, can mitigate the environmental impact of tourism and simultaneously stimulate economic growth (Jahanger et al., 2023; Khan et al., 2022a; 2022b).

Several countries, including Indonesia, Malaysia, China, India, Colombia, and Brazil, have observed a positive correlation between an increase in GDP per capita and a rise in the number of foreign visitors (Esquivias et al., 2022; Hor and Thaiprasert, 2015; Silva et al., 2023). Danish and Wang (2018) examined the complex relationship between the tourism industry and economic growth in BRICS nations from 1995 to 2014, noting that tourism has contributed significantly to economic expansion while also leading to adverse environmental consequences. In particular, they identified an Environmental Kuznets Curve (EKC) within BRICS economies, which suggests a curvilinear relationship between income levels and CO_2 emissions. Furthermore, Porto et al. (2023) confirmed the presence of an extended EKC hypothesis for tourist destinations in the Americas and Asia-Oceania, underscoring the urgent need for environmental policies to ensure the sustainability of tourism in highly polluted and rapidly expanding destinations. Sghaier et al. (2019) examined the environmental consequences of tourism and discovered contrasting outcomes in Egypt and Tunisia. Although Egypt experienced adverse environmental effects, Tunisia showed improvements in its environmental quality. Porto et al. (2023) found that while the Americas and Asian destinations suffered negative environmental impacts from tourism activities, European destinations experienced enhancements in their environmental quality. These discrepancies across nations suggest varying relationships between CO_2 emissions and income levels, with some displaying an inverted U-shaped correlation and others demonstrating a U-shaped pattern. Shaheen et al. (2019) confirmed the existence of the EKC hypothesis (inverted U-shaped curve) based on data spanning 1995 to 2016, encompassing the top ten tourist-receiving countries. Similarly, Wang (2014) arrived at a similar conclusion using panel data from 2001 to 2010 for the top 20 tourist destinations. Variations in the environmental impact of tourism often depend on multiple factors, such as the adoption of sustainable tourism development practices (Nematpour et al., 2022), the effectiveness of environmental regulations and policies (Hovelsrud et al., 2023), the sophistication of tourism infrastructure and technology (Balsalobre-Lorente et al., 2023), commitment to environmental conservation (Durani et al., 2023), energy sources (Zheng et al., 2023), the energy efficiency of tourism facilities (Rahman et al., 2022), and numerous other considerations (Wei and Lihua, 2023).

Research has uncovered a critical aspect of the complex interaction between economic activity, emissions, and the tourism sector in specific country groupings (Gössling et al., 2015). Tourism has the capacity to stimulate energy demand, leading to environmental consequences. Brahmasrene and Lee (2017) examined the long-term implications of CO_2 emissions, tourism, industrial development, urbanization, globalization, and economic growth in Southeast Asian countries.

They found that in the top ten most-visited nations, real GDP and tourism tend to increase emissions, but the use of renewable energy sources can decrease pollution levels. Similarly, Razzaq et al. (2023) conducted a study on the top 10 rich countries and revealed the dual impact of global tourism, fostering economic expansion while concurrently leading to amplified CO_2 emissions. Geo et al. (2021) reported similar results in their study on Mediterranean countries, confirming the connection between tourism activity and CO_2 emissions. Additionally, Qureshi et al. (2017) found that domestic tourism tends to curb greenhouse gas emissions, whereas international travel has a positive influence on energy demand, GDP, trade, and CO_2 emissions. This complex web of relationships is further intensified by the crucial roles of trade openness and economic growth, which contribute to an increase in inbound tourism (Deb, 2021).

The relationship between a country's tourism activities and their environmental impact has led to energy consumption being identified as a critical factor. Theoretical and empirical studies have established a clear connection between the increasing scope of tourism-related activities, such as travel, dining, and lodging, and rising energy demand, primarily driven by fossil fuels (Katircioglu, 2014). Several geographic contexts have been explored, including the European Union (EU) by Xia et al. (2022), Turkey by Katircioglu (2014), China by Irfan et al. (2023), and OECD countries by Banga et al. (2022). These studies arrive at a common conclusion that energy utilization plays a crucial role in driving tourism expansion. Building on this perspective, Doan et al. (2017) confirm that real GDP and tourism exert upward pressure on emissions in the top ten tourist-receiving countries, while the integration of renewable energy sources serves to mitigate pollution. Additionally, Zaman et al. (2017) found an association between per capita income growth and increased CO_2 emissions, which further aggravates environmental challenges in the top 10 tourist destination nations. In the pursuit of environmental sustainability, it is crucial for popular tourist destinations to carefully evaluate the impact of various socioeconomic and technological factors. Among these factors, population density, population growth, and urbanization have been identified as primary determinants of CO_2 emissions (Fethi and Senyucel, 2021; Begum et al., 2015; Umurvzako et al., 2023). While an increase in population density leads to higher overall CO_2 emissions, it also results in lower per-capita emissions.

However, previous research has produced conflicting results regarding population growth's impact on CO_2 emissions (Gao et al., 2021; Begum et al., 2015). Conversely, Owusu (2018) argues that population growth is positively correlated with CO2 emissions, which is supported by the findings of Sun et al. (2023) for 30 countries, Nathaniel et al. (2023) for emerging markets, and Farooq et al. (2023) for Gulf countries. This complexity underscores the need for comprehensive and region-specific assessments to address environmental sustainability in the context of tourism. After reviewing prior research, it is evident that the environmental impacts of tourism have been examined through a variety of methodologies, including direct surveys using questionnaires (Tovar and Lockwood, 2008), input-output analysis (Jones, 2023; Hartono et al., 2023), computed general equilibrium (CGE) assessments (Dwyer et al., 2010), and econometric-based investigations.

