Pol. J. Environ. Stud. Vol. XX, No. X (XXXX), 1-12
DOI: *10.15244/pjoes/195793* ONLINE PUBLICATION DATE: 2025-01-24

Original Research

Climate Crossroads: Exploring the Environmental Impact of Tourism and Urbanization on Ecological Footprints in Asia-Pacific

Ahsan Akbar[1, 3], Minhas Akbar[2, 3, 4], Hui Xie[5]*, Petr Hrusa[3], Asokan Vasudevan[4], YafangYan[6]

[1]International Business School, Guangzhou City University of Technology, Guangzhou 510800, China
[2]Department of Management Sciences, COMSATS University Islamabad, Sahiwal Campus, Sahiwal
[3]Department of Recreology and Tourism, Faculty of Informatics and Management, University of Hradec Kralove, Hradec Kralove, Czech Republic
[4]Faculty of Business, and Communications INTI International University, Persiaran Perdana BBN Putra Nilai, 71800 Nilai, Negeri Sembilan, Malaysia
[5]School of Jewelry, Guangzhou City University of Technology, Guangzhou 510800, China
[6]Faculty of Liberal Arts, Shinawatra University, 99 Moo 10, Bangtoey, Samkhok, Pathum Thani, Thailand 12160

Received: 6 July 2024
Accepted: 10 November 2024

Abstract

Since the mid-20th century, Environmental Degradation (ED) has been a paramount concern for humanity. Numerous researchers have found an association between various human activities and ED indicators. This paper aims to analyze the impact of tourism, urbanization, and Foreign Direct Investment (FDI) on the Ecological Footprint (EF) and CO_2 emissions in nine Asia-Pacific countries over 22 years. The theoretical foundations of this study are based on externality theory and public/common good theories that explain the cost of ED by certain human activities. We have employed Autoregressive Distributed Lag (ARDL), Non-Linear Autoregressive Distributed Lag (NARDL), and the Johansen co-integration techniques to see whether long-run causality exists between tourism, urbanization, FDI inflows, and the ED indicators. The findings reveal a long-run causality between tourism, urbanization, EF, and CO_2 territorial emissions in Asia-Pacific countries. The empirical outcomes also show a significant impact of tourism activities and urbanization on EF and CO_2 emissions. Moreover, a moderately significant long-run causality exists in the sample countries except for Japan. These findings suggest that governments and lawmakers should be concerned about the environmental consequences of tourism and urbanization-related activities and enact policy measures to preserve their ecosystems.

Keywords: tourism, urbanization, FDI, ecological footprint, CO_2 emissions, Asia-Pacific

*e-mail: xiehui@gcu.edu.cn

Introduction

Environmental Degradation (ED) has been a hot topic and is becoming a serious issue as the threat continues to endanger the environment. The Asia-Pacific region has experienced rapid tourism growth and urbanization over the past three decades, driven by exponential economic development and globalization. However, at a certain point of development, countries can impact the environment more than they can sustain [1]. The biggest challenge for the global community is to create a sustainable environment by reducing Greenhouse Gases (GHGs) and ecological footprint. Ecological footprint (EF) is described as an "accounting tool that enables us to estimate the resource consumption and waste assimilation requirements of a defined human population or economy in terms of a corresponding productive land area" [2]. Put simply, EF measures the human dependence on nature within a certain system. The system results will compare the biologically productive area that is still available for use by humans, estimated by its production of biological materials (Biocapacity). The EF and biocapacity are measured in total demand or supply of six indicators: built-up land, carbon emission, cropland, fishing grounds, forest products, and grazing land, which are accumulated into EF. These two tools are created by the Global Footprint Network (GFN) to study sustainability around the world and its implications for society at large. [3] proposed that EF analysis provides a unique, accurate, and comprehensive understanding of environmental sustainability.

Tourism is the world's third-largest export sector. In 2023, it contributed 9.1% to the global GDP, with around 330 million people employed in the sector [4]. International tourism receipt has reached over $ 1.5 trillion in 2023 [5].

Asia-Pacific countries have been the greatest contributors to tourism activity over the past decades. [6]. According to the Pacific Asia Travel Association's (PATA) forecasts, the number of international visitors is expected to exceed 516 million by the end of 2023. This expansion has exerted significant pressure on the region's environment. Tourism contributes to environmental degradation through increased waste production, energy consumption, and depletion of natural resources. This has raised concerns regarding implementing the Eco-tourism policy as an alternative to conventional tourism.

Among Asia-Pacific countries, China has been leading in terms of international tourist arrivals, with a total of 145.31 million people in 2019, which dropped to 27.47 million in 2020. However, the industry recovered after COVID-19, and tourist arrivals reached 82.03 million in 2023 [7]. Tourism accounted for 11.04% of Chinese GDP and provided direct and indirect employment to around 28.25 million people. Moreover, it is a well-established fact that tourism helps China in its economic development [8].

Tourism creates demand and attraction for goods and services related to the tourist spots. Global connectivity, new technologies, living standards, employment, and cultural development are also direct byproducts of the tourism industry. Therefore, it impacts other sectors of the economy that are a part of the value chain of this industry and helps to maintain a stable income stream for the people and the country.

Despite its increasing importance in the world economy, the tourism industry is also one of the largest contributors to greenhouse gas emissions. Tourism activities put pressure on local resources, which may lead to ED. Local land use, soil erosion, beach pollution, and habitat loss are the chain effects of gradually degrading the environment. Over-consumption of natural resources has a significant effect on the environment through tourism. Moreover, the GHGs emitted by the tourism sector have already breached the upper limit ratio. Tourism activities contribute to the depletion of natural resources, pollution, and physical impacts on tourist landscapes, thus damaging the ecosystem. Depleting the ozone layer, climate change, and loss of biodiversity are also some of the tourism-induced impacts on the environment.

