

Empirical Analysis of Tourism, Human Capital and Globalization to Achieve the Sustainable Development

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Abstract

This study examines to determine how globalization, tourism, and human capital promote sustainable development in high-income countries between 1996 and 2023. A Sustainable Environment Index is created using metrics like air quality, energy efficiency, biodiversity conservation, land use, public health, and ecological pressure in order to evaluate environmental quality thoroughly. The study determines the short- and long-term impacts of the variables selected on environmental sustainability using advanced panel data econometric techniques that take cross-sectional dependence into account. The empirical results show that tourism significantly improves the environment through the use of renewable energy, eco-friendly infrastructure, effective waste management, and increased environmental awareness. Human capital becomes an important factor in advancing environmental sustainability by promoting innovation and increasing public awareness. By encouraging innovation and raising public awareness, human capital becomes an essential component in promoting environmental sustainability. Globalization presents environmental risks due to increased industrial activity and consumption, but it also promotes sustainability through the sharing of technology and knowledge. These findings suggest that attaining sustainability objectives may require particular policies that support eco-friendly travel and enhance human resources. In order to guarantee long-term environmental sustainability, the study emphasizes the importance of balanced globalization strategies and offers useful guidance to policymakers in developed countries.

Keywords: Tourism; Sustainable Environment Index; Human Capital; Globalization.

Introduction

The quest for sustainable development has become a central theme in global economic and environmental policy, particularly within high-income economies that are grappling with the complex challenges of balancing growth with environmental stewardship. As nations continue to pursue economic advancement, there is an increasing recognition of the need to ensure that such progress does not come at the expense of environmental sustainability. This delicate balance is encapsulated in the concept of sustainable development, which aims to meet the needs of the present without compromising the ability of future generations to meet their own needs (Zapata-Cantu & González, 2021). This study focuses on examining the intricate relationships between three key drivers—globalization, human capital, and tourism—and their impact on environmental sustainability within the context of high-income economies.

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Globalization and Environmental Sustainability

Globalization, characterized by the increasing interconnectedness of economies, cultures, and political systems, has been a dominant force shaping the modern world. The process of globalization has facilitated the rapid exchange of goods, services, information, and technologies across borders, leading to significant economic growth and development. It can also exacerbate environmental degradation through increased consumption, resource exploitation, and pollution (Zapata-Cantu & González, 2021). The dual-edged nature of globalization necessitates a nuanced understanding of its impact on environmental sustainability, particularly in high-income economies where the effects are often most pronounced.

A substantial body of literature has explored the environmental impacts of globalization, often with mixed findings. For instance, (Grossman et al., 1995) seminal work on the Environmental Kuznets Curve (EKC) hypothesis suggests that economic growth initially leads to environmental degradation but eventually results in environmental improvement as economies reach higher levels of income and invest in cleaner technologies. Conversely, studies such as those by (Jorgenson & Clark, 2012) argue that globalization, particularly through trade and investment, has contributed to increased carbon emissions and resource depletion in both developed and developing countries. In high-income economies, the relationship between globalization and environmental sustainability is further complicated by the outsourcing of pollution-intensive industries to lower-income countries, a phenomenon known as the "pollution haven hypothesis" (Jorgenson & Clark, 2012). This process allows high-income countries to maintain relatively clean domestic environments while contributing to environmental degradation elsewhere. This study builds on these insights by examining how globalization influences environmental sustainability in high-income economies, using advanced econometric techniques to disentangle the complex interactions between trade, investment, and environmental outcomes.

Human Capital and Environmental Sustainability

Human capital, defined as the knowledge, skills, and competencies acquired by individuals through education, training, and experience, plays a crucial role in shaping the economic and environmental outcomes of a nation (Becker, 1993). In the context of sustainable development, human capital is not only a driver of economic productivity but also a key determinant of environmental stewardship. Higher levels of education and skills can lead to more efficient resource use, innovation in sustainable technologies, and a greater awareness of environmental issues (Alfalih & Hady, 2024). However, the relationship between human capital and environmental sustainability is not always straightforward. In some cases, higher levels of human capital can lead to increased consumption and environmental impact, particularly in high-income economies where lifestyles are often resource-intensive (Feng et al., 2024).