The majority of econometric studies have shown that tourism tends to increase CO_2 emissions. For example, Solarin (2013) found this pattern in Malaysia, while Katircioglu et al. (2014) documented similar results in the European context, supporting a common theme in the literature. Notably, Paramati et al. (2017) proposed that implementing sustainable tourism policies could raise awareness of environmental conservation and strengthen efforts to combat ecological degradation. Given these theoretical foundations, it is plausible to argue that tourism's influence on CO_2 emissions may either mitigate or exacerbate the situation in top tourist destinations. Still, in a study using an input-output methodology and focusing on Wales in the UK, Jones (2023) highlighted the slow pace of decarbonization efforts, indicating that the tourism sector has not yet made a substantial transition toward climate responsibility. Corroborating these results, Hartono et al. (2023) pointed out that activities associated with tourism, such as transportation, have experienced substantial growth in recent years. This trend suggests that the increase in tourist arrivals is contributing to the significant rise in CO_2 emissions.

METHODOLOGY

In the following Figure 2, all of the methodological steps are explained. The research methodology adopted a multi-step approach to thoroughly examine the impact of variable selection, data selection, and econometric model choice on the outcomes of econometric analysis. Initially, a stringent variable selection process was implemented to recognize the most relevant and statistically significant variables for the analysis. Moreover, three unit root tests, namely Harris-Tzavalis, Im-Pesaran-Shin (IPS), and Levin, Lin, and Chu (LLC), were employed to assess the stationarity of the time series data. Next, an suitable econometric model, the Generalized Method of Moments (GMM), was carefully chosen to analyze the dynamic relationships between the variables of interest. Finally, quantile regression was utilized as a robustness check to validate the findings of the baseline GMM model.

1. Data and Variable Selection

Environmental degradation is influenced by tourism, trade, GDP per capita, per capita electricity consumption, population, and consumption expenditure. This study offers empirical evidence of the variables influencing CO_2 emissions in the top 32 tourist countries. These countries were selected as top tourist-receiving countries from six different continents. Data were collected from 32 countries: Austria, France, Germany, Italy, Portugal, Switzerland, Spain, Turkey, the UK, Canada, Mexico, the USA, Brazil, Argentina, Chile, China, Hong Kong, India, Indonesia, Japan, Singapore, South Korea, Saudi Arabia, the UAE, Thailand, Vietnam, Egypt, Morocco, South Africa, Tunisia, Australia, and New Zealand.

Table 1 outlines the variables utilized in this research. All variables are expressed in logarithmic format (ln), which can help in mitigating skewness and normalizing the distribution of the data. These variables will be investigated for their associations with carbon emissions in the selected tourist countries using econometric techniques, such as GMM and quantile regression. Table 2 provides the descriptive statistics for the required variables used in the study. These statistics offer insights into the mean, standard deviation, and range of each variable. For instance, the mean total CO_2 emissions (lnCO2) is 12.52 with a standard deviation of 1.089, indicating a moderate level of variability around the mean value. Similarly, other variables such as international tourism arrivals (lnTA) and international tourism receipts (lnTR) exhibit distinct ranges and variability, providing a foundation for further analysis of their environmental implications in leading 32 global tourist destinations.

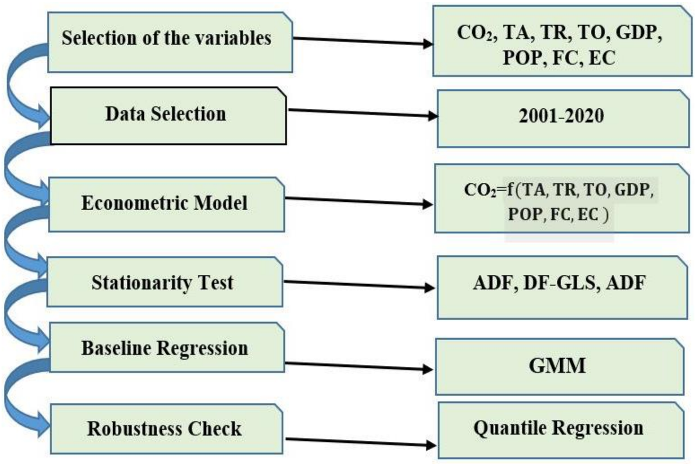

Figure 2. Flowchart of methodology

Table 1. Variables List

Variables name	Log format	Indicator Name
CO_2	lnCO_2	Total CO_2 emissions
TA	lnTA	International tourism, number of arrivals
TR	lnTR	International tourism, receipts (current US$)
GDP	lnGDP	GDP per capita (current US$)
TO	lnTO	Trade (% of GDP)
POP	lnPOP	Population, total
FC	lnFC	Final consumption expenditure (% of GDP)
EC	lnEC	Electric power consumption (kWh per capita)

Table 2. Descriptive Statistics

Variable Name	Mean	SD	Min	Max
lnCO_2	12.52	1.089	10.32	15.57
lnTA	16.75	1.221	14.46	19.17
lnTR	23.45	1.064	20.91	26.19
lnTO	4.252	0.697	3.084	6.093
lnGDP	9.611	1.222	6.003	11.13
lnPOP	17.63	1.162	15.01	19.61
lnEC	8.280	1.001	5.789	9.756
lnFC	4.301	0.138	3.735	4.587

2. Econometrics equations

This study selects two tourism-related variables to obtain a robust picture of our research. The two tourism-related variables are the number of international tourist arrivals and international tourism receipts (current US $). The research incorporates the relevant explanatory variables and CO_2 emissions into the following Equation (1).

Equation (1) represents the conceptual framework of the study, highlighting the relationship between environmental degradation and related factors, including tourism, socioeconomic aspects, technological advancements, population, and potentially other influencing elements. The equation suggests that environmental degradation is not solely determined by tourism but is rather a complex phenomenon influenced by a mixture of various factors.

$$\text{Environmental Degradation} = f\,(\text{Tourism, Population, Socio-economic, Technological, and other factors}) \quad (1)$$

The research employed the STIRPAT model, which is ideally suited for this study as it can empirically examine the complex relationship between tourism and carbon emissions. By accounting for population, consumption expenditure, and technological factors, the STIRPAT model provides a comprehensive framework for quantitatively assessing the impact of tourism on environmental sustainability. Its logarithmic transformations allow for nonlinear relationships and robust regression analysis, enabling us to isolate the specific impacts of tourism-related variables on carbon emissions.