Alongside tourism, urbanization and Foreign Direct Investments (FDI) are also considered to be the major factors that contribute to EF and CO_2 emissions in the environment. Urbanization has led to an increase in transportation demand, waste generation, resource utilization, and rapid energy consumption [9]. As city boundaries expand, the demand for infrastructure such as buildings, roads, and bridges also increases, which results in the consumption of large amounts of energy and materials. Similarly, metropolitan areas are also major sources of air pollution, which has a negative impact on the ecology and natural landscape [10].

FDI also leads to higher amounts of CO_2 emissions and ED as companies often prefer profit over ecological wellbeing [11]. The Asia-Pacific region has received substantial FDI over the past few decades. This FDI has played an imperative role in the economic prosperity of the countries. However, this prosperity has been achieved at a cost to the ecology. Meanwhile, FDI augments the development of tourism infrastructure, which may contribute to the upsurge in EF and CO_2 emissions.

By 2030, people are expected to have 56% less exposure compared to 2015 levels, leading to up to a 37% reduction in premature deaths. This provides countries with numerous benefits, including improved public health, economic growth, and a more sustainable climate for agriculture [12].

Fig. 1 shows the global heat map of biocapacity reserves [13] and biocapacity deficits (red). This indicates that most Asian countries are facing a severe deficit in biocapacity reserves. In other words, the consumption of biocapacity reserves is very high in these countries.

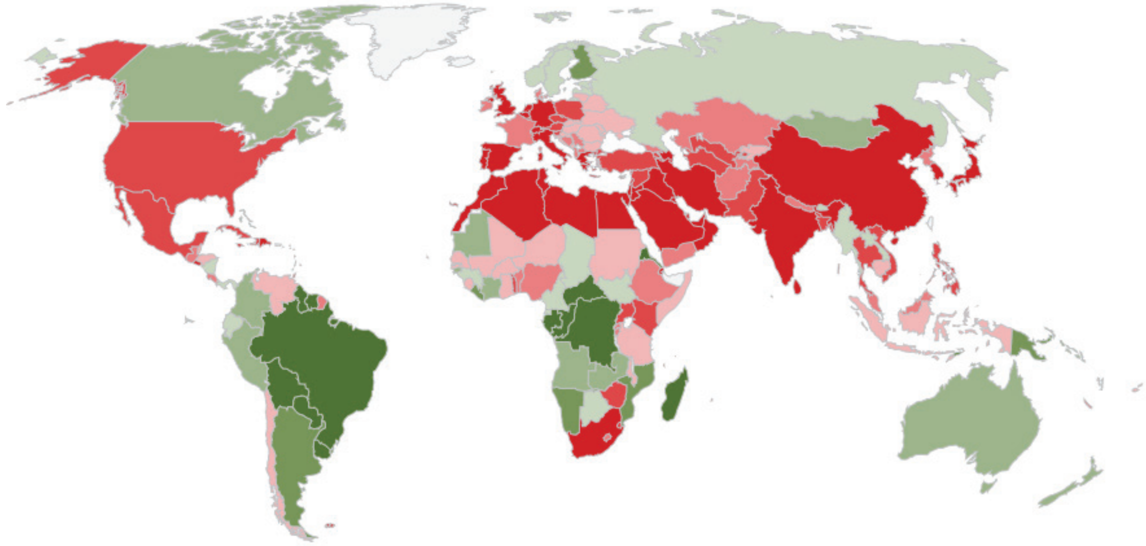

Fig. 1. Heat map of Countries with Bio Capacity Reserves and Deficits.

While air pollution has been deemed the worst in Asia-Pacific, land pollution is also considerably worse because of soil pollution, erosion, and salinization that affect agricultural sustainability. In Asia alone, a total of 315.8 million hectares of land area is affected by salt because of rigid irrigation and area expansion. Soil acidity, wind erosion, and metal contamination caused by heavy economic activity pose significant environmental threats. Furthermore, countries strive to enhance their tourism industries for economic gains. However, tourism exacerbates environmental challenges such as deforestation, biodiversity loss, and pollution, highlighting the need for eco-friendly tourism activities to mitigate ecological damage. Therefore, current research attempts to assess the impact of tourism activities, urbanization, and FDI on the Asia-Pacific region's ecological footprints and CO_2 emissions.

This paper will contribute to the existing literature in several ways. First, it contributes to the literature on the tourism-environment nexus with a fresh perspective from the Asia-Pacific region. Second, unlike earlier studies that overly focus on assessing the role of tourism and FDI on CO_2 emissions, the current research will use two different measures of ED, i.e., EF and CO_2 emission. This will help us understand how human activities can endanger the ozone layer, biological productive land, and other resources, specifically in Asia-Pacific countries. Third, the present research will also ascertain the crucial role of multinational corporations (via FDI) in ED in the host country. This will help policymakers include environmental considerations to attract foreign direct investment. Fourth, this study will ascertain the crucial role of urbanization in global warming, which will help to introduce new policy measures for waste management, construction, energy efficiency, and green spaces in the region. Finally, current research results will help promote environmentally friendly tourism spots with a keen focus on ecological well-being.

The rest of the paper is structured as follows: next Section evaluates the literature and theoretical foundations of the study. Materials and Methods Section describes the data and methodology. Results and Discussion Section provides the results of the statistical analyses. The final Section concludes the research and provides implications for the policymakers.

