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Article

Green infrastructural development of tourism to mitigate the ecological footprint of economic growth: A comparative study across Asian nations

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Abstract: This research examines the intricate connection between tourism and environmental destruction in 28 Asian countries, concentrating on the non-linear impacts of tourism. Moreover, this study contemplates how tourism can mitigate the effects of economic growth on environmental decline. Westerlund, Johansen-Fisher, and Pedronico-integration tests are necessary to detect the co-integration connection between the proposed factors. The research also uses the Augmented Mean Group; the dynamic system generalized method of moments, and fully changed Ordinary Least Squares (OLS). These tools help address econometric and economic problems such as co-integration, dynamism, variation, inter-sectional dependence, and endogeneity. The results demonstrate a U-shaped non-linear connection between ecological footprint and Tourism in Asian nations. Primarily, the tourism industry can initially decrease environmental damage. However, as it increases in size, it can worsen the harm. Additionally, the study suggests that tourism negatively influences how economic growth affects ecological footprint. This research contributes to the existing literature on tourism's effects on the environment. The research suggests that tourism significantly impacts the environment; therefore, initiatives to reduce damage should be aimed at tourism.

Keywords: tourism development; ecological footprint; economic development; non-linear approach; sustainable development

1. Introduction

The connection between the business and indigenous peoples, the majority of whom are poor and retain traditional territory on or near tourist attractions, has increased due to this rise (Anderson, 2006). In light of this, the World Tourism Organization of the United Nations has proposed that the tourist industry may enhance several societal, financial, historical, and ecological aspects of local growth, particularly regarding indigenous peoples. The tourism industry has experienced the highest development of the sector—doubling every ten years since 1991 and expanding significantly in emerging economies. The effects on community infrastructure require special consideration (Li et al., 2021). The tourism industry's financial, societal, and ecological effects are measured in this work using a comprehensive method of local resources. The opening of a new cruising terminal in Honduras allowed researchers to test these effects on nearby indigenous people using a scientific study. This novel multi-method testable theory enables more flexibility and precision than other investigations.

Problems concerning cruise travel in our environment go beyond academia, as is the case for most potential impacts (Wiedmann and Barrett, 2010). Afro-indigenous residents of Trujillo, Honduras, alleged exclusion from the procedure and its advantages as the start of cruise travel in the area in November 2014 pitted them with

wealthy Honduran and international people in business. The trial of Randy Jorgensen, the site's Canadian builder, who was charged with stealing property from the Garifuna to build his industry's cruise ship terminal and other visitor attractions, marked the height of these conflicts. Numerous protesters brandished signs ordering Canadians to "go back" and decried overseas investors in the tourist industry as "imperialism" as they marched. The entrepreneurs' representatives repeated that the town would profit from cruise tourism's revenues and that the protesters ignored its straightforward job and financial advantages (Malik et al., 2016; Zhu et al., 2023).

These issues relate to significant fundamental discussions in global trade on the potential benefits of locally supported economic schemes. On one side of this argument, proponents of free-market growth contend that the regional poor will profit from capital funding since financial expansion helps all stakeholders (MacNeill and Wozniak, 2018). Others argue that early disparities distort economies and subvert government in the service of the strong, a claim frequently made in connection with dependence and world-systems theory (Veltmeyer, 2016). Between these two views, some contend that the magnitude of economic inefficiencies caused by the supply of government commodities or perfectly competitive limits the extent to which free enterprise capital helps societies (Fine, 2011; Waddock, 2004). Additionally, certain scholars emphasize that progress should be assessed by assessing the financial impacts and the assessment of multifaceted local resources, which are frequently connected with the capabilities approach (Gigler, 2004; Smyth and Vanclay, 2017).

Different issues (For instance, the earth's climate, weather, water, polluted air, wildlife mortality, loss, and the depletion of essential commodities) represent a significant danger to the stability of the ecosystem (Wu et al., 2021). The issues primarily relate to ecologically negligent human conduct (Hopkins, 2020; Xu et al., 2020). Studies agreed that by changing human behavior to be environmentally friendly, troublesome concerns might be handled and remedied (Han, 2020). Ecological viability primarily depends on changes in people's consumption habits, such as buying and using things environmentally friendly (Kannan et al., 2021).

As a result, over the past few years, academics and the public sector have increasingly emphasized the critical problem of evoking ecologically friendly consumer behavior (Dong et al., 2020). It is challenging to define ecofriendly consumer behavior, but the term is widely used and used as an overarching framework to showcase a person's different behavior that conserve natural resources (such as water and energy), reduce ecological damage (such as waste reduction), fulfill the requirements of community, and enhance his or her standard of living. Buckley et al. (2021) and Wut et al. (2021) further states that ecological conduct is such activity which is typically (or based on understanding of ecological research) assessed in the framework of the examined community as a defensive manner of ecological behavior or a homage to the peaceful ecosystem. Thus, phrases like "ecologically sound behaviors" (Dong et al., 2020), "ecologically viable behaviors" (Cró and Martins, 2017), and "environment-protecting/preserving behaviors" (Mao et al., 2010) are all used to describe such environmental behaviors (Han, 2020; Gigler, 2004; Yang et al., 2010). They are frequently used as synonyms for pro-environmental behavior. Pro-social consuming practices, which ultimately help the ecosystem and the general

public, include ecologically responsible consumption behavior (Park et al., 2021; Shin et al., 2022).

In the tourism industry and service, economic sustainability is growing more and more of a problem (MacNeill and Wozniak, 2018; Wang et al., 2021). The issue of environmental usage and greener growth is more crucial than ever in the modern tourist industry and accommodation business sector as a growing number of individuals in the market realize that many severe ecological types of defects are deeply embedded in the tourist industry extracurricular (Trawoger, 2014; Wang et al., 2021). Consumers in this industry are increasingly prepared to engage in social sustainability and expect sustainable goods (such as ecologically friendly accommodations, cafes, voyages, aeroplanes, locations, resorts, conferences, and gambling) (Chen, 2013; Shin et al., 2021). Many tourist and hotel businesses are progressively demonstrating a propensity to become active in developing green processes and goods due to this need and the environmental and economic climate (Hopkins, 2020; Lee and Chen, 2011). Consumers in the tourism and hotel industries are simultaneously learning that ecologically friendly practices are inevitable in both the settings where they purchase products and in their daily lives (Kannan et al., 2021; Wang et al., 2021).