Equations (2)–(4) show the details of the model. The following Equation (2) and (3) represents the core concept of the STIRPAT model, capturing the notion that environmental impact (Impact) is a function of Population (P), Affluence or Asset (A), and Technological improvements (T). This simple yet powerful framework underscores the interconnectedness of these factors in shaping environmental outcomes. Equation (4) explicitly defines the dependent variable, CO_2 emissions, as a function of tourism, population, GDP, trade openness, final financial consumption, and electricity consumption. This comprehensive equation encompasses the key factors influencing CO_2 emissions, allowing for a nuanced understanding of the environmental implications of tourism and other contributing factors.

$$\text{Impact} = \text{PAT} \quad (2)$$

$$\text{Impact on Environment} = \text{Population* Affluence* Technologies} \quad (3)$$

$$CO_2 = f\,(\text{Tourism, Population, GDP, Trade, Financial Consumption, Electricity Consumption}) \quad (4)$$

Equation (5) shows the baseline equation for CO_2, tourist arrivals, and the interconnectedness of other attributes.

$$CO_{2i,t} = \alpha + \beta TA_{i,t} + \gamma X_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (5)$$

$$CO_{2it}= \beta_0+ \beta_1TA_{it} + \beta_2TO_{it}+ \beta_3GDP_{it} + \beta_4POP_{it} + \beta_5FC_{it} + \beta_6EC_{it} + \varepsilon_{it} \quad (6)$$

Equation (6) is the STIRPAT format and is the detailed form of Equation (5). In Equation (6), CO_{2it} represents the carbon dioxide emissions for the country "i" at a time "t." β0 is the intercept term, representing the baseline level of CO_2 emissions when all the independent variables are zero. β1, β2, β3, β4, β5, and β6 are coefficients associated with the independent variables in Equation (6).Equation (7) is the baseline equation for international tourist receipts (current US$). Equation (8) is the detailed form of the STIRPAT format and equation mentioned above.

Equation (9) is the log form of Equation (6). Equation (10) is the log form of Equation (8).

$$CO_{2i,t}= \alpha + \beta TR_{i,t}+ \gamma X_{i,t}+\mu_i+\delta_t+\varepsilon_{i,t} \quad (7)$$

$$CO_{2it}= \beta_0+ \beta_1TR_{it} + \beta_2TO_{it}+ \beta_3GDP_{it} + \beta_4POP_{it} + \beta_5FC_{it} + \beta_6EC_{it} + \varepsilon_{it} \quad (8)$$

$$lnCO_{2it}= \beta_0+ \beta_1InTA_{it} + \beta_2lnTO_{it}+ \beta_3lnGDP_{it} + \beta_4lnPOP_{it} + \beta_5lnFC_{it} + \beta_6lnEC_{it} + \varepsilon_{it} \quad (9)$$

$$InCO_{2it}= \beta_0+ \beta_1lnTR_{it} + \beta_2lnTO_{it}+ \beta_3lnGDP_{it} + \beta_4lnPOP_{it} + \beta_5lnFC_{it} + \beta_6lnECit + \varepsilon it \quad (10)$$

In these above Equations, TR represents international tourism receipts as a percentage of GDP for a country "i" at a time "t." Coefficient β_1 captures the relationship between tourism receipts and $lnCO_2$ emissions, indicating how changes in tourism receipts affect $lnCO_2$ emissions. TA indicates tourism arrivals. TOit represents trade as a percentage of GDP for the country "i" at a time "t." In similar way, GDPit refers to ln GDP per capita, POPit represents the total population, FCit represents final consumption expenditure as a percentage of GDP, and ECit refers to electric power consumption per capita. Ɛit represents the error term or residual, capturing the unexplained variation in CO2 emissions that the independent variables in the model do not account for. The coefficients (β_1 to β_6) provide insights into the magnitude and direction of these relationships (between TR, TA, TO, GDP, POP, FC, and EC towards CO_2), whereas the error term (Ɛit) captures any unexplained variability in CO_2 emissions.

3. Generalized Method of Moments (GMM)

Several econometric techniques, including the system GMM econometric approach, were used to attain our research objective. The total period is T = 21 years, from 2000 to 2020, smaller than the number of cross-sectional (N = 32 countries) cross-sections. According to Baltagi (2008), the dynamic nature of data is useful. Compared to other GMM econometric methodologies, the system GMM method yields more accurate and reliable estimations. Furthermore, our strategy addresses the expected link between the error term and country-fixed effects. The problem is more pronounced in dynamic punitive data because there is less time and more cross-sections (Nickell, 1981).

A system GMM methodology can be used to avoid endogeneity and heterogeneity issues. Our analysis may have a problem of reverse causality with carbon dioxide emissions because the independent variables are institutional and macroeconomic variables. Abdouli and Hammami (2017) also addressed the omitted variable bias using a GMM system and produced an estimate of its dependability. Arellano and Bover (1995) offered a specific solution, which Blundell and Bond (1998) expanded. The two-step GMM approach generates more accurate estimators than the one-step system. The Hansen test (Hansen, 1982) or the Sargan test should be used to determine the instrument's validity (Sargan, 1958) and be more suitable (Iqbal and Daly, 2014). The decision to use two-step GMM is for the following reasons: (1) the number of countries in our sample (N) is greater than the number of years (t); (2) the correlation between dependent variables and their lag is greater than 0.8; (3) the simultaneity and omitted variable bias problems in the estimates from the mean regression estimator; and (4) the two-step system GMM corrects biases that emerge while differentiating variables. The research estimates the following requirements at level and the first differences, as follows: Equations (11) and (12) are the two-step System GMM for total international tourist arrivals:

$$lnCO2_{i,t} = \alpha_0 + \alpha_1lnCO2_{i,t-t} + \alpha_2lnTA_{i,t} + \sum^4_{k=1}\Phi_3lnX_{k,i,t-t} + \varepsilon_{i,t} \quad (11)$$

$$lnCO2_{i,t} - lnCO2_{i,t-t} = \alpha_1 \, lnCO2_{i,t-t} - lnCO2_{i,t-2t} + \alpha_2 \, lnTA_{i,t} - lnTA_{i,t-t} + \sum_{k=1}^4 \Phi_3 \, lnX_{k,i,t-t} - lnX_{k,i,t-2t} + \varepsilon_{i,t} - \varepsilon_{i,t-t} \quad (12)$$

