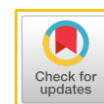


Green tourism and sustainable development in ASEAN-5: Evidence from panel data



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ABSTRACT

Tourism plays an important role in supporting sustainable development in ASEAN; however, its expansion can also generate environmental pressures that may undermine long-term sustainability. Green tourism offers an approach to balancing tourism development with environmental conservation and resource efficiency. This study examines the relationship between green tourism and sustainable development in five ASEAN countries—Indonesia, Malaysia, Singapore, Thailand, and Vietnam—during the 2006–2021 period. Green tourism is proxied by the Environmental Performance Index (EPI), Travel and Tourism Development Index (TTDI), and Renewable Energy Consumption (REC), while Gross Domestic Product (GDP) is included as a control variable. The Sustainable Development Index (SDI) is used as the dependent variable. Using panel data regression, the Fixed Effects Model (FEM) is selected as the most appropriate estimation approach. The results indicate that EPI and TTDI have positive and statistically significant relationships with SDI, suggesting that stronger environmental performance and tourism development are associated with higher levels of sustainable development. In contrast, REC and GDP show negative and statistically significant relationships with SDI. These findings highlight the importance of strengthening environmental governance, improving sustainable tourism competitiveness, and accelerating the transition toward cleaner energy systems. The study provides empirical evidence that can support policymakers in designing integrated tourism and environmental strategies to advance sustainable development across ASEAN-5 countries.

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1. Introduction

The development of the global tourism sector has contributed significantly to economic growth in various countries (Wijesekara et al., 2022). According to the International Monetary Fund (IMF), tourism was once again identified as a key driver of economic recovery and growth. UNWTO data indicates that by the end of the year, the number of tourists had returned to 95% of pre-pandemic levels. This highlights the positive impact of the sector's rapid recovery on economies across the globe (UNWTO, 2023). According to the World Travel and Tourism Council (WTTC), the travel and tourism sector contributes approximately US\$11.6 trillion or 9.8 percent to global Gross Domestic Product (GDP) by 2025 and support 366 million jobs. This aligns with Sustainable Development Goal 8 (Decent Work and Economic Growth) specifically target 8.9, which aims to promote beneficial and sustainable tourism. Through this target, countries are encouraged to formulate and implement policies through 2030 that support sustainable tourism, strengthen local products and culture, create jobs, and mitigate environmental impacts by promoting conservation

efforts and responsible travel behaviors, so that tourism development can benefit local communities without compromising the global sustainability agenda (United Nations, 2015).

The World Tourism Barometer report released by UN Tourism notes that the number of international tourist arrivals in 2025 is projected to reach approximately 1.52 billion trips, a 4% increase compared to 2024 and a record high for international tourism in the post-pandemic era. This growth is accompanied by an increase in global tourism revenue, which is projected to reach USD 1.9 trillion in 2025 a real increase of approximately 5% to 6% compared to the previous year (UN Tourism, 2026). These achievements indicate that tourism is a major contributor to job creation and foreign exchange earnings for countries, while also underscoring the urgency of applying principles of environmental sustainability and socioeconomic development in future tourism management.

However, tourism development also poses environmental, social, and cultural challenges, such as environmental degradation, the exploitation of natural resources, and the commodification of nature if not managed sustainably (Liodakis, 2023). The continuous increase in tourism activities particularly through transportation, infrastructure development, and the operation of tourist destinations contributes to high fossil fuel consumption and rising greenhouse gas emissions, which can accelerate climate change (Peeters & Landré, 2011; Wilkins et al., 2024). Sun et al (2024) argued the tourism sector accounts for approximately 8.8% of global greenhouse gas emissions. This situation is reflected in one of the metrics of the Environmental Performance Index (EPI), which evaluates a country's performance in mitigating climate change. Without mitigation efforts, the tourism sector will become one of the main drivers of climate change and deplete the world's remaining carbon budget (Gössling et al., 2023). Therefore, countries where tourism growth is not balanced by the implementation of environmental sustainability principles are likely to have poor environmental performance.