There is no consensus on what constitutes ecologically responsible behavior of customers at this time. The words “green behavior” and “pro-environment behavior” are frequently used in ecological and psychological research to describe ecologically friendly conduct (Huang et al., 2023; Hüsser and Ohnmacht, 2023). In other words, eco-friendly behaviour promotes sustainable development (Hu et al., 2021). Seo et al. (2009) gave one of the most concise explanations, stating that ecologically friendly behavior is any conduct that does not harm the ecosystem (or even good). A person’s conduct that scarcely hurts the ecosystem or benefits it in a retail setting of a good or service is considered ecologically sound customer behavior in the current work. Ecologically responsible actions are typically referred to as “pro-environmental activity” in the research on consumer behavior (Muller and Wittmer, 2023; Zhang et al., 2022).

2. Related literature

Several empirical researches on the tourist industry have examined how the sector affects neighborhood growth. Still, these works are rare, and even fewer use comprehensive local resource ratings. According to a current Meta, only 14 studies published since 1999 have focused on reducing local poverty (Andraz and Rodrigues, 2016). Those that collected data sets employed regional and travel industry views of effects to evaluate the effects. Semi-structured questionnaires conducted over a short period were the most popular data collection method in these studies; no test subjects were included, and the majority was solely financial. The most alarming result is that there needs to be more studies to truly comprehend the connection between the tourist industry and social inclusion, despite the researchers of the meta-study finding proof that alleviating poverty or growth in any aspect is unusual without significant public control of initiatives.

Farmaki (2021) advocates local-level effect research that employs multiple economic indicators and primary data collection techniques. Studies, particularly on cruise visitors, have been less thorough than general tourist research, and they have yet to incorporate multiple growth metrics or accurately examine local effects. Some studies use passenger questionnaires to quantify cruise visitor spending relative to land visitors (Liu and Pennington-Gray, 2015; Tsui, 2017; Wan, 2013). Others employ models for assessing the spillovers of travel demand on gross domestic product and the earnings of tourism industry businesses using data from gross domestic product statements and market surveys (Rossello et al., 2020; Smyth and Vanclay, 2017). According to this research, financial coefficients for cruise travel are often modest because most cruises are tied to tax-haven ports, and guests frequently dine, eat, rest, and pay money on the ship using debit cards. The detailed requirements for commercial vessels have been used to evaluate the ecological effects by contrasting the production requirements of the ship for pollutants with the capacity of terminals and the ecosystem to take such outputs (Adongo et al., 2021; Yeon et al., 2021).

Under voluntary Corporate Social Responsibility (CSR) reporting requirements, cruise ship owners voluntarily publish various environmental metrics; nevertheless, the study has shown gaps in these statements. According to Salem et al. (2021), the fact that business statements often only cover topics that are "marginal to the heart of the company and have a beneficial effect or preempt sector regulation" demonstrates how insensitive market analysts are to local member requirements and requests for indications. These results are backed by Femenia-Serra et al. (2022), while Ren et al. (2022) emphasize that studies frequently lack verifiability and exclude crucial topics like financial well-being and job standards. Ziakas (2021) underline the necessity of outside public effect assessments, taking related studies to prevent relying on unreliable and unsubstantiated corporate self-reports. It supports prior claims made by Waddock (2004) and Fine (2011) that research of effects or outcomes conducted independently of the cruise lines must be included when evaluating cruising travel.

Second, studies of demographic, financial, and environmental data are frequently used in research on travel and its impact on indigenous citizens. Qualitative methods are also commonly used in studies conducted after the start of tourist programming. Most people believe that the tourist industry doesn't do much for local areas since, in the democratic interactions among visitors, businesses, and indigenous populations, the latter frequently lose power and access to commodities (Wan, 2013; York and Zhang, 2010). While not directly targeting the cruise industry, some empirical research has been done to examine how Honduran Garifuna tribes interact with various forms of the tourist industry (Femenia-Serra et al., 2022; Gursoy et al., 2022; Smyth and Vanclay, 2017). These researchers have reported local assertions that the tourist industry has caused separation, displacement, property seizure, traditional eroding, carbon pollution, and marginalization, but these concerns have not been empirically evaluated.

Visitors' ecofriendly behaviour towards ecological goods for nature conservation is called "ecological buying" and is one fundamental kind of ecologically responsible customer behaviour in the travel and tourist industry (Han, 2020). Such ecologically conscious decisions result from complex ecological judgment methods (Chen, 2013; Hu et al., 2021). People who engage in environmentally friendly consuming practices

have less of an influence on the ecosystem and even help the ecosystem (Wut et al., 2021; Yeon et al., 2021). Similarly, in a scenario where tourists consume products, their ecologically friendly usage practices are crucial to maintaining the climate at a visitor location. In contrast, their ecologically reckless usage practices are fundamental causes of unfavorable ecological effects on travel locations (Ren et al., 2022). The current study seeks to enhance the existing tourist and industry research on green consumerism and buying behaviors by filling the gaps outlined below. However, researchers who study consumer and environmental behavior have identified ecologically friendly consumer behavior (Cró and Martins, 2017; Waddock, 2004). The tourist and hotel industries have yet to conceive it well.

Furthermore, despite significant efforts to use and advance social psychology theories Liu and Pennington-Gray (2015) and Shin et al. (2022) examine more in-depth analyses of ecologically friendly customer behavior and its concepts. Additionally, it is unquestionably essential to understand what motivates responsible behavior to develop solutions that effectively reduce the detrimental effects of the tourist industry on the ecosystem (Muller and Wittmer, 2023; Shin et al., 2021). However, more in-depth analyses and conversations should be conducted regarding the fundamental ideas that encourage environmentally friendly consumer behavior in travel and hotel.

Ecological awareness refers to a user's capacity to comprehend ecological ideas, challenges, and difficulties and to pattern their behavior accordingly (York and Zhang, 2010; Zhang et al., 2022). When information or knowledge to guide behavior in a specific scenario is insufficient, a consumer tends to eschew participating in a particular consuming behavior (Gursoy et al., 2022; Ziakas, 2021). This propensity to not behave in a given way aims to reduce the likelihood of ambiguity (Han, 2020; Kannan et al., 2021). Whenever a client feels that he or he understands an item, service, or behavior associated with consuming more than others, they often believe that their degree of understanding about that consuming is strong (Femenia-Serra et al., 2022; Yang et al., 2010). This data frequently assists in triggering one's fundamental need to engage in ecological conduct while consuming eco-friendly products (Wu et al., 2021). Despite the comprehensive nature of these descriptive researches and their propensity to involve stakeholders, some have suggested that authorities and corporations do not take them as correctly as quantitative research. Malik et al. (2016) make a note of this and call for the use of a mixed-method approach that combines empirical and statistical study. They assert that this method may provide a variety of data that can speak to many consumers, including the legislature, industry, and democratic institutions, helping to facilitate progressive reform.