Equations (13) and (14) are the two-step System GMM for International tourism receipts (current US $):

$$lnCO2_{i,t} = \alpha_0 + \alpha_1 \, lnCO2_{i,t-t} + \alpha_2 \, lnTR_{i,t} + \sum^4_{k=1} \Phi_3 \, lnX_{x,i,t-t} + \varepsilon_{i,t} \quad (13)$$

$$lnCO2_{i,t} -lnCO2_{i,t-t} = \alpha_1 \, lnCO2_{i,t-t} - lnCO2_{i,t-2t} + \alpha_2 \, lnTR_{\ i,t} – lnTR_{i,t-t} +\sum^4_{k=1} \Phi_3 \, lnX_{k,i,t-2t} + \varepsilon_{i,t} - \varepsilon_{i,t-t} \quad (14)$$

Where CO_2 it is the total carbon emissions in the ith country in year t, TA signifies foreign tourist arrivals in selected countries, TR signifies the amount received from tourists, X signifies the vector of control variables, τ signifies the auto-regression parameter, and ε signifies a disturbance term. Asongu and Odhiambo (2018) state that the GMM estimator has been used in several types of research to investigate how tourism, wealth, and information and communications technology (ICT) affect financial development, economic growth, and sustainability (Umurzakov et al., 2022).

4. Quantile Regression (QR)

The paper also applies the QR method to examine the relationship between CO_2 emissions and the other independent variables at 25%, 50%, and 75%. These quantiles provide a good estimate of CO_2 emissions.

Equation (15) is the quantile model for international tourist arrival.

$$QR_{i,t} = \alpha_i^q + \beta_i{}^q{}_{,lnTAit} \, QR_{lnTAit} + \beta^q{}_{i,lnTOit} \, QRln_{TOit} + \beta^q{}_{i,lnGDPit} \, QR_{lnGDPit} + \beta^q{}_{i,lnPOPit} \, QR_{lnPOPit} + \beta^q{}_{i,lnFCit} \, QR_{lnFCit} + \beta^q{}_{i,lnEC} \, QR_{lnEC,it} \ldots \ldots \ldots \ldots \quad (15)$$

Equation (16) is the quantile model for international tourism receipts (current US$):

$$QR_{i,t} = \alpha_i^q + \beta^q{}_{i,lnTRit} \, QR_{lnTRit} + \beta_i{}^q{}_{,lnTOit} \, QR_{lnTOit} + \beta_i{}^q{}_{,lnGDPit} \, QR_{lnGDPit} + \beta_i{}^q{}_{,lnPOPit} \, QRln_{POPit} + \beta_i{}^q{}_{,lnFCit} \, QR_{lnFCit} + \beta_i{}^q{}_{,lnECit} \, QR_{lnECit} \ldots \ldots \ldots \ldots \quad (16)$$

RESULTS

Table 3 displays the pairwise correlations between the dataset variables, all in a logarithmic form. The correlations range from -1 to 1 and provide insights into the strength and direction of the relationships between the variables. These correlations provide initial perceptions of the relationships between variables, such as lnCO_2 and lnTA, lnTR, lnGDP, lnPOP, lnFC and lnEC, suggesting that these variables may be positively associated with CO_2 emissions. In contrast, the negative correlation between lnCO_2 and lnTO indicates a potentially negative relationship between trade and CO_2 emissions. However, further analysis and modelling are necessary to determine the strength and significance of these relationships and account for other potential factors influencing CO_2 emissions. Panel data analysis uses the panel unit root test to determine whether the dependent and independent variables are stationary or non-stationary. Various panel unit root tests are available in the literature. Table 4 provides the data as the level or first difference for the unit root test of the dependent and independent variables. There is a unit root in H0, but none in H1, which is a nonstationary process. The table shows that all variables are stationary at I (1). Therefore, this study applies GMM and QR models.

Table 3. Correlation (Source: authors calculation) *** p<0.01, ** p<0.05, * p<0.1

Variables	InCO$_2$	InTA	InTR	InTO	InGDP	InPOP	InFC	InEC
InCO$_2$	1.000							
InTA	0.585***	1.000						
InTR	0.666***	0.800***	1.000					
InTO	-0.501***	-0.016	-0.058	1.000				
InGDP	0.301***	0.450***	0.570***	0.066	1.000			
InPOP	0.718***	0.291***	0.264***	-0.604***	-0.382***	1.000		
InFC	0.349***	0.169***	0.066	-0.667***	-0.167***	0.493***	1.000	
InEC	0.290***	0.342***	0.451***	0.079	0.931***	-0.440***	-0.145**	1.000

Table 4. Unit Root Test Result (Source: Author's Calculation)

Note: ***, **, and *denote significance at the 1 %, 5 %, and 10% levels. Presume as trend and intercept

Variables	At Level			At 1st Difference		
	Harris-Tzavalis	Im-Pesaran-Shin	Levin, Lin and Chu	Harris-Tzavalis	Im-Pesaran-Shin	Levin, Lin and Chu
InCO$_2$	0.258	0.826	-0.471	-30.35***	-8.765***	-5.613***
InTA	1.52	2.194	4.70	-32.44***	-9.13***	-7.29***
InTR	-1.18	-0.636	-0.559	-31.93***	-9.177***	-7.82***
InTO	-0.236	-0.663	-0.373	-30.19***	-11.33***	-15.88***
InGDPpc	0.911	1.045	.362	-32.10***	-8.956***	-5.15***
InPOP	-0.536	-0.763	-0.073	-38.19***	-9.33***	-7.88***
InFC	-1.18	-0.636	-0.559	-31.93***	-9.177***	-7.82***
InEC	-1.11	0.517	0.545	-37.52***	-9.769***	-7.72***