Research on the role of human capital in environmental sustainability has produced a range of findings. (Alfalih & Hady, 2024) argued that human capital, particularly in the form of education and technological innovation, could offset the pressures of population growth on the environment by enabling more efficient resource use. Similarly, (Ali et al., 2021) found that higher levels of education are associated with lower fertility rates and reduced pressure on natural resources. On the other hand, (Feng et al., 2024) suggest that increased levels of human capital can lead to higher consumption levels and greater environmental impact, particularly in affluent societies.

This study seeks to explore these complexities by examining the impact of human capital on environmental sustainability in high-income economies. Specifically, it investigates whether the positive effects of human capital on environmental awareness and technological innovation are

sufficient to counterbalance the potential negative effects of increased consumption and resource use.

Tourism and Environmental Sustainability

Tourism is another critical factor influencing environmental sustainability, particularly in high-income economies where the tourism industry is a significant contributor to economic growth. The tourism sector is inherently linked to the environment, as natural landscapes, cultural heritage, and biodiversity are often key attractions for tourists (Bentley & Halim, 2024). As such, tourism has the potential to both positively and negatively impact environmental sustainability. On the positive side, sustainable tourism practices can promote conservation, raise environmental awareness, and generate revenue for environmental protection. Conversely, poorly managed tourism can lead to environmental degradation, including habitat destruction, pollution, and increased carbon emissions (Torsney & Buckley, 2025).

The literature on tourism and environmental sustainability is extensive, with many studies emphasizing the potential for tourism to contribute to conservation and sustainable development. For instance, (Bentley & Halim, 2024) highlights the role of ecotourism in promoting biodiversity conservation and generating funds for protected areas. Similarly, they discuss the concept of sustainable tourism, which seeks to minimize the negative environmental impacts of tourism while maximizing its economic and social benefits. However, the literature also points to significant challenges in achieving sustainable tourism, particularly in terms of managing the environmental impacts of mass tourism and ensuring that tourism revenues are effectively reinvested in environmental protection.

This study builds on these insights by analyzing the impact of tourism on environmental sustainability in high-income economies. It examines whether tourism development in these countries has contributed to environmental degradation or whether it has been managed in a way that supports sustainable development.

Methodological Framework

To assess the impact of globalization, human capital, and tourism on environmental sustainability, this study constructs a Sustainable Environment Index (SEI) for high-income economies. The SEI captures multiple dimensions of environmental quality, including air quality, energy use, biodiversity, land use, public health, and ecological pressure (Guloglu & Caglar, 2023). Advanced econometric techniques are employed to address cross-sectional dependence commonly found in panel data and to ensure robust estimation. Specifically, second-generation unit root tests are applied to account for inter-country correlations (Econometrics, 2007), and the Pooled Mean Group (PMG) estimator is used to explore both short- and long-term relationships among the variables (Maddala et al., 1999).

Significance of the Study

The empirical findings contribute to the discussion of sustainable development by demonstrating the complex relationships among globalization, human capital, tourism, and environmental sustainability in high-income economies. Tourism has been demonstrated to decrease environmental degradation, despite the fact that globalization has mixed effects, promoting sustainability in some locations while reducing sustainability in others (Cole, 2004). Depending on the application and level of economic development, human capital has different effects (Agarwalla & Sahu, 2024). The study's conclusion highlights the importance of an all-

encompassing approach to environmental sustainability. It offers recommendations for policies that balance ecological preservation and development, as well as policies that combine economic growth and environmental preservation.

Literature Review

A plenty of research plethora has supported this research work. (Kanval et al., 2024) found that human capital, foreign direct investment, renewable energy, and physical capital positively impact Pakistan's economic growth in both the short and long run. FDI significantly enhances human capital, further enhancing economic growth. Conversely, carbon emissions and urbanization negatively affect economic growth over time. (Bahmani et al., 2023; Ni et al., 2023; Zhang et al., 2023) examined the role of green human capital and environmental regulations in promoting green innovation and industry upgrading for sustainable development. The result showed that green human capital significantly contributes to innovation and sustainability, while environmental regulations show limited effectiveness. The study emphasized prioritizing green human capital to achieve SDGs 7, 9, and 12. (Munawar et al., 2022) conducted a study in Pakistan's hotel industry, found that Green HRM practices enhance green human capital and environmental knowledge, which in turn significantly increase green innovation.