Additionally, according to Farmaki (2021), mixed methods reduce scientist biases in the analysis since cross-referencing enables a more impartial data perspective. It is similar to the argument made by Andraz and Rodrigues (2016) that affect assessments need to employ a variety of metrics that incorporate both global sustainability growth goals and local specifics. The selection of tourism-related metrics that impact disadvantaged populations is heavily influenced by a meta-analysis on Indigenous peoples and the tourist industry conducted by Wang et al. (2021).

Wang et al. (2021) could provide a financial property paradigm for studying tourists in indigenous regions by carefully examining previous research through the lens of capacities strategy to growth. They argued that localities are best placed to gain from growth initiatives when they have access to specific capital investments. An increase in pooled resources is both the realization of present growth and an item of expenditure in continued expansion since such resources serve as both means and goals for human progress. Environmental consumption is increasingly problematic in the tourist industry and hotels (Dong et al., 2020; Gigler, 2004). The problem of ecological utilization and greener growth is more crucial than ever in the modern tourist industry and hotel business as more and more individuals in the economy realize that several severe ecological types of defects are deeply embedded in the tourist industry extracurricular (Salem et al., 2021; Xu et al., 2020). Consumers in this industry now request sustainable items more frequently (such as ecologically friendly accommodations, eateries, voyages, aeroplanes, locations, resorts, congresses, etc.) and often desire green consumerism (Hu et al., 2021; Wut et al., 2021). Many tourist and hotel businesses rapidly demonstrate a propensity to proactively develop green activities and goods due to this need and the environmental marketplace (Ren et al., 2022; Yeon et al., 2021). Consumers in the tourist and hotel industry are simultaneously learning that ecologically friendly practices are inevitable in both their goods purchases and daily lives (Cró and Martins, 2017; Huang et al., 2023).

3. Research method

3.1. Specification of proposed model

According to the relevant work, this research uses the below model to analyze how the tourist industry affects ecological deterioration (Liu and Pennington-Gray, 2015; Waddock, 2004).

$$\mathrm{EF}_{it} = \alpha_0 + \alpha_1 \mathrm{GDP}_{it} + \alpha_2 \mathrm{EU} + \alpha_3 \mathrm{TOUR}_{it} + \eta_i + \mu_{it} \quad (1)$$

In this equation, EF represents ecological footprint, which is the CO_2 emission as a proxy per capita (measured in metric tons). GDP represents actual GDP per capita (expressed in constant 2010 USD). EU means energy utilization per capita (measured in kilograms of oil equivalent). TOR represents the tourism industry, proxies by either the income from overseas travel or the number of international tourist arrivals. $\eta_i$is a country-specific factor that is unobserved. μ_{it} represents an error term that is independent and identically distributed. i is a country index. i is a time index

We add the quadratic of the tourist industry to the model as follows to examine the non-linear effect of tourists on ecological deterioration:

$$\mathrm{EF}_{it} = \alpha_0 + \alpha_1 \mathrm{GDP}_{it} + \alpha_2 \mathrm{EU} + \alpha_3 \mathrm{TOR}_{it} + \alpha_4 \mathrm{TOR}_{it}^2 + \eta_i + \mu_{it} \quad (2)$$

where, the concept denoted as TOUR^2 is the square of the term "tourism."

Using this framework, we can assess whether the tourist industry's influence on ecological deterioration is U-shaped or inverted U-shaped. A substantially positive 33 and a considerably negative 44 suggest a strongly inverse U-shaped association between the tourist industry and ecological damage. On the other hand, a largely positive 44 and a substantially negative 33 point to a U-shaped link between the tourist

industry and ecological deterioration. However, if both indices share the same sign, we can infer a monotonic link between the tourist industry and environmental decline.

Additionally, we include the following interaction terms among the tourist industry and ecological pollution in the model to assess the moderate effects of the tourist industry on the impact of financial development on pollution problems.

$$\mathrm{EF}_{it} = \alpha_0 + \alpha_1 \mathrm{GDP}_{it} + \alpha_2 \mathrm{EU} + \alpha_3 \mathrm{TOR}_{it} + \alpha_4 \mathrm{TOR}_{it}^2 + \alpha_5 (\mathrm{GDP} \times \mathrm{TOR}_{it}) + \eta_i + \mu_{it} \quad (3)$$

Reworded: The product of $GDP \times TOR$ represents the combined impact of economic growth and tourism on a given system.

We investigate if the tourist industry mitigates the negative or positive effects of financial development on ecological deterioration through the interaction effect. Therefore, using the second derivative of Equation (3), we calculate the marginal impact of industrial expansion on pollution problems as follows:

$$\frac{\partial EF_{it}}{\partial GDP_{it}} = \alpha_1 + \alpha_5 TOR_{it} \quad (4)$$

Reworded: The focus of our analysis is on the signs of the coefficients α_1 and α_5. If $\alpha_1 > 0$ is positive and $\alpha_5 < 0$, is negative, it indicates that financial development exacerbates damage of the environment, but travelling has a positive effect on mitigating this harm. If $\alpha_1 < 0$ is negative and $\alpha_5 > 0$, is positive, it implies that economic growth has a mitigating effect on environmental degradation, but tourism exacerbates that positive impact. If both $\alpha_1 < 0$ and $\alpha_5 > 0$, are negative, which shows that economic growth and tourism both positive impaction reducing environmental degradation. Conversely, if both $\alpha_1 > 0$ and $\alpha_5 > 0$, are positive; it suggests that both economic growth and tourism have a negative impact on exacerbating environmental degradation. The marginal effect $\alpha_1 + \alpha_5 TOR$ is also considered, with a positive marginal effect indicating a worsening of environmental degradation and a negative marginal effect suggesting otherwise. The marginal impacts' significance in statistics is determined by computing their standard errors and t-statistics, as emphasized by Shin et al. (2022). The variance is first calculated using the formula from the coefficient covariance matrix.

$$\sigma^2_{\frac{\partial EF}{\partial GDP}} = \mathrm{var}(\hat{\alpha}_1) + TOR^2 \mathrm{var}(\hat{\alpha}_5) + 2TOR \mathrm{cov}(\hat{\alpha}_1 \hat{\alpha}_5) \quad (5)$$

The confidence interval is obtained by taking the scale factor of the variation, and the standard deviation then reduces the significant impact of getting the t-statistics. The marginal effect is statically meaningful when the t-statistic is high.