Table 5 presents the log-log model with the dynamic panel data estimate. Columns 1, 2, and 3 indicate the various two-step System-GMM models. As a precaution, this study excluded the top five tourist-receiving countries with the highest and lowest adjusted tourist arrivals (Columns 2 and 3, respectively). As a result, five of the most visited countries dropped from Model 2, whereas the bottom five countries dropped from Model 3. Table 5 provides information on the effects of various independent variables on lnCO_2 in each model. InCO_2 (logarithm of CO_2 emissions) was the dependent variable in all models. The independent variables in the various models were compared as follows: This variable represents the lagged value of lnCO_2 that accounts for the impact of previous CO_2 emissions on current levels. In all three models, the L.lnCO_2 coefficient is uniformly significant and positive. This implies that past CO_2 emissions had a positive effect on CO_2 emissions. LnTA represents the logarithm of international visitor arrivals. The coefficient for lnTA is consistently negative and statistically significant in all three models. This finding suggests a relationship between higher foreign visitor arrivals and reduced CO_2 emissions. The logarithm of the trade-to-GDP ratio is lnTO, and in none of the models is the coefficient of lnTO statistically significant, indicating that trade does not have a significant effect on lnCO_2. This suggests that in the context of overall tourist arrivals, CO_2 emissions are not significantly influenced by trade levels. GDP per capita is represented by lnGDP, and the coefficient of lnGDP is positive and statistically significant in all the three models.

This suggests that higher GDP per capita is associated with higher CO_2 emissions. The logarithm of the total population is lnPOP, and the coefficient of lnPOP is consistently positive and statistically significant in all three models. The final consumption expenditure logarithm, expressed as a proportion of GDP, is lnFC, and the coefficient of lnFC is consistently negative and statistically significant in all three models. This suggests that reducing final consumption spending as a percentage of GDP leads to lower CO_2 emissions. The logarithm of the electric power consumption per person is lnEC. In Models 1 and 3, but not in Model 2, the coefficient of lnEC is positive and statistically significant.

Although the relevance varies across models, increasing electric power usage per capita may be positively correlated with CO_2 emissions. None of the models' constant terms (intercepts) is statistically significant, implying that the independent variables have a more substantial influence on lnCO_2 than the constant term itself. A comparison of the three models demonstrates that the effects of foreign tourist arrivals (lnTA), GDP per capita (lnGDP), population size (lnPOP), and final consumption expenditure (lnFC) on CO_2 emissions (lnCO2) are consistent with each other. Elevated CO_2 emissions result from tourism and increased economic activities. Nonetheless, emissions can be lowered by adopting sustainable consumption habits, underscoring the need for further research and robustness tests.

Table 6. Two-step System GMM model for international tourism receipts (current US$)
(Source: Calculation by the author) Robust standard errors in parentheses- *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Variables	Model 1	Model 2	Model 3
L.lnCO2	0.847***(0.0484)	0.897***(0.0484)	0.869***(0.0484)
lnTR	- 0.0435***(0.0141)	- 0.0416***(0.0141)	- 0.0445***(0.0141)
lnTO	-0.0117(0.0290)	-0.0156(0.0290)	-0.0126(0.0290)
lnGDP	0.0341(0.0179)	0.0441(0.0169)	0.0352(0.0169)
lnPOP	0.146***(0.0492)	0.146***(0.0492)	0.146***(0.0492)
lnFC	-0.0190(0.0689)	-0.0190(0.0689)	-0.0190(0.0689)
lnEC	0.0962**(0.0463)	0.0962**(0.0463)	0.0962**(0.0463)
Constant	-1.456*(0.835)	-1.456*(0.835)	-1.456*(0.835)
Excluded	None	Top-5	Bottom-5
AR(1)	0.00	0.00	0.00
AR(2)	0.08	0.12	0.18
Hansen Test	0.34	0.35	0.29
Number of ids	32	27	27

Table 5. Two-step System GMM model for total tourist arrivals (dependent variable is LCO_2)
(Source: Calculation by the author) Robust standard errors in parentheses- *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Variables	Model 1	Model 2	Model 3
L.lnCO_2	0.848***(0.0602)	0.848***(0.0602)	0.848***(0.0602)
lnTA	-0.0265***(0.0109)	-0.0255***(0.0109)	-0.0281***(0.0109)
lnTO	-0.0298(0.0255)	-0.0298(0.0255)	-0.0298(0.0255)
lnGDP	0.0359*(0.0188)	0.0348*(0.0168)	0.0357*(0.0177)
lnPOP	0.140**(0.0617)	0.142**(0.0617)	0.138**(0.0617)
lnFC	-0.141**(0.0633)	-0.143**(0.0633)	-0.152**(0.0633)
lnEC	0.113*(0.0537)	0.104*(0.0537)	0.1054*(0.0537)
Constant	-0.543(0.840)	-0.543(0.840)	-0.543(0.785)
Excluded	None	Top-5	Bottom-5
AR(1)	0.00	0.00	0.00
AR(2)	0.08	0.12	0.18
Hansen Test	0.34	0.35	0.29
Number of ids	32	27	27

As presented in Table 6, feature CO_2 emissions (lnCO_2) as the dependent variable. This table examines the effects of several independent variables on lnCO_2 (the logarithm of CO_2 emissions) and compares three distinct models (Model 1, Model 2, and Model 3). The following is a comparison of the models and an explanation of the effects of each independent variable: All three models incorporate the lagged value of lnCO_2 (past CO_2 emissions), which has a statistically significant and favorable effect on lnCO2 (present CO_2 emissions). This suggests that historical CO_2 emissions consistently influence current emissions across all models. The independent variable in this model is lnTR (international tourism receipts), whereas earlier models employed lnTA (international tourist arrivals). The coefficient for lnTR is consistently negative and statistically significant in all three models. This indicates that lower CO_2 emissions are associated with increased international tourism receipts. Tourism-related activities with higher revenue streams may have lasting environmental impacts.