Theoretical Foundation and Literature Review

Externality Theory

Externality theory is defined as any cost or benefit brought upon the third party in a condition that the third party has no control over the formulation of the cost or benefit. This theory is relevant when the economy of a country's production or consumption in aggregate affects the third party. These harmed parties are "external" (such as the environment) to those who are producing and consuming the goods or services (businesses).

The effect of externality always results in goods and services that do not reflect the true price of consumption or production, meaning that the price for any good or service that has an externality impact is not in equilibrium [14]. For the price of any goods and services to perfectly reflect the true equilibrium in the market, it has to be adjusted by considering all of the costs, including external costs borne by the third party. In a nutshell, the environmental externalities should be internalized by imposing taxes/fines on the activities that generate negative externalities.

Common Goods Dilemma

The common good is a term mainly used in microeconomics. It is characterized by the fact that the goods are non-excludable, meaning that a particular person cannot stop others from obtaining the good, and people can use it until it reaches zero quantity. In the case of environmental issues, common goods tragedy in the area has created several dilemmas [15]. It is too costly to exclude a group of people from using the common good, such as water, trees, coal, etc. On the other hand, when this type of good is non-excludable, it raises cases where a group of people or firms are over-exploiting them without being hindered. The market for this type of good is more likely to be inefficient because of the scattered resources of free, non-excludable goods.

In retrospect, an example of public goods related to ED is Climate Change Mitigation (CCM). CCM consists of numerous actions that minimize the magnitude of real-time global warming and its effects. Examples of climate change mitigation could include reducing emissions, either natural or human, and policies limiting firms' activities that damage the environment [16]. One example of a positive externality is when a company mitigates climate change through self-governed policies that try to sustain or repair the environment. One party's benefit of mitigation also does not eliminate the benefit of others. That is why countries around the globe are forming the United Nations Framework Convention on Climate Change [17].

This convention aims to discuss strategies to reduce GHG concentration levels to a sustainable minimum.

Tourism and Environment

Previous literature suggests that tourism generates a significant amount of national income in Asia-Pacific countries, but lacks research on its possible detrimental impact on the countries [18]. On the other hand, those who have explored these adverse consequences have mainly used a single proxy of ED: the amount of carbon emissions. [19] have observed the effect of incoming tourists on pollution, caused mainly by CO_2 emissions in Malaysia, Thailand, and Singapore. Findings suggest a positive relationship exists between tourism and CO_2 emissions in Malaysia, but an inverse association was observed in Thailand and Singapore. [20] found a causal relationship between emissions, tourist arrivals, and economic growth, but it was only present in the short run. Tourism activities and transportation are the key contributors to CO_2 emissions in the tourism sector. [21]. Tourism exerts higher pressure on the environment than residents. [22].

Furthermore, [23] suggests that the integration between tourist arrival and environmental policy should be tightened to facilitate the transition towards a better tourist factor. [24] Turkey's energy utilization has increased as the tourism sector develops, resulting in increased emissions and climate change. Further, a long-term positive relationship between CO_2 emissions and tourism growth was observed using the ARDL approach. [25] found that since China has the largest number of tourist arrivals and, at the same time, is the largest emitter of CO_2, the increase in the number of tourist arrivals results in an increase in GDP, CO_2 emission, and energy consumption but is relatively limited compared to other countries. Further, in the context of the Hubei province of China, a low level of coordination between tourist activities and environmental management is reported by [26]. Similarly, [27] I also explored the impact of tourism development on ED in the USA using the wavelet transform framework. Results iterate that tourism development significantly impacts carbon emissions in both the short and long run. However, [28] observes the impact of tourism development on EF and uses the top 10 tourist countries as a sample. Results prove that tourism development exerts a positive influence on environmental quality. Some other studies have also observed the direct impact of tourism on the EF of the different geographical areas [29-32].

The work of [33] observes the relationship between tourism and CO_2 based on five South Asian countries. The paper confirms that there exists an EKC relationship between income and respective ED. [6] reveals that once tourism impact reaches a certain point, it reduces the effect on CO_2 emission, especially in developed economies. In addition, [34] showed that in the long-run income has a negative association with CO_2 emission in China and Brazil. Moreover, the study of [35] found the short-run and long-run causal relationship between tourism and CO_2 emission and economic growth. Thus, we have developed the following hypotheses:

H_1 = Tourism has a positive impact on EF of Asia-Pacific countries.

H_2= Tourism has a positive impact on carbon emissions in Asia-Pacific countries.

Urbanization, FDI and Environment

There are very few studies that link urbanization and FDI with EF. Most of the existing literature only focuses on the impact of degradation on CO_2 emission, and few studies have used EF as a proxy for environmental degradation. [36] developed a methodological framework for systemizing and calculating the EF related to tourism. [37] reported tourism's positive role in accelerating South-Asian economies' economic growth. [38] studies the effect of natural resources, human capital, and FDI with the EF using time series data of the US from 1970 to 2015. The results show that economic growth and FDI can significantly increase the EF in the long run.

In addition, in [39] the impact of financial development on the environment was examined using panel data from 131 countries from 1971 to 2017. Findings show that domestic credit helps to reduce the EF thus lessening the ED. Urbanization has a negative effect on EF. On the other hand, [40] shows that urbanization contributes to reducing the EF. Similarly, [41] revealed that energy consumption and urbanization, lead to ED.

Furthermore [42] used proxies such as CO_2 emissions, carbon footprint, and EF. Surprisingly, the results show that the FDI does not affect the ED in the 20 largest

EF contributor countries. A study of [43] modified the EKC by employing EF instead of only CO_2 emission as the indicator of ED. The results show that the EKC hypothesis holds in low-income, middle-income, and high-income countries. Based on the above studies, we propose the following hypotheses:

H_3 = Urbanization has a positive impact on EF of Asia-Pacific countries.