Based on the latest environmental performance data for the ASEAN-5 which is the focus of this study, Singapore ranks highest in the region with a score of 53.0 (47th globally), followed by Thailand with a score of 45.7 (90th), Malaysia with a score of 41.0 (118th), and Indonesia with a score of 33.6 (163rd globally), while Vietnam ranks lowest among the 180 countries assessed, with a score of 24.6 (Block et al., 2024). This range of scores indicates that there are disparities in environmental performance across the ASEAN-5 region, while the tourism sector continues to grow post-pandemic, raising concerns that tourism expansion is not always matched by adequate environmental management capacity. A similar phenomenon can be observed in indicators of travel and tourism development. The 2024 Travel & Tourism Development Index report released by the World Economic Forum reveals inconsistent performance; for instance, Singapore saw its global ranking drop from 9th in 2021 to 13th in 2024, while Vietnam excels in the policy and sustainability dimensions but lags behind in infrastructure and tourism resources compared to other upper-middle-income in the region (Clickable Insights, 2024). These varying patterns of achievement across countries indicate that tourism competitiveness in ASEAN is not yet fully aligned with the principles of sustainability that lie at the core of the green tourism concept.

This aligns with the findings of a study by Sun et al (2026) identified a U-shaped nonlinear relationship between tourism development and renewable energy consumption. When the tourism industry reaches a high level, it can accelerate the adoption of renewable energy consumption through industrial restructuring, increased productivity, and strengthened national energy resilience. This situation demonstrates that the relationship between the tourism sector and renewable energy consumption is reinforced by each country's structural characteristics in addressing the urgency of sustainable development, particularly SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action). According to Pan et al (2018) identified renewable energy consumption as one of the dimensions that shape the framework of green tourism, along with green transportation and green infrastructure. Thus, the use of a proxy for renewable energy consumption in this study is highly relevant.

This study analyze the importance of the green tourism concept in ASEAN countries for achieving the sustainable development agenda. Green tourism is operationalized through three proxies: the Environmental Performance Index, which represents the environmental sustainability dimension; the Travel and Tourism Development Index, which represents the economic sustainability and tourism competitiveness dimensions; and renewable energy consumption, which represents the clean energy transition dimension. Gross domestic product serves as a control variable to isolate the influence of a country's level of economic development on these three proxies. This concept of green tourism

aligns with the Sustainable Development Goals (SDGs), specifically within the triple bottom line framework, which is divided into environmental sustainability through eco-friendly practices, economic sustainability through financial performance and competitiveness, and social sustainability through local community engagement and social equity (Aransyah et al., 2025). Therefore, the researchers integrated the EPI, TTDI, and REC variables to address a research gap in previous studies and to highlight the importance of green tourism balanced with a commitment to environmental, social, and economic sustainability.

Studies that specifically integrate EPI, TTDI, and REC simultaneously as proxies for green tourism within a single analytical framework for SDI remain very limited in the existing literature. Most previous studies examined these variables in isolation, thus failing to capture the synergistic interactions between environmental performance, tourism competitiveness, and foreign investment in driving sustainable development. Existing empirical studies generally still rely on qualitative methods that are not fully capable of capturing the complexity of the economic, environmental, and socio-cultural impacts of green tourism (UNWTO, 2022). A previous study by Ali et al (2024) used a qualitative approach and identified challenges in managing ecotourism due to complex environmental, social, and economic impacts, thus failing to fully capture the dynamics of these three pillars of green tourism. This methodological gap underscores the urgent need for a quantitative approach based on panel data that can measure these relationships more precisely..