Finally, using the Error Correction Model (ECM) technique described below, we examine the immediate and long-term causal connections between ecological deterioration, the tourist industry, and financial development.

$$\Delta EF_{it} = \phi_{1i} + \sum_{i=1}^{m} \phi_{11i} \Delta EF_{it-i} + \sum_{j=0}^{n} \phi_{12i} \Delta GDP_{it-j} + \sum_{k=0}^{o} \phi_{13i} \Delta EU_{it-k} + \sum_{l=0}^{p} \phi_{14i} \Delta TOR_{it-l} + \varpi_{1i} ECT_{it-1} + \mu_{it} (2)$$

$$\Delta GDP_{it} = \phi_{1i} + \sum_{i=1}^{m} \phi_{11i} \Delta GDP_{it-i} + \sum_{j=0}^{n} \phi_{12i} \Delta EF_{it-j} + \sum_{k=0}^{o} \phi_{13i} \Delta EU_{it-k} + \sum_{l=0}^{p} \phi_{14i} \Delta TOR_{it-l} + \varpi_{1i} ECT_{it-1} + \mu_{it} \quad (3)$$

$$\Delta EU_{it} = \phi_{1i} + \sum_{i=1}^{m} \phi_{11i} \Delta EU_{it-i} + \sum_{j=0}^{n} \phi_{12i} \Delta EF_{it-j} + \sum_{k=0}^{o} \phi_{13i} \Delta GDP_{it-k} + \sum_{l=0}^{p} \phi_{14i} \Delta TOR_{it-l} + \varpi_{1i} ECT_{it-1} + \mu_{it} \quad (4)$$

$$\Delta TOR_{it} = \phi_{1i} + \sum_{i=1}^{m} \phi_{11i} \Delta TOR_{it-i} + \sum_{j=0}^{n} \phi_{12i} \Delta EF_{it-j} + \sum_{k=0}^{o} \phi_{13i} \Delta GDP_{it-k} + \sum_{l=0}^{p} \phi_{14i} \Delta EU_{it-l} + \varpi_{1i} ECT_{it-1} + \mu_{it} \quad (5)$$

where ECT = lagged phrase for mistake correcting, *m*, *n*, *o*, *p*, *q*, *r*, and *s* are the ideal lag durations chosen to use a step-down process, with a limit of two lags. We compare the alternate theory to the assumptions, which state that there is no reciprocal short-run causative link:$H_0: \phi_1 = \phi_2 = \phi_3 = \phi_4 = 0$. In a likewise manner, we compare the alternative explanation to the assumptions of no joint long-run causal link as follows: $H_0: \varpi = 0$. If the F-statistic of the linear regression values is statically important at the 5% level, the null hypothesis that there is no single short-term causative connection is disproved. Also, the statistically significant difference of the indices of ECT, which has to be low, is used to analyze the combined long-run causal connection.

3.2. Empirical techniques

First, we use several panel unit root tests created by Shin et al. (2021), Ren et al. (2022), Dong et al. (2020) and MacNeill and Wozniak (2018) to look at the integrating features of the model's components. We may consider cross-sectional dependency, standard unit root systems, and people using these many tests. Second, utilizing several panel co-integration tests created by Park et al. (2021) and Seo et al. (2009) tests, we ascertain the co-integrating connection among the factors.

Third, we employ the Wut et al. (2021) Fully Modified Ordinary Least Squares (FMOLS) estimate approach, which is appropriate for panel co-integration. We use the intricate detail Generalized Method of Moments (GMM) estimate established by Xu et al. (2020) to correct for country-specific impact, possible unobserved heterogeneity, and synchronization. Utilizing the over-identification Sargan test limitation (used to evaluate the joint reliability of the measurement) and the Arellano and Bond test for autocorrelation, we confirm the constancy of the GMM estimator (used to determine whether a sequential connection exists).

In addition, Zhang et al. (2022) asserted that if cross-sectional dependence is neglected, variable estimations may be significantly biased, and their magnitude may be misinterpreted. To account for cross-sectional dependence, we use the Augmented Mean Group (AMG) created by Salem et al. (2021). We test for cross-sectional dependence before estimating using the basic CD test established by Gursoy et al. (2022). According to Liu and Pennington-Gray's (2015) argument, prediction

mistakes may be caused by panel estimate methods that ignore country-level diversity and cross-sectional dependence. The GMM estimator is better suited for a larger cross-section (N) panel than time series.

In contrast, the Fully Modified Ordinary Least Squares (FMOLS) and Augmented Mean Group (AMG) demand that both factors be integrated at order one (T). As a result, these predictors work well with the peculiarities of our datasets. Finally, we apply the Error Correction Model (ECM) method to identify the factors' short- and long-term causal linkages.

3.3. Data collections

This analysis uses panel data from 28 Asian nations covering 1990–2020. The World Development Indicators (2018) report, released by the World Bank, served as the source of the information. The report's breadth was constrained due to the lack of data on the tourist industry for several nations, preventing us from covering Asia for at least three decades. Given Asia's wide geographical and economic diversity, the selection of these 28 countries is intended to represent a balanced cross-section of both developed and developing economies, ensuring that the results reflect broader regional trends. The chosen time frame allows for analyzing long-term trends and identifying potential structural changes in the relationship between tourism and environmental outcomes. However, the breadth of the report was somewhat constrained by data availability. Despite the extensive efforts of international organizations like the World Bank, consistent and complete data on the tourism industry remains challenging for several Asian nations, particularly those with less developed statistical infrastructure. This limitation has affected the study's ability to cover the entire continent comprehensively, resulting in the exclusion of some countries where data on critical variables was either missing or inconsistent over the three decades under review.