H_4= Urbanization has a positive effect on carbon emissions of Asia-Pacific countries.

Materials and Methods

Data

The panel data of nine Asia-Pacific countries (subject to availability of data) from 1995 to 2016 is used to conduct the present research. Data on CO_2 emissions, FDI, tourism, urban population, and trade is retrieved from World Development Indicators (WDI). EFs data is fetched from Global Footprint Network. The panel data is log-transformed to standardize and unify the measurements.

Variables

Dependent Variable

ED is the dependent variable of our study. We have employed two diverse measures of ED to get robust findings. Our first measure is EF [44] provided by Global Footprint Network. It measures how much area of biologically productive land and water a country requires to produce all the resources it consumes. The second measure of ED is annual carbon emissions by each country [45].

Independent Variables

Tourism is our core independent variable. We use two different proxies to measure the level of tourism in the Asia-Pacific region. Our first proxy is the total number of tourist arrivals in a calendar year [46] while the second measure is tourism revenue generated by each country [47]. Apart from this, the study also employed FDI, trade, and urbanization as control variables to mitigate the omitted variable bias. The description, calculation, and source of the variables are provided in Table 1.

Econometric Models

We have developed the following four different econometric models to examine the proposed association

$$EF_{i,t} = \alpha_0 + \alpha_1 TA_{i,t} + \alpha_2 FDI_{i,t} + \alpha_3 TD_{i,t} + \alpha_4 URB_{i,t} + \varepsilon_{i,t} \tag{1}$$

$$EF_{i,t} = \alpha_0 + \alpha_1 TR_{i,t} + \alpha_2 FDI_{i,t} + \alpha_3 TD_{i,t} + \alpha_4 URB_{i,t} + \varepsilon_{i,t} \tag{2}$$

$$CO2_{i,t} = \alpha_0 + \alpha_1 TA_{i,t} + \alpha_2 FDI_{i,t} + \alpha_3 TD_{i,t} + \alpha_4 URB_{it} + \varepsilon_{i,t} \tag{3}$$

$$CO2_{i,t} = \alpha_0 + \alpha_1 TR_{i,t} + \alpha_2 FDI_{i,t} + \alpha_3 TD_{i,t} + \alpha_4 URB_{it} + \varepsilon_{i,t} \tag{4}$$

In model (1), EF is EF in the global hectare of country *i* at time *t*. TA is the number of tourism arrivals in country *i* at time *t*. In model (2) TR is tourism revenue in country *i* at time *t*. In model (3) CO_2 is the carbon emissions by country *i* at time *t*. FDI, TD, and URB denote foreign direct investment, foreign trade, and urbanization, respectively. $\varepsilon_{i,t}$ is the error term.

Statistical Technique

At first, we employ a panel unit root test to test the stationarity of the variables. For this purpose, we choose Levin–Lin–Chu test (LLC) [48] and Im–Pesharan–Shin test (IPS) [49], respectively. The LLC test makes different asymptotic assumptions with different sizes of the panel data and time periods, while the IPS test is employed to allow for unbalanced panels.

Table 1. Variables Description.

Variable Name	Description	Calculation	Source
Dependent Variables			
EF	Ecological Footprint	Global Hectare	EF Network
CO_2	Territorial Carbon Emission	Metric Tons	WDI
Independent Variables			
TA	Tourist Arrivals	Number of people in millions	WDI
TR	Tourism Revenue	USD	WDI
FDI	Foreign Direct Investment	USD	WDI
TD	Trade	Trade % of GDP	WDI
URB	Urbanization	Urban population % of the total population	WDI

Second, this study employs the Autoregressive Distributed Lag cointegration technique (ARDL) (commonly known as bound test or error correction) to observe whether there exists cointegration between the variables [13]. The technique is useful for determining if a variable is a function of its own lagged time-series values, indicating that it depends on itself and can be described as non-stationary. It can also disentangle long-run relationships from short-run dynamics commonly known as an error term in the standard regression model. To avoid the negligence of the non-linear lagged impact of the independent variables on the dependent variables, the Non-Linear Autoregressive Distributed Lag technique is also applied to capture the asymmetric impact.

Finally, the Johansen co-integration test is applied to calculate the co-integration between the variables for each country. Johansen's co-integration test allows more than one co-integrating relationship between variables for respective countries.

Results

Descriptive Statistics

The descriptive statistics provided in Table 2 show that on average 15.64 million tourists visit the sampled Asia-Pacific countries every year, with a minimum value of 11.17 and a maximum value of 17.89 million. The average EF is 18.965 global hectares with a standard deviation of 1.752.

Correlation Analysis

Table 3 presents the correlation analysis of each variable. We can see that EF has a high correlation with CO_2 emission. EF also has a moderate to strong correlation with FDI +0.5756; TA +0.7011; TR +0.6741; and TD +0.7037. The endogenous variable, CO_2 emission results, produces nearly the same correlation with the independent variables: FDI +0.6306; TA +0.7630; TR +0.7460; and TD +0.6480.

Panel Unit Root Test

Table 4 presents the results of the panel unit root test derived from the conventional time series unit root test of LLC and IPS methods. The core purpose of conducting a unit root test is to check whether the variable is stationary or non-stationary. For both tests, the null hypothesis is "H_0: each panel contains a unit root". However, the LLC method is deemed more restrictive than IPS because it relies on the cross-sectional independence of the data set. The IPS method of unit root test also allows for heterogeneous coefficients, meaning that a certain part of the result coefficient may include unit root depending on the T-test.

Table 2. Descriptive Statistics.