Many researchers have examined how human capital, natural resources, and economic growth are connected. For example, (Lahiani et al., 2021) pointed out that a skilled workforce increases productivity. Overall, the research suggests that even though natural resources can create challenges, investing in people through education and skill-building can help ensure sustainable and inclusive growth. Some argue that having too many natural resources can actually slow down economic growth and weaken the development of human capital a situation often referred to as the "resource curse" (Shahbaz et al., 2017). To address this, they suggested investing more in education. On the other hand, other scholars emphasized the positive role human capital plays in enhancing economic growth.

(Dai et al., 2024) explored that higher income levels in ASEAN countries support the expansion of the load capacity factor (LCF) and improve environmental quality. Human capital and green energy adoption both positively influence LCF and environmental quality. However, population density and economic globalization contribute to environmental degradation. (Asghar et al., 2024) revealed that investments in human capital, innovation, green energy, and political stability positively impact sustainable development. Conversely, natural and produced capital are found to have a negative effect, suggesting that modernization and conservation efforts are essential for advancing sustainability in developing nations. In order to create sustainable behaviors, (Guloglu & Caglar, AE, 2023) addressed several different actions, such as making investments in renewable energy sources, establishing energy-efficient technologies, developing sustainable transportation systems, and raising public awareness and education about climate change. Additionally, it enhances sustainability and resource efficiency. By encouraging involvement in eco-friendly practices like the use of renewable energy, human capital advances sustainability. The companies themselves have set goals besides only their own profit, such as a dedication to environmental and social outcomes, as the emphasis on social responsibility and sustainable development increases (Opoku, 2019; Wang et al., 2020). Zafar et al. (2019) conduct empirical research that examines how natural resources, human capital, and foreign direct investment affect sustainable development in the context of economic growth and energy consumption for the US economy. The data was gathered between 1970 and 2015.

Data characteristics were examined using the Zivot-Andrews unit root method, and the Auto Regressive Distributive Lag (ARDL) model was utilized to estimate the ' long- and short-term elasticity (Liu, Y., & Faye, 2021). According to the study, there are fewer carbon emissions and more opportunities for attaining sustainable development in a nation with a high human capital index, which shows the availability of skilled, educated, and healthy workers. (Dube & Nhamo, 2021) examined that a good quality working environment, an efficient labor force, and natural resources both for present and future use, environmental protection covers a major part of Sustainable development goals. Furthermore, enhancing the social well-being of the nation along with sustainable economic development is environmental protection. (Talha et al., 2021) suggested that companies which show tendency to use biomass, biofuel, or solar energy for different technologies, production plants, or logistics do not contribute CO2 emission into the atmosphere. Therefore, the company offers the general people natural resources and a good surroundings.

Data and Methods

This study has estimated the impact of globalization, human capital and tourism on sustainable environment in case of high income economies following the specification given below:

$$SEI_{it} = \beta_0 + \beta_1 HC_{it} + \beta_2 GLO_{it} + \beta_3 TOUR_{it} + \varepsilon_{it} \quad (1)$$

where SEI, HC, GLO, and TOUR stand for sustainable environment index, human capital, globalization, and tourism respectively. ε is the error term. Further, this study has been extended by adding two control factors as shown in the 2nd specification. $SEI_{it} = \beta_1 HC_{it} + \beta_2 GLO_{it} + \beta_3 TOUR_{it} + \beta_4 GDPG_{it} + \beta_5 IND_{it} + \varepsilon_{it}$ (2)

Where GDP growth and industrial output denoted by GDPG and IND are control factors.

The dependent factor i.e. Sustainable Environment Index has been constructed to evaluate developed nations' environmental sustainability. To assess the state of the environment towards sustainability goals, numerous environmental indicators are often taken into consideration. Despite the fact that there isn't a single, widely accepted "Sustainable Environment Index," numerous organizations and researchers have created their own indices to evaluate environmental sustainability. This study has utilized the following indicators well explained in the table below:

Table 1: Indicators of the Sustainable Environmental Index

Main components	Sub-indicators	Unit	Data source
Air quality and pollution	Greenhouse gases	kt	WDI
	PM2.5 air pollution, mean annual exposure (micrograms per cubic meter)	Micrograms per cubic meter	WDI
Energy management	Combustible renewables and waste (% of total energy)	%	WDI
Forest and bio-diversity	Forest area (% of land area)	%	WDI
Land use and agriculture	Agricultural land (% of land area)	%	WDI
Human health and disaster	Incidence of tuberculosis (per 100,000 people)	Number	WDI
	Mortality rate, infant (per 1,000 live births)	Number	WDI
Population pressure on ecosystem services	Fertility rate, total (births per woman)	Number	WDI
	Population growth (annual %)	%	WDI
Water generation management	Total renewable energy consumption	%	WDI

In the independent variables like globalization, human capital, GDP growth, tourism and industrial output growth, "globalization" refers to the growing connectivity and interdependence of nations and people around the world in terms of economics, politics, culture, technology, and communication. A more integrated and connected global society is the result of the cross-border movement of people, commodities, services, information, ideas, and people (Rodrik, 1997).