4. Data analysis and results

4.1. Statistical description and correlation

The factors' quantitative data and causal research are shown in **Table 1**. The factors exhibit significant variance. The average climate change (measured by greenhouse gases), actual Gross domestic product, power use, foreign tourist industry receivables, and number of worldwide visitors were 1.73 tons of carbon dioxide comparable for every individual, Dollars 2899, 784.1 kilograms of oil equivalent for every individual, Dollars 1090 hundred thousand, and 1,359,725 people, including both. The accompanying standard deviations of 2.31, 3054.4, 784.8, USD2139 million, and 2,347,591 indicate that the statistical values are widely dispersed across the averages. The correlation of the factors is shown in **Table 1**'s lower panel. It suggests a significant correlation between all the factors and ecological deterioration. The gross domestic product for every person and tourist industry statistics also demonstrates a good link.

Table 1. Descriptive statistics.

Variables	Minimum	Mean	Maximum	Standard Dev.	T.O.U.N	T.O.R	EU	G.D.P
E.F	0.128	1.684	10.154	2.439	0.228***	0.474***	0.893***	0.927***
G.D.P	170.87	2799.3	13,963.4	3054.3	0.239***	0.258***	0.876***	
E.U	63.223	764.45	3369.3	764.33	0.434***	0.453***		
T.O.R	100,000	1.01×10^9	1.36×10^{10}	2.13×10^9	0.876***			
T.O.U.N	5000	1,359,425	14,051,000	2,345,581				

Notes: ***shows statistically significant at 1% level. EF = Ecological Footprint (proxies by CO2 emission), GDP = Actual GDP per capita, EU Energy Utilization, TOR = Tourism occurrence from throughout the world as a proxy for the tourism industry, TOUN = Ratio of visitors from other nations as a proxy for tourism.

4.2. Panel unit toot

Table 2 displays the findings of the panel data regression. It reveals that the panel has unit roots, and all the factors are merged to order one [I(1)] at a 1 per cent meaningful scale. So, it's essential to establish the correlation between the factors.

Table 2. Panel unit root.

Variables	EF	GDP	EU	TOR	TOUN	DEF	Δ DGDP	Δ DEU	Δ DTOR	Δ DTOUN
LLC	−0.893	−4.942***	−2.456***	−1.323	−3.432***	−4.554***	−12.423***	−9.350***	−9.320***	−11.590***
IPS	3.789	−1.432	0.498	2.443	−0.243	−7.239***	−13.392***	−10.489***	−10.298***	−12.783***
Breitung	1.765	−3.753***	−0.633	2.554	−2.458***	−3.976***	−8.887***	−3.765***	−1.346*	−8.765***
Pesaran	1.778	−2.667***	−1.654	−0.786	0.767	−2.443**	−5.554***	−4.356***	−3.655***	−2.866***

***, ** and * indicate statistical significance at 1%, 5% and 10%.Im et al. (2002) conducted a test on IPS.The Breitung (2000) test, the Pesaran (2007) test, and the test from 2003 are all used to measure similar outcomes.

Table 3 shows the findings of the co-integrating tests for frame serial correlation. It reveals that all of the models' factors have a co-integrating connection. To calculate the parameters, we use estimation methods appropriate for co-integrating panels.

Table 3. Co-integration test outcomes.

Pedroni (1999) co-integration tests							
	Panel *v*-Statistic	**Panel rho-Statistic**	**Panel PP-Statistic**	**Panel ADF-Statistic**	**Group rho-Statistic**	**Group PP-Statistic**	**Group ADF-Statistic**
1	0.765	1.456	−2.675***	−0.876	2.323	−4.876***	−1.936**
2	−0.321	1.383	−3.282***	−1.328*	3.238	−6.195***	−1.716**
3	−1.343*	2.343	–1.876**	1.357	4.987	−4.564***	−0.786
Johansen Fisher cointegration tests Hypothesized No. of CE(s)							
	None	At most 1	At most 2	At most 3	At most 4		
1	408.0***	217.4***	139.5***	135.3***	–		
2	830.9***	436.5***	235.4***	150.9***	137.1***		
3	832.3***	428.1***	233.5***	166.1***	154.0***		

Table 3. (*Continued*).

Pedroni (1999) co-integration tests							
	Panel *v*-Statistic	**Panel rho-Statistic**	**Panel PP-Statistic**	**Panel ADF-Statistic**	**Group rho-Statistic**	**Group PP-Statistic**	**Group ADF-Statistic**
Westerlund (2007) cointegration tests							
	Group-τ	Group-α	Panel-τ	Panel-α			
1	−1.568	−5.529	−8.629	−6.756**			
2	−1.410	−3.321	−6.730	−4.613**			
3	−1.163	−1.100	−3.675	−1.127*			

***, ** and * show statistical significance at 1%, 5% and 10%, respectively, with the rejected null hypothesis of no co-integration. The Fisher statistics from the trace variant of the Johansen Fisher panel co-integration test are included in this document. However, there is not enough room to show the Fisher statistics from the max-eigen test. Nevertheless, these can be provided if requested.

4.3. Long-run estimations

Ecological deterioration is significantly and favorably impacted by industrial expansion, according to the FMOLS estimate findings shown in **Table 4**. It suggests that industrial expansion makes ecological deterioration in Asian nations worse. This result aligns with Tsui (2017), Hu et al. (2021) and Mao et al. (2010), who found that industrial development negatively influences the ecosystem. The findings also show that resource use has a negative impact on ecological deterioration, highlighting the adverse effects of fuel use on environmental pollution in Asian nations. This result corroborated previous findings by Fine (2011), Smyth and Vanclay (2017) and Yang et al. (2010) that fuel usage exacerbates ecological deterioration. The findings also suggest that the tourist industry has a sizable and advantageous effect on environmental decline, implying that the tourist industry aggravates ecological deterioration in Asian nations. This outcome is expected with a panel co-integration study by Waddock (2004), OECD country research by Park et al. (2021) and Eastern European country research by Veltmeyer (2016).

Table 4. Estimations from the FMOLS method.

Variables	**(1)**	**(2)**	**(3)**
G.D.P	0.267*** (0.139)	0.065*** (0.023)	0.803*** (0.126)
E.F	0.067*** (0.008)	0.068*** (0.007)	0.071*** (0.006)
T.O.R	0.146*** (0.008)	–0.908*** (0.045)	–0.947*** (0.042)
$T.O.R^2$		0.043*** (0.001)	0.028*** (0.002)
G.D.P*T.O.R			0.066*** (0.009)
R square	0.984	0.987	0.987
Adjusted. *R* square	0.983	0.986	0.986

Note: Significance of the results has been indicated with **, **, and * representing statistical significance at the 1%, 5%, and 10% levels, respectively, with the standard errors for these results noted in parentheses. Ecological deterioration is the dependent variable.