In none of the models, lnTO, which represents trade as a percentage of GDP, has a statistically significant effect on lnCO_2. The coefficient for lnGDP, which represents GDP per person, is not statistically significant in any of the models. This suggests that GDP per capita does not have a significant impact on CO_2 emissions in the context of international tourism receipts. In all three models, the logarithm of the total population (lnPOP) consistently has a positive and statistically significant effect on lnCO2. This shows that a larger population size is linked to increased CO_2 emissions, regardless of the revenue generated by international tourism. None of the models lnFC, which represents final consumption spending as a percentage of GDP, has a statistically significant effect on lnCO_2. This implies that when taking foreign tourism receipts into account, the ratio of final consumption spending to GDP does not significantly affect CO_2 emissions. The coefficient for lnEC, which represents electric power consumption per person, is consistently positive and statistically significant in all three cases. This suggests that energy consumption patterns should be considered when analyzing the correlation between revenue from international tourists and CO_2 emissions as it has detrimental effects for environmental quality. The results of the comparison of the three models indicate that the effects of electric power consumption per capita, total population, and international tourist receipts on CO_2 emissions are consistent. The significance of factors such as GDP per capita and final consumption spending varies among the models, underscoring the necessity of considering multiple variables and conducting further research to fully understand the complex relationship between international tourism receipts and CO_2 emissions.

Table 7 displays the results of the quantile regression analysis for international tourist arrivals, considering different quantiles: Q25 (25th percentile), Q50 (50th percentile), and Q75 (75th percentile). The table shows the coefficients and their corresponding standard errors for each independent variable at each quantile. Here is an explanation of the findings: The coefficient for lnTA (international tourist arrivals) is negative and statistically significant at the 25th and 50th percentiles. This suggests that higher international tourist arrivals are associated with lower CO_2 emissions for countries at these quantiles. However, at the 75th percentile, the coefficient is negative and statistically significant at a higher level, indicating an even stronger negative relationship between tourist arrivals and CO_2 emissions.

The coefficient for trade as a percentage of GDP (lnTO) is negative and statistically significant at all levels, indicating that a higher proportion of trade relative to GDP is associated with lower CO_2 emissions across all levels. The negative coefficient becomes more pronounced at higher levels, suggesting a stronger negative relationship between trade and CO_2 emissions for countries with higher levels of tourist arrivals. The coefficient for GDP per capita (lnGDP) is not statistically significant, indicating that GDP per capita does not significantly impact CO2 emissions for international tourist arrivals at all levels. The coefficient for total population (lnPOP) is positive and statistically significant at all levels, implying that a larger population size is associated with higher CO_2 emissions for countries at all levels of international tourist arrivals. The coefficient for final consumption expenditure as a percentage of GDP (lnFC) is negative and statistically significant at the 50th and 75th percentiles, indicating that a higher proportion of final consumption expenditure relative to GDP is associated with lower CO_2 emissions for countries at these quantiles. However, the negative coefficient is not statistically significant at the 25th percentile. The coefficient for electric power consumption per capita (lnEC) is positive and statistically significant at all levels, suggesting that higher electric power consumption per capita is associated with higher CO_2 emissions across all levels of international tourist arrivals. The quantile regression results indicate that the association between independent variables and CO_2 emissions varies with the level of international tourist arrivals. Some variables, such as lnTA, lnTO, lnPOP, and lnEC, consistently display significant effects, but the impact of lnGDP and lnFC fluctuates based on the quantile. These findings underscore the significance of accounting for the varying effects of independent variables at different levels of tourist arrivals when examining the determinants of CO_2 emissions.

Table 7. Quantile Regression for international tourist arrivals Models (Source: Calculation by the author) Standard errors in parentheses- *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Variables	Q25	Q50	Q75
lnTA	-0.0597**(0.0227)	-0.0577***(0.0133)	-0.0817**(0.0358)
lnTO	-0.0590***(0.0109)	- 0.104***(0.0339)	-0.246***(0.0656)
lnGDP	0.0459(0.0816)	0.0348(0.0255)	0.0676(0.0493)
lnPOP	1.093***(0.0510)	1.093***(0.0159)	1.014***(0.0308)
lnFC	-0.513(0.471)	-0.630***(0.147)	-0.983***(0.285)
lnEC	0.860***(0.0910)	0.751***(0.0284)	0.715***(0.0550)
Constant	-11.49***(2.663)	-10.54***(0.832)	-6.471***(1.610)
Observations	462	462	462

Table 8. Quantile Regression for International tourism receipts (current US$) (Source: Calculation by the author) Standard errors in parentheses- *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Variables	Q25	Q50	Q75
InTR	-0.057**(0.02760)	-0.0629**(0.0273)	-0.0391***(0.0147)
InTO	- 0.143***(0.034)	-0.153***(0.0480)	- 0.245***(0.0835)
InGDP	0.191(0.121)	0.0154(0.0433)	0.0666(0.0753)
InPOP	1.030***(0.0696)	1.007***(0.0250)	0.994***(0.0434)
InFC	-0.926(0.563)	-0.889***(0.202)	-0.958***(0.351)
InEC	0.950***(0.120)	0.733***(0.0432)	0.762***(0.0750)
Constant	-9.867***(3.051)	-8.512***(1.096)	-5.792***(1.905)
Observations	478	478	478

Table 8 presents the findings of a quantile regression analysis for international tourism receipts. Instead of utilizing lnTA as an independent variable, the analysis employs lnTR (international tourist receipts). At the 25th and 50th percentiles, the coefficient for lnTR is negative and statistically significant, indicating that lower CO_2 emissions are associated with higher international tourism receipts for countries in these quantiles. The coefficient is negative and statistically significant at a lower level at the 75th percentile, but the correlation between tourism receipts and CO_2 emissions is weaker. The results of the quantile regression analysis demonstrate the impact of multiple variables on CO_2 emissions for international tourism revenues at different quantiles. While lnGDP and lnFC do not consistently show significant effects across all quantiles, the variables lnTR, lnTO, lnPOP, and lnEC do.