Variable*	Obs	Mean	Std.Dev.	Min	Max
TA	198	15.64	1.39	11.17	17.898
TR	198	22.545	1.595	16.811	24.683
EF	198	18.965	1.544	16.165	22.383
CO_2	198	5.447	1.752	2.013	9.192
FDI	198	22.413	1.963	-7.234	26.39
TD	198	4.481	0.762	2.814	6.081
URB	198	4.089	0.343	3.41	4.605

Table 3. Correlation Matrix.

	FDI	TA	TR	TD	URB	EF	CO_2
FDI	1.0000						
TA	0.8028	1.0000					
TR	0.7808	0.9644	1.0000				
TD	-0.0156	-0.0756	-0.1125	1.0000			
URB	0.0705	-0.0890	0.0006	0.2514	1.0000		
EF	0.5756	0.7011	0.6741	0.7037	-0.2840	1.0000	
CO_2	0.6306	0.7630	0.7460	0.6480	-0.1695	0.9800	1.0000

Table 4. Panel Unit Root Test.

Variable	LLC		IPS	
	Level	1st Difference	Level	1st Difference
TA	2.013	-4.155***	5.543	-7.1245***
TR	-0.821	-5.716***	2.816	2.817***
EFP	-0.232	-4.568***	2.387	-6.371***
CO_2	-0.546	-5.897***	2.308	-6.151***
FDI	-3.384***	-7.248***	-4.266***	-7.735***
TD	-0.814	-5.041***	0.569	-6.659***
URB	-0.999	-3.369***	-0.779	-6.294***

*** indicates p<0.01

From the table, we can see that the results of the panel unit root tests support that all the variables are stationary at the level or first difference without suppressing the panel-specific means.

Regression Results

In Table 5, we run a long-run estimation ARDL model known as the bound test. The objective is to estimate the long-run and short-run relationships of the variables. Similarly, the Non-Linear Autoregressive Distributed Lag (NARDL) test is also applied to see the impact on non-linear negative and positive numbers. We have regressed TA and TR in two different models to avoid the issue of multicollinearity.

The ARDL and NARDL test results for dependent variable EF have shown a significant coefficient with TA and TR, confirming a long-run association between tourism and ED measure EF in the Asia-Pacific region. Urbanization and FDI also had a significantly positive coefficient with EF. These findings suggest that although urbanization and FDI benefit the economy, both have long-lasting impacts on the country's biological resources. Interestingly, TD is negatively ($p<0.01$) associated with EF in the third and fourth models.

The short-run estimation reveals that the error-constant term for both ARDL and NARDL models falls between -0.3 and -0.5 boundary with 99% significance, implying that the variables converge in the long run rather than in the short run. TA and TR delta

Table 5. ARDL and NARDL test with EF as Proxy.

Dependent Variable: EF				
	Symmetry (ARDL)		Asymmetry (NARDL)	
Variables	(1)	(2)	(3)	(4)
Long run estimation				
TA	0.243***			
	(0.075)			
TR		0.161***		
		(0.043)		
TA_Pos			0.273***	
		(0.034)		
TA_Neg			0.100*	
			(0.059)	
TR_Pos				0.154***
				(0.028)
TR_Neg				0.043
				(0.054)

URB	1.647***	1.733***	0.462***	0.587***
	(0.557)	(0.522)	(0.159)	(0.211)
FDI	0.052***	0.044***	0.010	0.008
	(0.017)	(0.016)	(0.007)	(0.009)
TD	0.059	0.106	-0.089***	-0.132***
	(0.089)	(0.095)	(0.025)	(0.047)
Constant	2.190***	2.060***	7.067**	4.999**
	(0.766)	(0.735)	(2.839)	(1.942)
Short run estimation				
ECT	-0.303***	-0.304***	-0.452***	-0.333***
	(0.110)	(0.113)	(0.158)	(0.114)
ΔTA	0.093*			
	(0.048)			
ΔTR		0.161***		
		(0.043)		
ΔTA_Pos			0.068	
			(0.050)	
ΔTA_Neg			0.099	
			(0.145)	
ΔTR_Pos				-0.048
				(0.046)
ΔTR_Neg				0.261**
				(0.109)
ΔURB	3.371	1.733***	1.869	-0.800
	(2.893)	(0.522)	(2.623)	(2.123)
ΔFDI	-0.012	0.044***	-0.010	-0.009
	(0.010)	(0.016)	(0.012)	(0.009)
ΔTD	0.040	0.106	0.127*	0.144***
	(0.056)	(0.095)	(0.065)	(0.034)
Observations	189	189	189	189

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

1st difference short-run estimation of ARDL confirms short-run relationship with a coefficient of 0.093 and 0.161, respectively. It indicates that tourism harms the environment in the short and long run.

Robustness Test

To test the robustness of our results reported in Table 5, we have applied another widely used proxy for ED: CO_2 emissions. As shown in Table 6, carbon emissions have a positive and statistically significant ($p<0.01$) coefficient in both models (1) and (2). These results strengthen our proposition that tourism has a long-lasting impact on the host country's environment.

Short-run estimation confirmed the previous indictment that it has a significant and negative coefficient for ECT. However, contrary to the findings of Table 5, TA and TR have an insignificant association with CO_2 emissions in Asia-Pacific countries. One plausible explanation for this insignificant association could be that, in the short run, tourism may be managed through existing capabilities and infrastructure. However, sustained tourism growth ultimately increases the demand for transportation,

Table 6. ARDL and NARDL test with CO_2 emission as Proxy.