Additionally, we include the tourist industry squared in Model 2, and the findings demonstrate that although the tourist factor is highly positive, the tourist squared value is strongly negative. It shows that the tourist industry has a non-linear U-shaped effect on ecological deterioration. More specifically, the tourist industry initially slows down environmental decline but accelerates it when it grows after a specific point. The signals and importance of the industrial development and power usage indices are still favourable compared to the other factors in the framework.

We include an interplay factor between the tourist industry and industrial development in Model 3. The findings show that the direct relationship has a substantial and positive value, suggesting that the Asian tourist industry negatively modifies the industrial expansion's negative impact on ecological deterioration. At the minimal, median, and amounts exceeding the tourist industry, the proportional effects of industrial development on environmental pollution are calculated to be 1.365, 1.655, and 1.889, respectively. The residuals are statically significant, according to the *t*-statistics that were calculated. It suggests that the amount of tourist industry in Asian nations influences how the impact of industrial development on ecological damage differs. The cumulative effect of industrial effect on ecological deterioration increases with visitor concentration and conversely. The degree of correlation (R2) for each model shows that a sizable fraction of the fluctuations in the predictor variables can be attributed to the independent factors.

4.4. Robustness checks

To determine the accuracy of the prediction findings, we run specific tests. We use different estimating methodologies to consider possible unobserved variability, diversity, and cross-sectional dependency. We also use other tourist proxies.

4.4.1. Endogeneity

The dynamic panel Generalized Method of Moments (GMM) model has been utilized to evaluate the potential impact of endogeneity. The FMOLS estimation and GMM modelling findings shown in **Table 5** as anticipated, the lagged reliance on the variable's value is substantial and favorable. We discover that the tourist industry, power usage, and industrial expansion all have high and significant correlations, indicating that these factors harm the ecosystem. Additionally, we discover a non-linear U-shaped effect of the tourist industry on ecological deterioration. At standard levels, the value of the mediating variable is vanishingly rare. The Arellano and Bond test for stationarity uncovers that the framework does not contain second-order auto-correlation, whereas the Sargan test implies that the tools are legitimate.

Table 5. Dynamic GMM estimations for robustness checks.

Variables	**(1)**	**(2)**	**(3)**
Lagged dependent variable	0.978*** (0.025)	0.801*** (0.047)	0.800*** (0.033)
G.D.P	0.214*** (0.029)	0.255*** (0.018)	0.764*** (0.186)
E.F	0.011*** (0.002)	0.008*** (0.003)	0.008*** (0.002)

Table 5. (*Continued*).

Variables	(1)	(2)	(3)
T.O.R	0.007*** (0.001)	−0.208*** (0.024)	−0.171*** (0.044)
$T.O.R^2$		0.008*** (0.001)	0.017*** (0.003)
G.D.P*T.O.R			0.042 (0.013)
Constant	−0.261*** (0.098)	1.047*** (0.229)	−0.638 (0.703)
Sargan test (p-value)	30.238 (1.000)	27.073 (1.000)	27.851 (1.000)
2nd order autocorrelation test (*p*-value)	0.919 (0.357)	0.932 (0.351)	0.918 (0.358)

Note: Significance of the results has been indicated with **, **, and * representing statistical significance at the 1%, 5%, and 10% levels, respectively. Each regression model includes significant time dummies. Ecological deterioration is the dependent variable.

4.4.2. Issue of cross-sectional dependence

Using the Augmented Mean Group (AMG) model, we consider cross-sectional dependency in the panellist. The findings in **Table 6** agree with those from the FMOLS model. In particular, the indices for industrial development, power usage, and tourist industry are all positive and substantial, showing that these factors have a negative impact on the ecology. There may be a non-linear link between the tourist industry and ecological pollution, as indicated by the indices of the tourist industry and tourist squares, which have various signs (albeit insignificant at the conventional level). Cross-sectional dependency (CD) in the panellists is evident from the Pesaran CD test's inability to reject the null hypothesis that there is no cross-sectional reliance on the factors.

Table 6. AMG for robustness checks.

Total Variable	(1)	(2)	(3)	Pesaran-CD-Test
G.D.P	0.405*** (0.158)	0.442*** (0.146)	11.713** (6.272)	30.987*** [0.000]
E.N.C	0.025* (0.018)	0.034** (0.017)	0.032** (0.014)	38.939*** [0.000]
T.O.R	0.050*** (0.016)	0.932 (1.233)	4.624* (2.791)	61.945*** [0.000]
$T.O.R^2$	3.724*** (1.006)	0.024 (0.045)	0.040 (0.053)	62.403*** [0.000]
G.D.P*T.O.R			0.970 (0.612)	61.174*** [0.000]
Constant		3.832 (9.000)	57.133** (29.349)	

Note: Significance of the results has been indicated with **, **, and * representing statistical significance at the 1%, 5%, and 10% levels, respectively. The Pesaran (2004) test for cross-sectional dependency uses the null hypothesis that there is no cross-sectional dependence to define the Pesaran CD test. CD test probability values in the squared bracket. Ecological deterioration is the dependent variable.

4.4.3. Issue of heterogeneity

We use the Pooled Mean Group (PMG) established by Wan (2013), which likewise illustrates both the short-run and long-run impacts, to compensate for variability between the nations in the panellists. The results of the FMOLS experimental study align with the findings of 5. In particular, industrial expansion, power use, and the tourist industry positively and significantly impact ecological deterioration. Travel and environmental decline appear to have a non-linear U-shaped connection. A positive and substantial score for the equation indicates that the tourist industry negatively moderates the adverse effects of industrial expansion on ecological damage in Asian nations. In every PMG model, the value and statistical importance of the delayed mistake-correcting term parameter suggest that environmental deterioration and the explanatory factors are co-integrated. When a unit is momentarily thrown out of balance, the converging parameters demonstrate how quickly the based-on-relevance stabilizes.

4.4.4. Issue of heterogeneity

We use an alternate tourism proxy, which is precisely the quantity of arriving foreign visitors. The FMOLS estimate findings shown in **Table 7** are comparable with the estimated outcomes when foreign visitors' revenues were used as a proxy for tourists. We discover that the tourist industry, power usage, and financial expansion all have positive and substantial indices, indicating that these factors have a negative impact on the ecosystem. Additionally, we demonstrate that the interaction phrase's value is positive and statistically substantial, suggesting that the Asian tourist industry negatively mediates industrial expansion's negative effects on ecological damage.