Three common dimensions of globalization i.e. economic, financial and trade globalizations are more likely to cause environmental quality. First, economic globalization improves global economic integration by lowering obstacles to trade. Diversifying consumption might result in a decrease in emissions by using resources more efficiently. But it results in more mobility of people and products, which raises GHG emissions (Ganiyev et al., 2024). Second, financial globalization accelerates international financial institutions and markets' integration. Environmental quality and financial globalization have a complicated relationship. Last but not least, trade globalization promotes economic growth and development, improving environmental rules and protections in developed countries. The performance of the environment is also significantly influenced by globalization (Rehman et al., 2022).

Human capital is the pool of knowledge, competencies, schooling, training, and experience that human beings own that improves their productivity, employment, and that brings their economic, social and environmental improvement is referred to as human capital (Becker, 1993). The data on human capital is taken from Pan World Table from 1990 to 2021. Similarly, that data on annual GDP growth, tourism and industrial output growth have been retrieved from WDI.

Estimation Method

Tests for Cross Sectional Dependency

The analysis begins with tests for cross-sectional dependence, which refers to correlations across units (e.g., countries) due to common shocks or spillover effects. Ignoring such dependence can lead to biased estimators and misleading inferences. To address this, the study applies the Pesaran, Friedman, and Frees tests (Danish et al., 2019). Given the limitations of first-generation unit root tests in the presence of cross-sectional dependence, second-generation tests specifically the Cross-Sectionally Augmented Im-Pesaran-Shin (CIPS) test are employed to ensure robustness in both short- and long-term analyses (Econometrics, 2007; Maddala et al., 1999).

The Pooled Mean Group (PMG) estimator

The Pooled Mean Group (PMG) estimator, developed by Pesaran et al. (1999), is suited for panel data models with both time-series and cross-sectional dimensions. It assumes long-run relationships are homogeneous across entities, while allowing short-term dynamics and error variances to be heterogeneous. Particularly useful for dynamic panels with lagged dependent variables, the PMG estimator operates within an Error Correction Model (ECM) framework, capturing both long-run equilibrium and short-term adjustments. Its consistency and efficiency make it more reliable than purely pooled estimators, especially in macroeconomic and financial studies where such dynamics are common.

Results and Discussion

In the context of developing economies, this study has examined the short- and long-term dynamics of human capital, globalization, and tourism development with respect to environmental quality.

Table 2: Cross-Sectional Independence Tests

Pesaran's test of cross sectional independence =	23.429, Pr = 0.0000
Frees' test of cross sectional independence =	9.077, Pr = 0.0000
Warning: A normal distribution had been used to approximate Frees' Q distribution	
Friedman's test of cross sectional independence =	197.899, Pr = 0.0000

The significant estimated Pr values in the above reported cross-sectional dependence tests statistics show cross-sectional dependence among the given panel of interest. Further, average correlation coefficient and pesaran (2004) test statistics also confirms the existence of cross-sectional dependence among the panel for all variables as reported in Table 2 and 3. The presence of cross-sectional dependence has mostly gives us biased and inefficient estimators, misleading inference, spurious regression results, dynamic panel biased. It leads to the use of second generation unit root test statistics because 1st generation unit root tests are unable to represent cross-sectional dependence.