Dependent Variable: CO_2 Emission				
	Symmetry (ARDL)		Asymmetry (NARDL)	
Variables	(1)	(2)	(3)	(4)
Long run estimation				
TA	0.300***			
	(0.070)			
TR		0.262***		
		(0.047)		
TA_Pos			0.799***	
			(0.169)	
TA_Neg			1.344***	
			(0.364)	
TR_Pos				0.250***
				(0.061)
TR_Neg				0.271**
				(0.120)
URB	0.627***	0.401*	2.655***	3.681***
	(0.209)	(0.205)	(0.817)	(0.796)
FDI	0.007	0.009	0.045**	0.004
	(0.016)	(0.015)	(0.022)	(0.025)
TD	-0.285***	-0.241***		
	(0.097)	(0.084)		
Constant	-0.332***	-0.549***	-0.017	-3.123***
	(0.125)	(0.144)	(0.226)	(0.870)
Short run estimation				
ECT	-0.310***	-0.332***	-0.170**	-0.301***
	(0.100)	(0.106)	(0.068)	(0.080)
ΔTA	(0.100)			
	0.018			
ΔTR		-0.071		
		(0.053)		
ΔTA_Pos			-0.011	
			(0.125)	
ΔTA_Neg			-0.065	
			(0.321)	
ΔTR_Pos				-0.089
				(0.074)
ΔTR_Neg				0.046
				(0.075)
ΔURB	(0.050)	-0.580	3.640	4.034
	0.798	(3.221)	(3.557)	(3.385)

ΔFDI	(2.482)	-0.002	0.004	0.004
	-0.010	(0.017)	(0.014)	(0.011)
ΔTD	(0.021)	0.064		
	-0.022	(0.089)		
Observations	189	189	189	189

Standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 7. Country-Level Presence of Co-integration.

No.	Country	DV: Ecological footprint				DV: Territorial Carbon Emission			
		Symmetry		Asymmetry		Symmetry		Asymmetry	
		1	2	3	4	1	2	3	4
		TA	TR	TA	TR	TA	TR	TA	TR
1	China	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	Indonesia	No	No	Yes	Yes	Yes	Yes	No	No
3	Japan	No	No	No	No	No	No	Yes	Yes
4	Malaysia	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	Mongolia	Yes	Yes	Yes	Yes	No	No	Yes	Yes
6	Philippines	Yes	No	No	No	Yes	Yes	Yes	Yes
7	Singapore	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8	South Korea	Yes	Yes	Yes	No	Yes	Yes	No	No
9	Thailand	No	No	Yes	Yes	Yes	Yes	No	No

Co-integration existence is accepted when the degree of constant and the trend value has $p<0.5$ for the trace statistic and max statistic of the residual test to each individual time-series for at least 2 co-integrating variables.

roads, and residential infrastructure, which amplifies carbon emissions.

Co-integration Level of Countries

In Table 7, all the sampled countries show either moderate or higher levels of co-integration. Malaysia and Singapore confirmed co-integration in the previous ARDL-NARDL model, meaning that these two countries are more likely to absorb shocks in the short run, and the variables would converge again in the long run. China accepted only one null hypothesis: there is no co-integration in the ARDL-TA model. At the same time, Mongolia has no other co-integration than its asymmetrical model for both TA and TR. Indonesia, the Philippines, South Korea, and Thailand have a medium degree of co-integration, while Japan only accepts two asymmetrical co-integration models for CO_2 emission. Further, long-run and short-run asymmetries of the variables have been reported in Appendix 1.

Conclusions

This study investigated the long-run impact of tourism, urbanization, and FDI on the Asia-Pacific region's ecological footprint and CO_2 emissions. For this purpose, the IPS and LLC panel unit root tests, ARDL-NARDL bounds testing approach, and Johansen co-integration test were employed on the sampled dataset. The empirical results showed that tourism and urbanization had a long-run relationship with EF and CO_2 territorial emission. Further, the analysis revealed a positive and statistically significant influence of tourism proxies—tourism arrivals and tourism revenue—on environmental degradation measures, namely the ecological footprint and CO_2 emissions. This association confirms the existence of a common goods dilemma where people are over-exploiting the environment without any hindrance. Similar results have been reported by [50, 51]. On the contrary, [52] discovered a 'U' shaped association between tourism and environmental degradation. While [53] reported an inverted 'U' shaped relationship. They found that tourism initially has adverse implications for the natural environment; however, after a certain point, an increase in tourism activities helps improve the environment.

The tourism industry has significantly contributed to the global economy and brought wealth to many Asia-Pacific countries due to its attractiveness. However, the cumulative impact of human activities, including tourism, has adversely impacted the environment. Therefore, it is crucial that all parties contributing to environmental degradation, including the tourism industry, undertake efforts to protect and preserve the environment. More specifically, the tourism ministries of Asia-Pacific countries should introduce stringent policies for inbound tourists to protect their ecological assets and minimize CO_2 emissions. The positive impact of urbanization on environmental degradation underscores the need to promote public transportation, develop green spaces, encourage sustainable building practices, and implement comprehensive recycling programs for waste management.

Limitations and Future Research Agenda

There is no doubt about the profundity and reliability of the current research results. However, like any other empirical research, our study bears certain limitations regarding the effectiveness and generalizability of the findings. First, we reported a unilateral association between studied variables. However, future research should explore whether bi-directional causality exists between tourism and environmental degradation. Second, the Asia-Pacific region is home to countries at varying stages of development; therefore, an individual country-level analysis will help to understand the role of country-specific characteristics on the tourism-environment nexus. Finally, the Asia-Pacific countries have great potential for the development of the tourism industry, with tourism arrivals expected to reach 535 million by 2030. Thus, further studies incorporating a broad range of environment-related variables will help devise eco-friendly policies to protect the environment from the adverse effects of this growth.