Table 7. Checking robustness with a tourism proxy.

Total Variable	**(1)**	**(2)**	**(3)**
G.D.P	0.320*** (0.025)	0.204*** (0.133)	0.205*** (0.021)
E.F	0.058*** (0.007)	0.059*** (0.006)	0.081*** (0.006)
T.O.U.N	0.435*** (0.015)	0.443*** (0.015)	–0.798*** (0.105)
$T.O.U.N^2$		0.008** (0.004)	–0.034*** (0.005)
G.D.P*T.O.U.N			0.189*** (0.014)
R square	0.894	0.894	0.892
Adjusted. *R* square	0.8895	0.8915	0.889

Note: Significance of the results has been indicated with **, **, and * representing statistical significance at the 1%, 5%, and 10% levels, respectively. The FMOLS estimator was used to estimate the model. Parenthesis around common errors. Ecological deterioration is a dependent variable.

Following is a summary of the panel VECM Granger causality data shown in **Table 8**: Although the long-term causation is shaky, there is a shared short-run causative connection between industrial development, power use, tourist industry, and air pollution. (ii) Industrial expansion, the tourist industry, and air pollution all have a short-run causal connection with power use. (iii) There is no connection between

power use, travel, or air pollution and financial development. (iv) No link exists between the tourist industry and industrial development, power use, or air pollution. The number of foreign visitors was utilized as a substitute proxy for the tourist industry in **Table 8**'s lower section, and the research was redone. The empirical results are consistent with the prior results, showing robust research results.

Table 8. Granger causality analysis from panel VECM.

Outcome variable		**Causalflow**	***F*-test**	**ECT-test**
Model 1	EF	EF (GDP, EU, TOR)	9.251*** (0.137)	−0.001 [_0.253]
	GDP	GDP (EF, EU, TOR)	0.327 (0.964)	0.002 [1.438]
	EU	EU (EU, GDP, TOR)	18.024*** (0.111)	0.024*** [5.621]
	TOR	TOR (EF, GDP, EU)	4.161 (0.355)	–0.002 [–0.380]
	EF	EF (GDP, EU, TOUN)	12.041*** (0.118)	0.004*** [3.085]
	GDP	GDP (EF, EU, TOUN)	0.672 (0.988)	–0.001 [_0.015]
	EU	ENC (EF, GDP, TOUN)	32.221*** (0.111)	–0.022*** [–4.670]
	TOUN	TOUN (EF, GDP, EU)	5.233 (0.266)	0.006*** [2.199]

Note: Significance of the results has been indicated with **, **, and * representing statistical significance at the 1%, 5%, and 10% levels, respectively. The parentheses provide the *p*-values for the *F*-statistics, while the square brackets contain the *t*-statistics for the ECT coefficients.

5. Discussion

In this work, we demonstrate that financial expansion harms ecological deterioration, indicating that in Asian nations, financial progress occurs at the cost of deterioration. Shin et al. (2021), in a panel of 122 nations, and Ren et al. (2022) for GCC nations supported this conclusion. This work offers factual proof of the damaging ecological effects of the current spectacular financial expansion in Asian nations. Most Asian nations neglected the ecology insufficiently despite pursuing industrial expansion. Therefore, it might be required for Asian nations to practice sustainable development by switching from manufacturing practices that create a lot of waste to manufacturing strategies that generate minimal damage. The value of study and innovation cannot be overstated in this context. Further study should be done to identify eco-friendly manufacturing methods. Asian nations cannot manage to exchange financial development for higher ecological standards. Still, they can use various strategies and regulations to mitigate the adverse environmental effects of industrial development.

Second, this research shows that power use negatively impacts ecological damage in Asian nations, suggesting ecological deterioration occurs due to power use. These results are align with Muller and Wittmer (2023) for the Gulf Cooperation Council nations (GCC) nations and Yeon et al. (2021) for 12 Middle East and North Africa nations (MENA) nations. This study likely indicates that most Asian nations

rely more on dirty or non-renewable power resources that worsen ecological deterioration for their energy needs (that prevent further ecosystem deterioration). Alternatively, compared to green or renewable power, Asian nations likely consume a large share of quasi-energy. Research has proven that renewables slow ecological deterioration, whereas non-renewable power magnifies it (Kannan et al., 2021). Thus, to reduce environmental deterioration, Asian nations may need to boost the percentage of renewable in their power use mix. They should enhance their expenditure on research and development (RandD) to guarantee ecological responsibility and make it more attractive for power generation that can track greenhouse gases and greener industrial technology. The nations should implement power efficiency or ecological restoration to lessen environmental damage. It is essential to promote the adoption of eco-friendly technologies in manufacturing, economic, farming, domestic, and public infrastructure power usage.

Third, our analysis shows that the tourist industry has a non-linear U-shaped effect on ecological deterioration in Asian nations. It shows that while the tourist industry may slow down ecological damage initially, it will exacerbate it once it reaches a particular point. Diverse panels Fine (2011), Tsui (2017) and Mao et al. (2010) all found a negative sequential impact of the tourist industry on greenhouse gases. In Eastern European nations, Smyth and Vanclay (2017) did find a comparable evidence-based result. By exposing the non-linear relationship between the tourist industry and ecological pollution in Asian countries, our work has added to the body of existing material.

Lastly, we demonstrate how the Asian tourist industry negatively moderates the impact of financial expansion on ecological deterioration. Depending on the extent of the tourist industry, industrial expansion has varying adverse effects on ecological decline. The incremental impact of industrial development on ecological deterioration increases with tourist industry density and conversely. Tourist industry inflows into Asian nations likely boost commercial expansion and exacerbate ecological decline. The tourist industry fuels more commercial activity, which worsens global warming. This conclusion indicates that sustainable or ecological tourism is required in Asian nations. Because of the negative impact of the tourism industry on the ecology, legislators and researchers have recently become more interested in ecotourism. However, the tourist industry is essential for financial progress because it creates revenue and job possibilities. Asian nations cannot stand to decrease the tourist industry; instead, they should engage in ecological or sustainability to find a balance between tourism, economic development, and ecology. It is essential because it has a significant impact on economic growth. As a result, it may be hard to achieve ecological sustainability if greenhouse gas prediction systems, power, and ecological laws do not consider the impacts of the tourist industry on carbon pollution.