The ASEAN regional context makes this study even more important and relevant, as ASEAN is the region with the highest tourism growth in the world while also facing significant ecological vulnerabilities; however, panel data studies specifically examining the relationship between green tourism and SDI in this region remain a little (ASEAN, 2020). This study examines the impact of green tourism on sustainable development using panel data from five ASEAN countries (Indonesia, Malaysia, Singapore, Thailand, and Vietnam). This study aims to determine the extent to which the Environmental Performance Index (EPI), the Travel and Tourism Development Index (TTDI), and Renewable Energy Consumption (REC) influence the Sustainable Development Index (SDI), using Gross Domestic Product (GDP) as a control variable. The novelty of this research lies in three aspects: first, the simultaneous integration of the EPI, TTDI, and REC as proxies for green tourism, which has never been done in a single analytical model within the ASEAN-5 context; second, the use of the SDI as a dependent variable that integrates environmental, economic, and social dimensions; third, the use of GDP as a control variable to ensure the influence of independent variables on the dependent variable; and fourth, the application of a quantitative approach based on cross-country panel data (5 ASEAN countries) over the period from 2006 to 2021, which yields stronger empirical evidence. The findings of this study are expected to contribute theoretically to the development of the literature on sustainable tourism while also providing evidence-based policy recommendations for stakeholders in the ASEAN region.

2. Literature Review

The key elements discussed in this study are the notions of green tourism and sustainable development. Sustainable development is a multidimensional concept that includes economic, social and environmental (Lovisceck, 2021). Sustainable development in this study aligns with the findings of Hickel (2020) that proposed a more nuanced measure of sustainable development that takes into account human well-being and ecological sustainability. In this context, green tourism is positioned as a strategic approach to achieving the sustainable development agenda. This study employs the classical theory of sustainable development pioneered by the World Commission on Environment and Development in its report our common future, which defines sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. In line with this, the Triple Bottom Line (TBL) theory by John Elkington, provides an operational perspective at the level of individual entities and the national level by emphasizing that sustainability can only be achieved if economic (profit), social (people), and environmental (planet) performance are managed simultaneously (Lovisceck, 2021).

Both of these theoretical foundations were subsequently formalized globally through the 2030 Agenda in the 17 Sustainable Development Goals (SDGs) agreed upon by all member states of the United Nations. The seventeen goals are: a). No Poverty; b). Zero Hunger; c). Good Health and Well-being; d). Quality Education; e). Gender Equality; f). Clean Water and Sanitation; g). Affordable and Clean Energy; h). Decent Work and Economic Growth; i). Industry, Innovation, and Infrastructure;

j). Reduced Inequalities; k). Sustainable Cities and Communities; l). Responsible Consumption and Production; m). Climate Action; n). Life Below Water; o). Life on Land; p). Peace, Justice, and Strong Institutions; q). Partnerships for the Goals (United Nations, 2015). This SDG measurement framework is based on the Sustainable Development Index (SDI), an alternative index developed to measure progress toward sustainable development by considering not only human well-being but also ecological impacts. Countries with high SDI scores are those that have successfully positioned their development within a safe range, achieving high human well-being without exceeding their environmental carrying capacity (Hickel, 2020). Thus, in this study, the SDI serves as a measure of the success of green tourism's contribution to the SDGs, particularly SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), SDG 14 (Life Below Water), and SDG 15 (Life on Land).

According to Maneejuk, Yamaka dan Srichaikul (2022) also indicate that tourism's contribution to economic growth is influenced by structural conditions and the level of development in each country. Referring to the TBL framework, in addition to economic growth, tourism sustainability must also simultaneously consider social and environmental dimensions; therefore, this study selected three green tourism proxies: a). The EPI as a representation of the environmental pillar because it measures the quality and effectiveness of environmental management policies; b). The TTDI as a representation of the institutional-economic pillar of the tourism sector due to its focus on competitiveness, governance, infrastructure, and a country's readiness to develop a sustainable tourism sector; and c). RE as a representation of the energy transition, which serves as a means of mitigating carbon emissions from tourism activities. d). GDP is used as a control variable because it reflects a country's level of economic development (Hailiang et al., 2023; Sun et al., 2023; Wu et al., 2024).