Table 3: Average correlation coefficients & Pesaran (2004) CD test

Variable	CD-test	p-value	corr	abs(corr)
Environment index	49.720	0.000	0.350	0.444
Human Capital	134.960	0.000	0.950	0.950
Globalization	133.880	0.000	0.943	0.943
GDP growth	53.620	0.000	0.378	0.433
Tourism	77.710	0.000	0.547	0.611
Industry	56.980	0.000	0.401	0.579
Notes: Under the null hypothesis of cross-section independence $CD \sim N(0,1)$				

Table 4: Average correlation coefficients & Pesaran (2004) CD test

Variable	CD-test	p-value	corr	abs(corr)
e	107.360	0.000	0.756	0.824
Notes: Under the null hypothesis of cross-section independence $CD \sim N(0,1)$				

Table 5: Second Generation Panel Unit Root Tests (A) Maddala and Wu (1999) Panel Unit Root test (MW)

Variable	Specification	without	trend
	lags	Chi-sq	p-value
Environmental Index	0	146.497	0.000
Environmental Index	1	181.773	0.000
Human Capital	0	617.159	0.000
Human Capital	1	43.690	0.997
Globalization	0	432.684	0.000
Globalization	1	234.607	0.000
GDP growth	0	641.929	0.000
GDP growth	1	392.440	0.000
Tourism	0	45.775	0.993
Tourism	1	81.619	0.05
Industry	0	123.505	0.000
Industry	1	116.169	0.001

	Specification	with	trend
Variable	lags	chi_sq	p-value
Environment index	0	78.957	0.269
Environment index	1	175.028	0.000
Human Capital	0	47.461	0.989
Human Capital	1	94.813	0.037
Globalization	0	135.018	0.000
Globalization	1	65.274	0.699
GDP growth	0	526.307	0.000
GDP growth	1	313.814	0.000
Tourism	0	43.948	0.996
Tourism	1	67.552	0.627
Industry	0	65.206	0.702
Industry	1	71.107	0.508

Table 6: (B) Pesaran (2007) Panel Unit Root test (CIPS)

	Specification		without	trend
Variable	lags	Zt-bar	p-value	t-bar
Environment index	0	0.287	0.613	.
Environment index	1	-2.372	0.009	.
Human Capital	0	9.544	1.000	.
Human Capital	1	0.012	0.096	.
Globalization	0	-2.247	0.012	.
Globalization	1	-0.937	0.174	.
GDP growth	0	-12.637	0.000	.
GDP growth	1	-10.415	0.000	.
Tourism	0	5.818	1.000	.
Tourism	1	0.059	0.031	.
Industry	0	-1.236	0.108	.
Industry	1	-1.624	0.052	.

	Specification		With trend	
Variable	lags	Zt-bar	p-value	t-bar
Environmental Index	0	1.623	0.948	.
Environmental Index	1	-1.849	0.032	.
Human Capital	0	11.172	1.000	.
Human Capital	1	0.028	0.099	.
Globalization	0	-0.016	0.069	.
Globalization	1	0.859	0.805	.
GDP growth	0	-9.281	0.000	.
GDP growth	1	-6.322	0.000	.
Tourism	0	5.822	1.000	.
Tourism	1	0.237	0.099	.
Industry	0	1.560	0.941	.
Industry	1	0.725	0.766	.

Null for MW and CIPS tests: series is I (1). MW test assumes cross-section independence. CIPS test assumes cross-section dependence is in form of a single unobserved common factor. The empirical outcomes of second generation unit root tests are interpreted that at least some of the individual series in the panel are stationary at level or at first difference as reported in their p-values. These empirics recommend the use of PMG regression to find the short and long term dynamics.

Table 7: Pooled Mean Group Long Run Result

D Environmental Index	Coefficients	Std. Err.	P> z	95% Confidence	Interval
Human Capital	.0535691	.08844	0.545	-.11977	.2269147
Globalization	.0037781*	.00223	0.089	-.00057	.008134
GDP growth	.0132867***	.00312	0.000	.00716	.0194127
Tourism	-0.35***	.0024	0.00	-.00392	.852
Industry	.0016952	.0029	0.569	-.0041419	.0075324

Table 8: Pooled Mean Group Short Run Results

D. Environmental index	Coefficients	Std. Error	P> z	95 % Confidence	Interval
SR ECT	-0.1417***	0.026046	0	-0.192	-0.0906
Human Capital D1.	0.216275	0.91121	0.812	-1.5696	2.00221
Globalization D1.	0.008087*	0.004939	0.102	-0.0015	0.01776
GDP growth D1.	-0.00067	0.000514	0.194	-0.0016	0.00034
Tourism D1.	0.145	0.0031	0.163	-0.1753	1.794
Industry D1.	-0.00127	0.002622	0.629	-0.0064	0.003872
Constant	-0.04563	0.036103	0.206	-0.116	0.025132