5.1. Practical implications

The study's implications for policymakers, industry leaders, and tourism and energy stakeholders in the Asian region are given below: These adverse effects of financial expansion and power use on ecological deterioration confirm the necessity for a change of development model. Policymakers should focus on shifting from the

timeframe characterized by high levels of waste production typical to the industrial approach towards more sustainable and environmentally friendly manufacturing methods. This transition will not only avoid the continuation of ecological destruction on the planet but will also guarantee sustainable economic development.

5.1.1. Engaging with industry stakeholders

To get a better insight into the issues involved and the possibilities for future tourism development, it is necessary to address the industry's key stakeholders—the representatives of tourism-related businesses, energy companies, and the local population. Subsequent studies should use interview or questionnaire data on the views of the major stakeholders, i.e., tourist industry providers, local government officers, and community representatives. These qualitative views will supplement the results of quantitative rather than quantitative research and offer a broader view of how the tourism development process is seen and reconciled in different countries of Asia. It can expose the feasibility or lack thereof in actualizing sustainable practices, thereby making for policy prescriptions, not mere ethereal projections.

5.1.2. Promoting sustainable tourism practices

The observation made by the study shows that there is an inverse 'U' shaped path that shows how tourism enhances the protection of ecology and then loses this efficiency as the expansion of tourism leads to further deterioration of ecology. Policymakers must, therefore, think of ways to achieve sustainable tourism while benefitting the economy and protecting the environment. It could include encouraging green tourism activities like ecotourism that do not compromise the environment but at the same time earn revenue. Likewise, measures that restrain other activities that form part of tourism and exacerbate the depletion of natural resources should be implemented in equal measure while the industry grows.

5.1.3. Balancing economic growth and environmental sustainability

Given the study's findings that financial expansion and energy use have contributed to ecological deterioration, Asian nations must seek a balance between economic growth and environmental sustainability. It can be achieved by transitioning towards greener energy sources and adopting cleaner industrial practices. Governments should invest in research and development (RandD) to discover and implement eco-friendly technologies in various sectors, including manufacturing, agriculture, and public infrastructure. By doing so, they can reduce economic activities' environmental impact while maintaining or enhancing economic growth.

6. Conclusion and recommendations

This study looks at the non-linear relationships between the tourist industry and ecological deterioration in Asian nations. It also establishes how much the tourist industry can mitigate the harmful effects of industrial expansion on the ecosystem. The work uses experimental techniques considering cross-sectional interdependence, omitted variables, and variability. According to the report's results, ecological deterioration is negatively impacted by both industrial expansion and power use. It demonstrates how the tourist industry has a non-linear U-shaped effect on ecological decline. Additionally, this research shows that tourism negatively moderates the

impact of financial expansion on climate change. Depending on the extent of the tourist industry, industrial expansion has varying negative effects on ecological deterioration. The negative impact of industrial expansion on ecological deterioration increases as tourist industry levels rise. The non-linear and modulating effects of the tourist industry on the ecosystem are revealed in this research, making a substantial addition to the body of existing work. The results adhere to various estimating methods and additional tourist industry proxies.

This paper's key recommendation is that Asian nations should use green manufacturing methods to boost their economies. To slow down pollution problems, they should use more renewable energy in their power generation than non-energy. As the tourist industry contributes to ecological deterioration, Asian nations may need to implement an appropriate tourist industry to capitalize on the industry's advantages without endangering the ecosystem. The ecological impacts of the tourist industry in Asian nations should be considered in any prediction models for greenhouse gases, power use, and ecological issues.

This research has successfully revealed the non-linear and modifying impacts of the tourist industry on pollution problems in a sample of emerging nations. Further research is recommended to look at the situation in industrialized countries for conclusions due to disparities in the number of tourist revenues, level of co-pollution, quality of organizations, and level of technology and financial progress among industrialized and emerging economic systems. Future research should also address the problem using time series data in each nation. It is crucial since developing effective policies depends on understanding how and where tourist numbers affect pollution problems. Considering that our study used greenhouse gas pollution as a stand-in for ecological harm, we advise using different proxies in future studies (such as environmental impact, air pollutants, and fluorinated pollutants).

Future research directions and limitations

This study has provided significant insights into the complex interactions between tourism, economic growth, and environmental sustainability in Asian nations. However, there remain several areas that future research could explore to deepen our understanding and address the limitations encountered in this study. One of the promising directions of further studies is the expansion of the use of interviews or surveys with governmental and non-governmental bodies, tourism companies, and local communities. Although the present study employs econometric techniques in measuring the impact of tourism on environmental deterioration, qualitative information may provide rich insights into the possibilities of applying sustainable tourism principles as well as hurdles experienced in the course of the application. Such stakeholder perspectives would be instrumental in developing more specific and less idealistic policy solutions for implementable contexts.

Another possible direction for future research is the analysis of the specific effects of the crisis within the tourism sphere. In the current study, tourism has been conceptualized as a single sector. However, subsectors of the tourism industry (for instance, ecotourism, mass tourism and cultural tourism) produce differential environmental impacts. Subsequent research could categorize tourism into different

sub-categories to ascertain the specific effects of each segment on the natural environment and, accordingly, determine which tourism segments are most sustainable for the environment. This disaggregation could lead to more targeted policy changes that foster the sustainability of environmentally friendly tourism. On the other hand, it could limit the impacts of more damaging activities.

However, this study has some limitations, as follows: Possibly, one such study sheds light on the absence and reliability of data from 28 Asian nations offered in the study. As much as the survey used sophisticated econometric techniques and models in the analysis that guard against potential problems like cross-sectional dependence and unobserved heterogeneity, there are a few issues that may have emanated from some of the following drawbacks: The data used in the analysis were incomplete and inconsistent for some countries. The abovementioned limitation of the study could be complemented by the subsequent research, which will have more extensive and current databases concerning, for instance, satellite information or other remote sensing tools to assess the environmental effects more effectively. Furthermore, the study's reliance on historical data from 1990 to 2020 may limit its applicability to the current and future context, particularly given the rapid technological advancements and policy changes in renewable energy and sustainable tourism. Future research could focus on more recent data or even real-time data collection to capture the evolving dynamics of tourism and environmental sustainability. Longitudinal studies that track changes in response to new policies or technological innovations would also be valuable in understanding the long-term effects of different interventions.

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