Conflict of Interest

The authors declare no conflict of interest.

References

1. AGENCE FRANCE-PRESSE. Asia's smog exodus: companies forced to offer 'pollution premiums' to recruit top talent. South China Morning Post. **2019**.
2. WACKERNAGEL M., REES W. Our ecological footprint: reducing human impact on the earth. In New Catalyst Bioregional Series. New Society Publishers, Philadelphia. **1998**.
3. HUNTER C., SHAW J. The ecological footprint as a key indicator of sustainable tourism. Tourism Management. **28** (1), 46, **2007**.
4. WTTC Economic Impact Report. The World Travel and Tourism Council. **2024**.
5. UNWTO. Country Profile. **2024**.
6. PARAMATI S.R., ALAM M.S., CHEN C.-F. The Effects of Tourism on Economic Growth and CO_2 Emissions: A Comparison between Developed and Developing Economies. Journal of Travel Research. **56** (6), 712, **2016**.
7. STATISTA. Overseas visitor arrivals in China from 2010 to 2023. **2023**.
8. ZHENG C., WU S., TENG Y.-P., WU S., WANG Z. Natural resources, tourism resources and economic growth: A new direction to natural resources perspective and investment. Resources Policy. **86**, 104134, **2023**.
9. MOHSIN M., ABBAS Q., ZHANG J., IKRAM M., IQBAL N. Integrated effect of energy consumption, economic development, and population growth on CO_2 based environmental degradation: a case of transport sector. Environmental Science and Pollution Research. **26**, 32824, **2019**.
10. CAO W., SOFIA G., TAROLLI P. Geomorphometric characterisation of natural and anthropogenic land covers. Progress in Earth and Planetary Science. **7**, 1, **2020**.
11. KHAN S., YAHONG W. Income inequality, ecological footprint, and carbon dioxide emissions in Asian developing economies: what effects what and how? Environmental Science and Pollution Research. **29** (17), 24660, **2022**.
12. CAO B., BRAY F., ILBAWI A., SOERJOMATARAM I. Effect on longevity of one-third reduction in premature mortality from non-communicable diseases by 2030: a global analysis of the Sustainable Development Goal health target. The Lancet Global Health. **6** (12), e1288, **2018**.
13. SHIN Y., YU B., GREENWOOD-NIMMO M. Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In Festschrift in Honor of Peter Schmidt, pp. 281-314, Springer, New York. **2014**.
14. MANKIW N.G. Principles of economics. Cengage Learning. **2020**.
15. WIESMETH H. Environmental Economics. Springer International Publishing AG. **2012**.
16. ULANOV V.L. The Need for the Green Economy Factors in Assessing the Development and Growth of Russian Raw Materials Companies. Journal of Comprehensive Business Administration Research. **1** (1), 19, **2024**.
17. United Nations Framework Convention on Climate Change. Full Text of the Convention, Article 2: Objectives. **2002**.
18. AHMAD F., DRAZ M.U., SU L., RAUF A. Taking the bad with the good: The nexus between tourism and environmental degradation in the lower middle-income Southeast Asian economies. Journal of Cleaner Production. **233**, 1240, **2019**.
19. AZAM M., MAHMUDUL ALAM M., HAROON HAFEEZ M. Effect of tourism on environmental pollution: Further evidence from Malaysia, Singapore, and Thailand. Journal of Cleaner Production. **190**, 330, **2018**.
20. SHARIF A., AFSHAN S., NISHA N. Impact of tourism on CO_2 emission: evidence from Pakistan. Asia Pacific Journal of Tourism Research. **22** (4), 408, **2017**.
21. LIU T., YANG T. Study on Carbon Emission and Its Influencing Factors in China's Tourism Industry. Polish Journal of Environmental Studies. **33** (6), 6259, **2024**.
22. MIRALLES C.C., BARIONI D., MANCINI M.S., JORDÀ J.C., ROURA M.B., SALAS S.P., ARGELAGUET L.L., GALLI A. The footprint of tourism: A review of water,