The empirical estimates of PMG regression in Table 5 show that the negative significant estimate of tourism “-0.35***” means that rising tourism development has significantly helped to reduce poor environment quality in developed nations. The positive coefficient “.0037781*” of globalization exerts that environmental quality has significantly been deteriorated with increasing globalization. The highly significant estimate “.0132867***” of GDP growth indicates rising poor environment index holding other factors constants. In our empirical analysis, industrial output and human capital have been reported with insignificant coefficients signs. The highly significant coefficient (-0.1417***) of ECT term implies the existence of long term nexus among the variables of interest in this specification and it also indicates that 14.17% of the disequilibrium is adjusted in each period. In other words, this means that the system will come back to equilibrium at a rate of 14.17% per period if it is out of balance.

Discussion

This study investigates the short- and long-term dynamics between tourism, human capital, globalization, and environmental quality in high-income economies from 1996 to 2022. The findings provide critical insights into the role of these factors in shaping sustainability outcomes, supported by established economic and development theories. Tourism has shown a significant and positive role in reducing environmental degradation in developed nations. This outcome aligns with the principles of sustainable tourism theory, which emphasizes that the adoption of eco-

friendly infrastructure, renewable energy, and efficient waste management can lead to improved environmental outcomes. Tourism also promotes environmental awareness among both visitors and local communities through educational programs and eco-tours, promoting a culture of conservation. These mechanisms reflect the environmental stewardship model, where tourism not only supports economic growth but also contributes to the protection of natural and cultural resources (Africa, 2020; Torsney & Buckley, 2025). In contrast, economic growth is found to be a major contributor to environmental degradation. This relationship corresponds with the early phase of the Environmental Kuznets Curve (EKC), which proposes that environmental degradation initially increases with economic expansion due to industrialization and energy consumption, and may only decline in later stages with the adoption of cleaner technologies and stricter regulations (Grossman & Krueger, 1995; Dube et al., 2021). Rapid urbanization, increased energy demands, deforestation, and reliance on fossil fuels are key drivers of environmental stress in this context. Globalization, surprisingly, is associated with environmental deterioration in high-income economies. This result supports the pollution haven hypothesis, which argues that globalization may lead to the relocation of polluting industries to regions with less strict environmental laws, increasing emissions, and ecological pressure (Frankel & Rose, 2002; Apergis et al., 2021). According to Sibte-Ali et al. (2023), this finding challenges theories such as the economic complexity hypothesis, which holds that globalization stimulates creativity and efficiency, leading to long-term environmental benefits. Contrary evidence highlights the need for governance frameworks that ensure globalization contributes to environmental sustainability rather than diminishes it. The effect of human capital on environmental quality is found to be statistically positive but insignificant. This aligns with studies by Danish et al. (2019) and Hassan et al. (2019), who also report limited or no impact of human capital on ecological outcomes in developing countries. Although human capital theory shows that education and skills enhance environmental awareness and technological innovation, these benefits may not be realized without strong institutions, targeted environmental education, and supportive policy frameworks. In some cases, as noted by Ali et al. (2021), advanced human capital in high-income countries may be associated with higher emissions due to increased industrial and consumption activities. Overall, the results show that although tourism can be an important tool for achieving sustainable development, economic expansion and globalization present difficult problems that indicate for well-organized, situation-specific environmental regulations. The role and importance of human capital is still complex, necessitating further research into how skill development and education contribute to environmental advantages in various economic contexts.

Conclusion

This study has reported the significant empirics regarding the nexus of tourism development, globalization, and human capital with environmental degradation in case of the developed countries. The empirical outcomes show that tourism advances contribute to the reduction of environmental deterioration in the developed countries by encouraging sustainable activities, increasing environmental awareness, offering financial incentives for conservation, supporting legislative frameworks, and utilizing technical advancements. These outcomes imply that through the integration of these systems, tourism has the potential to promote economic growth and community development, as well as environmental preservation (Torsney & Buckley, 2025). Economic growth has significantly damaged the environmental quality due to increased energy resources' consumption, transportation expansion, urbanization, and the intensive agricultural methods in the developed nations. While economic growth brings many benefits, these

mechanisms highlight the importance of implementing sustainable practices and policies to mitigate the negative environmental impacts (Zhang et al., 2023).

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