Elgin & Elveren (2024) investigated that there is a significant positive correlation between green tourism and the achievement of sustainable development, as reflected in various dimensions of community well-being. In this study on green tourism, the EPI is used as a tool for assessing environmental performance; developed by experts from Yale University and Columbia University, it encompasses 58 indicators and 11 issue categories to calculate an overall score regarding efforts to mitigate climate change, ensure ecosystem vitality, and maintain environmental health. The EPI aims to measure environmental protection efforts, thereby fostering positive competition among countries to innovate and support sustainable development (Block et al., 2024). Countries with low EPI scores are encouraged to improve water management and air quality through policy reforms, such as strengthening emissions regulations and enhancing waste management practices (Smallenbroek et al., 2023). Consequently, the EPI can serve as a benchmark for green policy commitments in the ASEAN tourism sector that directly contribute to the achievement of SDG 7 (Clean and Renewable Energy), SDG 13 (Climate Action), SDG 14 (Life Below Water), and SDG 15 (Life on Land).

The environment of Green tourism is supported by the Travel and Tourism Development Index (TTDI), a global index developed by the World Economic Forum (WEF) that assesses the factors and policies enabling the development of the travel and tourism sector across various countries. The TTDI consists of four main sub-indices: enabling environment; travel and tourism policy and enabling conditions; infrastructure and services; travel and tourism resources; and travel and tourism sustainability. Each sub-index comprises pillars that cover factors such as safety, environmental cleanliness, international openness, and cultural diversity (World Economic Forum, 2024). The findings of Uyar et al (2023) examined the relationship between the tourism competitiveness index and the development of the tourism sector, revealed that the "policies and enabling conditions" sub-index had a positive correlation with the number of tourist arrivals, while the infrastructure sub-index had a positive correlation with tourism revenue. These findings indicate that the TTDI contributes to sustainable development outcomes, which are relevant to SDG 8 (Decent Work and Economic Growth), which includes tourism-related targets.

The third proxy, renewable energy consumption (REC), represents the energy transition dimension that mitigates tourism's carbon footprint. Findings by Ali, et al., (2021), using panel data analysis, show that tourism and renewable energy consumption jointly influence the ecological footprint and the use of natural resources. Renewable energy plays a role in curbing environmental degradation caused by the expansion of the tourism sector. According to Amin et al (2024) found

that renewable energy consumption reduces CO₂ emissions in ASEAN countries, contributing to the achievement of SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action). The relationship between GDP and environmental quality was identified in a study by Liu et al (2025) through testing the Environmental Kuznets Curve in the ASEAN region, indicating that economic growth can create a trade-off with sustainability in the early stages of development before environmental quality improves as income rises. Therefore, in this study, GDP is included as a control variable to ensure that the estimation of the coefficients of EPI, TTDI, and RE on the SDI is more methodologically valid. Based on the literature review, the following hypotheses are proposed:

- H1 The Environmental Performance Index (EPI) has an effect on the Sustainable Development Index (SDI).
- H2 The Travel and Tourism Competitiveness Index (TTDI) has an effect on the Sustainable Development Index (SDI).
- H3 Renewable Energy Consumption (REC) has an effect on the Sustainable Development Index (SDI).

3. Method

This study used a quantitative approach aimed at examining the progress of the sustainable development agenda through green tourism. In this study, the researcher analyzed available data from five ASEAN countries (Indonesia, Singapore, Malaysia, Thailand, and Vietnam) covering the period from 2006 to 2021. This panel data regression model employs model selection tests, namely the Fixed Effects Model (FEM), Random Effects Model (REM), and Common Effects Model (CEM), to analyze the role of green tourism in sustainable development. The dependent variable in this study is sustainable development, measured by the Sustainable Development Index (SDI). The independent variables include the Environmental Performance Index (EPI), the Travel and Tourism Development Index (TTDI), renewable energy consumption (RE), and Gross Domestic Product (GDP) as a control variable.