DISCUSSION

The study's findings suggest that tourists' arrivals and revenues have a negative correlation with CO_2 emissions. There are various reasons that contribute to reduced CO_2 emissions in the tourism sector. Technological advancements in transportation and accommodation, such as fuel-efficient aircraft, hybrid and electric vehicles, and energy-saving practices in hotels and resorts, have led to a reduction in carbon intensity. The transportation sector is the primary source of CO_2 emissions, accounting for almost 70% of total emissions. The tourism industry has also placed a greater emphasis on sustainable practices and policies in recent years. Many destinations, tourism organizations, and businesses have implemented sustainability initiatives to minimize their ecological footprint and conserve natural resources. These programs cover trash reduction and recycling campaigns, energy and water conservation, community involvement, and the promotion of regional and organic goods. Overall, the tourism industry's efforts towards sustainability have contributed to a reduction in CO_2 emissions. Our findings are consistent with previous research, which has demonstrated that tourism activity can lead to reduced environmental degradation in destinations such as the Middle East (Voumik et al., 2023a), G7 Countries (Ahmad et al., 2022), top visited destinations (Ansari and Villanthenkodath, 2022), selected top tourist destinations (Fethi and Senyucel, 2021), and countries participating in the Belt and Road initiative (Umurzakov et al., 2023). However, our results contradict those of Gao et al. (2021) for Mediterranean countries, Balsalobre-Lorente et al. (2023) for OECD countries, Farooq et al. (2023) in Gulf countries, Irfan et al. (2023) in China, Onifade et al. (2023) in the Middle East, Rahman et al. (2022) in Malaysia, and Nathaniel et al. (2023) in emerging markets.

In line with Ozturk et al. (2023), Jahanger et al. (2023), and Banga et al. (2023), variations in the relationship between CO_2 emissions and tourism can be attributed to differences in policies, energy sources, tourist attractions, transportation, technology, and other environmental regulations. This underscores the significance of actively promoting environmentally responsible practices. Plausible explanations include the inclusion of countries in the top 32 list that have increased the use of renewable energy, such as Austria, France, Germany, Italy, Portugal, Switzerland, Spain, the UK, Canada, and New Zealand. These countries have made significant investments in renewable energy and have a substantial share of renewables in their energy mix. Additionally, emerging destinations have shifted their economic activities from sectors with higher energy intensity to services and tourism, which typically have lower energy intensity. Furthermore, improvements in energy efficiency, implementation of new energy policies, and growing demand for sustainable destinations are likely to contribute to tourism's positive impact on environmental quality. The study suggests that rising CO_2 emissions are associated with population growth. As the population increases, CO_2 emissions have risen due to two primary factors: the need for energy to power homes, transportation networks, businesses, and other sectors has climbed alongside the population. When fossil fuels, such as coal, oil, and natural gas, are burned to provide energy, they release CO_2 into the atmosphere. Furthermore, population expansion is often accompanied by changes in consumer habits and lifestyles, leading to an increase in transportation-related emissions. For example, a growing population may result in more transportation-related emissions (Hartono et al., 2023). The findings in Sun et al. (2023) for 30 tourist destinations, Nathaniel et al. (2023) for emerging markets, and Farooq et al. (2023) for Gulf countries support the positive correlation between population and CO_2 emissions.

The study suggests that trade can lead to a reduction in CO_2 emissions, primarily due to the development and innovation that it spurs, resulting in cleaner and more energy-efficient production methods. This may lead to a shift towards greener energy sources, increased manufacturing energy efficiency, and the adoption of environmentally friendly business practices. Technological improvements can help decrease the carbon intensity of trade-related activities, which would reduce CO_2 emissions. Trade agreements and environmental legislation can also help promote sustainable trading practices and reduce CO_2 emissions. The study also indicates that rising CO_2 emissions are linked to power generation, with the high reliance on fossil fuels such as coal, oil, and natural gas being a significant contributor to the increase in emissions from power production. Thermal power stations primarily use these fossil fuels to generate electricity, which is becoming increasingly necessary, particularly in rapidly developing countries where the use of fossil fuels in energy production is on the rise. This reliance on fossil fuels leads to increased CO_2 emissions, exacerbating the issue of climate change. According to Durani et al. (2023), when environmental regulations become less strict, the number of tourists visiting a country decrease. Therefore, countries should take unique steps to encourage tourism while enforcing strict environmental rules. Additionally, tourists should be offered incentives to counterbalance the negative effects of these regulations. To ensure sustainable tourism destinations thrive, it is crucial to complement them with sustainable urban areas, transportation systems, and infrastructure that collectively reduce the overall environmental footprint of tourism.

Overall, the findings of our study shed light on the intricate relationship between various socio-economic factors and their influence on CO_2 emissions in leading global tourist destinations. Notably, tourist arrivals, tourism receipts, and trade openness exhibit negative coefficients, indicating that an increase in these variables is associated with a decrease in CO_2 emissions. This suggests that a thriving tourism sector, coupled with an open economy, may contribute to environmental sustainability by reducing CO_2 emissions. Conversely, our analysis reveals that variables such as population and electricity consumption have positive and significant impacts on CO_2 emissions, signifying that higher population density and increased energy consumption tend to elevate environmental footprints. Interestingly, while GDP exhibits a positive coefficient on CO_2 emissions, it is not statistically significant, implying that economic prosperity alone may not be a dominant driver of environmental impact in these destinations. Additionally, final consumption expenditure emerges as a noteworthy factor, displaying a negative and significant impact on environment. This underscores the potential of mindful consumption patterns in mitigating environmental harm, highlighting a promising avenue for sustainable tourism practices. These findings contribute to a nuanced understanding of the multi-faceted dynamics between tourism, economic variables, energy, and environmental outcomes, offering valuable insights for policymakers and stakeholders seeking to foster environmentally responsible tourism development.