carbon, and ecological footprint applications to the tourism sector. Journal of Cleaner Production. **422** (22), 138568, **2023**.
23. NEPAL R., INDRA AL IRSYAD M., NEPAL S.K. Tourist arrivals, energy consumption and pollutant emissions in a developing economy–implications for sustainable tourism. Tourism Management. **72**, 145, **2019**.
24. KATIRCIOGLU S.T. International tourism, energy consumption, and environmental pollution: The case of Turkey. Renewable and Sustainable Energy Reviews. **36**, 180, **2014**.
25. KUO K.C., LIU M., LAI S.L. Effect of Tourism Development on Energy Consumption, CO₂ and Economic Growth in China. Advanced Materials Research. **524-527**, 3380, **2012**.
26. YUE Y., HAOMIAO R. Coordinated Development of the Tourism Industry and Ecological Environment: A Case Study of Hubei Province in China. Polish Journal of Environmental Studies. **33** (4), 4903, 2024.
27. RAZA S.A., SHARIF A., WONG W.K., KARIM M.Z.A. Tourism development and environmental degradation in the United States: evidence from wavelet-based analysis. Current Issues in Tourism. **20** (16), 1768, **2016**.
28. KATIRCIOGLU S., GOKMENOGLU K.K., EREN B.M. Testing the role of tourism development in ecological footprint quality: evidence from top 10 tourist destinations. Environmental Science and Pollution Research. **25** (33), 33611, **2018**.
29. COLE V., SINCLAIR A.J. Measuring the Ecological Footprint of a Himalayan Tourist Center. Mountain Research and Development. **22** (2), 132, **2002**.
30. PEETERS P., SCHOUTEN F. Reducing the Ecological Footprint of Inbound Tourism and Transport to Amsterdam. Journal of Sustainable Tourism. **14** (2), 157, **2006**.
31. PATTERSON T.M., NICCOLUCCI V., BASTIANONI S. Beyond "more is better": Ecological footprint accounting for tourism and consumption in Val di Merse, Italy. Ecological Economics. **62** (3-4), 747, **2007**.
32. CASTELLANI V., SALA S. Ecological Footprint and Life Cycle Assessment in the sustainability assessment of tourism activities. Ecological Indicators. **16**, 135, **2012**.
33. SHERAFATIAN-JAHROMI R., OTHMAN M.S., LAW S.H., ISMAIL N.W. Tourism and CO_2 emissions nexus in Southeast Asia: new evidence from panel estimation. Environment, Development and Sustainability. **19** (4), 1407, **2016**.
34. ALAM M.M., MURAD M.W., NOMAN A.H.M., OZTURK I. Relationships among carbon emissions, economic growth, energy consumption and population growth: Testing Environmental Kuznets Curve hypothesis for Brazil, China, India and Indonesia. Ecological Indicators. **70**, 466, **2016**.
35. ZHANG L., GAO J. Exploring the effects of international tourism on China's economic growth, energy consumption and environmental pollution: Evidence from a regional panel analysis. Renewable and Sustainable Energy Reviews. **53**, 225, **2016**.
36. GÖSSLING S., HANSSON C.B., HÖRSTMEIER O., SAGGEL S. Ecological footprint analysis as a tool to assess tourism sustainability. Ecological Economics. **43** (2), 199, **2002**.
37. NAZIR M., AKBAR M., BATOOL I., HUSSAIN A. Is tourism an accelerator of economic growth? Evidence from South Asian region. Acta Oeconomica. **72** (4), 553, **2022**.
38. ZAFAR M.W., ZAIDI S.A.H., KHAN N.R., MIRZA F.M., HOU F., KIRMANI S.A.A. The impact of natural resources, human capital, and foreign direct investment on the ecological footprint: The case of the United States. Resources Policy. **63** (10), 101428, **2019**.
39. MAJEED M.T., MAZHAR M. Financial development and ecological footprint: a global panel data analysis. Pakistan Journal of Commerce and Social Sciences (PJCSS). **13** (2), 487, **2019**.
40. AHMED Z., WANG Z., MAHMOOD F., HAFEEZ M., ALI N. Does globalization increase the ecological footprint? Empirical evidence from Malaysia. Environmental Science and Pollution Research. **26** (18), 18565, **2019**.
41. AL-MULALI U., OZTURK I. The effect of energy consumption, urbanization, trade openness, industrial output, and the political stability on the environmental degradation in the MENA (Middle East and North African) region. Energy. **84**, 382, **2015**.
42. SOLARIN S.A., AL-MULALI U. Influence of foreign direct investment on indicators of environmental degradation. Environmental Science and Pollution Research. **25** (25), 24845, **2018**.
43. ULUCAK R., BILGILI F. A reinvestigation of EKC model by ecological footprint measurement for high, middle and low income countries. Journal of Cleaner Production. **188**, 144, **2018**.
44. LENZEN M., SUN Y.-Y., FATURAY F., TING Y.-P., GESCHKE A., MALIK A. The carbon footprint of global tourism. Nature climate change. **8** (6), 522, **2018**.
45. AKBAR M., HUSSAIN A., AKBAR A., ULLAH I. The dynamic association between healthcare spending, CO_2 emissions, and human development index in OECD countries: Evidence from panel VAR model. Environment, Development and Sustainability. **23**, 10470, **2021**.
46. SEABRA C., REIS P., ABRANTES J.L. The influence of terrorism in tourism arrivals: A longitudinal approach in a Mediterranean country. Annals of Tourism Research. **80**, 102811, **2020**.
47. SAK N., KARYMSHAKOV K. Relationship between tourism and economic growth: A panel Granger causality approach. Asian economic and financial review. **2** (5), 591, **2012**.
48. LEVIN A., LIN C.-F., CHU C.-S.J. Unit root tests in panel data: asymptotic and finite-sample properties. Journal of Econometrics. **108** (1), 1, **2002**.
49. IM K.S., PESARAN M.H., SHIN Y. Testing for unit roots in heterogeneous panels. Journal of Econometrics. **115** (1), 53, **2003**.
50. GUPTA M.R., DUTTA P.B. Tourism development, environmental pollution and economic growth: A theoretical analysis. The Journal of International Trade & Economic Development. **27** (2), 125, **2018**.
51. RAZA S.A., SHARIF A., WONG W.K., KARIM M.Z.A. Tourism development and environmental degradation in the United States: evidence from wavelet-based analysis. Current Issues in Tourism. **20** (16), 1768, **2017**.
52. EHIGIAMUSOE K.U. Tourism, growth and environment: Analysis of non-linear and moderating effects. Journal of Sustainable Tourism. **28** (8), 1174, **2020**.
53. RAZA S.A., QURESHI M.A., AHMED M., QAISER S., ALI R., AHMED F. Non-linear relationship between tourism, economic growth, urbanization, and environmental degradation: evidence from smooth transition models. Environmental Science and Pollution Research. **28**, 1426, **2021**.

Appendix

Appendix 1. Long-run and short-run asymmetries of variables.

Dependent Variables	EF		Carbon emission	
	(1)	(2)	(3)	(4)
	TA	TR	TA	TR
Long run asymmetry	4.55**	4.61**	4.53**	4.67**
Short run asymmetry	0.85	5.21**	0.89	2.00