CONCLUSION

The current study investigates the connection between tourism and carbon emissions, as it has a significant impact on top tourist destinations. Furthermore, the study examines the relationship between trade, consumption, GDP, and population variables. The findings suggest that tourism can both positively and negatively impact the environment, with CO_2 emissions increasing due to factors such as GDP growth, per capita electricity consumption, and population growth. Additionally, trade openness and final consumption can also reduce CO_2 emissions. The study also discovered that the effects of the two models are the same, but the coefficients of the two models are different. Previous research by Udemba et al. (2020) found a positive correlation between CO_2 emissions and factors such as energy consumption, FDI, and population, which negatively impacts GDP. The study has shown that high levels of energy consumption, GDP growth, and population growth lead to increased CO_2 emissions. Furthermore, these factors are interrelated, with population growth driving the need for urbanization and increased energy use, which in turn leads to higher CO_2 emissions. However, GDP growth is supported by industrialization and the extreme use of power and energy, which also contributes to increased CO_2 emissions. The findings suggest that trade liberalization has a significant impact on CO_2 emissions, and the importance of trade openness varies depending on the level of CO_2 emissions. This is supported by a previous study conducted by Chen et al. (2021).

The study revealed a negative correlation between tourism-related CO_2 emissions, with the top 32 tourism destinations from six world regions. These nations have well-developed tourism industries, which may use contemporary equipment and engage in sustainable tourism. Tourism businesses prioritize technology innovation in their daily operations, contributing to the reduction of CO_2 emissions. These findings suggest the need for legislative interventions and sustainable practices in the travel and tourism sector to minimize the negative environmental effects of tourist-related activities. Promoting eco-friendly products, sustainable consumption habits, and carbon-offset programs could be efficient ways to reduce CO_2 emissions while fostering the growth of the tourism industry. Overall, this research contributes to the larger discussion on sustainable tourism development and environmental management by providing valuable information about the complex relationship between international tourism, CO_2 emissions, and various factors.

Policy Implications

The environmental threat posed by CO_2 emissions is a significant concern for countries (Voumik et al., 2023b), and it is crucial for studied countries to take it seriously. This study offers theoretical implications for future research and practical policies for sustainable tourism and economic growth. The novelty of this study provides a comprehensive understanding of the relationship between tourism, economic growth, and environmental degradation, which will aid in generating further research. The study found that in top tourist destinations, CO_2 emissions increased due to population growth in a destination, but technological advancements and a shift to renewable energies may have led to increased energy efficiency and reduced carbon intensity. Additionally, the transportation sector is the primary source of CO_2 emissions.

Furthermore, Koçak et al. (2020) suggest that the economies of the region should rely more on renewable energy sources to offset CO_2 emissions resulting from population growth and GDP expansion and to support the sustainable growth of the tourism industry (Shaheen et al., 2019). Policymakers can promote economic growth and tourism while reducing environmental degradation by decreasing the use of coal-based energy sources and increase the use of environmentally friendly sources like wind and solar power (in line with Fethi and Senyucel, 2021). The study suggests that the government should embrace climate-friendly technology to reduce CO_2 emissions, enhance sustainable tourism, promote sustainable population growth, and responsible consumption. Additionally, to reduce environmental destruction in the tourism sector, it is important to raise awareness among tourists and local communities about sustainable tourism practices (Halim et al., 2022). Furthermore, policymakers can gain sustainable technological knowledge from developed countries and use it to support sustainable tourism development in developing countries through Foreign Direct Investment (FDI) (Deb, 2021; Koçak and Şarkgüneşi, 2018). This will provide policymakers and future researchers with a clear understanding of the relationship between tourism and CO_2 emissions.

Table 9. Countries List

Continents	Countries
Europe	Austria, France, Germany, Italy, Portugal, Switzerland, Spain, Turkey, The UK
North America	Canada, Mexico, The USA
South America	Brazil, Argentina, Chile
Asia	China, Hong Kong, India, Indonesia, Japan, Singapore, South Korea, Saudi Arabia, The UAE, Thailand, Vietnam,
Africa	Egypt, Morocco, South Africa, Tunisia
Oceania	Australia, New Zealand

Table 10. Abbreviations

Abbreviation	**Details**
ARDL	Autoregressive Distributed Lag
CO_2	Carbon-dioxide
CSD	Cross-sectional dependence
CIPS	Cross-section Im-Pesaran-Shin
DOLS	Dynamic Ordinary Least Square
EFP	Ecological Footprint
EKC	Environmental Kuznets Curve
FOS	Fossil fuel
FMOLS	Fully Modified Ordinary Least Square
GDP	Gross Domestic Product
G20	Group of 20
GMM	Generalized Method of Moments
HO	Health outcome
IMF	International Monetary Fund
PMG-ARDL	Panel Mean Group Autoregressive Distributed Lag
QR	Quantile Regression
REC	Renewable Energy Consumption
R&D	Research & Development
TA	Tourists' Arrival
TO	Trade openness
TR	Tourism Receipts
WB	World Bank

Limitations and Future Scope of Study

The limitations of the study are related to the availability and quality of data. The study relies on the provided data, and there may be constraints regarding data coverage, accuracy, and consistency among nations. To enhance the validity of the findings, future studies can benefit from access to larger and more reliable datasets. Although econometric methods are used to examine the relationships between variables, it is important to remember that the analysis is correlational and does not establish causality. Moreover, unreported factors may influence international tourism and CO_2 emissions, potentially causing endogeneity issues. Future studies can address these issues by using alternative methods or experimental layouts, and by carefully choosing variables and model specifications. Future research has several avenues for exploration, such as alternative model specifications, incorporating other influential variables like environmental policies, infrastructure development, and cultural factors, and conducting comparative analyses across different countries or regions to better understand the relationship between tourism and CO_2 emissions. Additionally, sector-specific evaluations of tourism sub-sectors, such as accommodation, transport, and attractions, could provide insight into the contributions of each sub-sector to CO_2 emissions, allowing decision-makers and stakeholders to focus environmental interventions and sustainability initiatives on specific geographic areas. It is important to note that the research findings cannot be generalized to other situations due to the specific group of nations and period studied.

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