availability of data in the sample countries, and its relevant use in the literature on the sustainable development agenda. Although no single set of indicators can perfectly capture all aspects of sustainable development, the researchers' selection provides a robust framework for analyzing the various impacts of tourism. We obtained all these time series from data collected by the Central Statistics Agency (BPS) and such as the World Bank, the World Economic Forum, the United Nations Development Programme (UNDP), and Trading Economics. To combine these various data sources, we applied data harmonization procedures. First, conceptual definitions and reporting standards were aligned based on the methodological guidelines of each institution. Second, all variables were converted to a consistent annual format in accordance with the requirements of the ASEAN-5 panel data. Finally, all datasets were combined by country and year as required. The research model used in this study is formulated as follows:

$$SDI_{it} = \alpha_0 + \beta_1 EPI_{it} + \beta_2 TTDI_{it} + \beta_3 REC_{it} + \beta_4 GDP_{it} + \varepsilon_{it} \quad (1)$$

Where *SDI* is the Sustainable Development Index; *EPI* is the Environmental Performance Index; *TTDI* is the Travel and Tourism Development Index; *REC* is renewable energy consumption; *GDP* is Gross Domestic Product; α_0 is a constant; $\beta_1 - \beta_4$ are the regression coefficients of the respective independent variables; ε_{it} is the error term; the notation of *i* refers to cross-section and *t* refers to time-series.

4. Results and Discussion

Table 1 shows the descriptive statistics show the mean, median, minimum, maximum, and standard deviation of the SDI, EPI, TTDI, REC, and GDP variables for the five ASEAN countries during the study period. The EPI variable has a mean of 70.55 with a standard deviation of 7.3. The minimum value is 60 and the maximum is 87, reflecting variations in sustainable environmental performance among the five ASEAN countries. The TTDI variable has a mean of 4.4 with a standard deviation of 0.47. The minimum value is 3.57 and the maximum is 5.4, indicating differences in the competitiveness of the travel and tourism sectors across countries. The REC variable has a mean of 17.86 with a standard deviation of 14.1, indicating a fairly high dispersion. This is further supported by a minimum value of 0.5 and a maximum value of 44.2. The GDP variable, used as a control

variable, has a mean of 14778.2 with a standard deviation of 19965.94. The minimum value of 1,699.68 and the maximum value of 67,846.86 indicate that the GDP data for the five ASEAN countries have a fairly wide range. The SDI variable has a mean of 67.57 with a standard deviation of 3.34. The minimum value of 59.85 and the maximum value of 74 indicate that the sustainable development achievements of the five ASEAN countries fall within a relatively narrow range.

Regarding the distributional characteristics, SDI is slightly negatively skewed (-0.368), while EPI (0.916), TTDI (0.286), REC (0.090), and GDP (1.536) are positively skewed, with GDP displaying the strongest right-skewed distribution. The kurtosis values indicate that SDI, EPI, TTDI, and REC have relatively flatter distributions than a normal distribution, whereas GDP has a kurtosis value of 3.595, indicating a relatively more peaked distribution. The Jarque–Bera test further shows that SDI and TTDI have probability values above 0.05, suggesting that their distributions do not significantly deviate from normality. In contrast, EPI, REC, and GDP have probability values below 0.05, indicating departures from normality. Overall, these descriptive statistics reveal substantial cross-country heterogeneity, particularly in renewable energy consumption and GDP, which should be taken into consideration when interpreting the panel regression results.

Table 1. Descriptive Statistics

	SDI	EPI	TTDI	REC	GDP
Mean	67.57000	70.55000	4.396500	17.86125	14778.21
Maximum	73.90000	87.00000	5.400000	44.20000	67846.86
Minimum	59.85000	60.00000	3.570000	0.500000	1699.676
Std. Dev.	3.344777	7.298170	0.470454	14.09999	19965.94
Skewness	-0.368390	0.916214	0.285506	0.089689	1.535653
Kurtosis	2.517009	2.790695	2.317534	1.647703	3.594585
Jarque-Bera	2.587079	11.33866	2.639381	6.202947	32.62152
Probability	0.274298	0.003450	0.267218	0.044983	0.000000
Sum	5405.600	5644.000	351.7200	1428.900	1182257.
Sum Sq. Dev.	883.8150	4207.800	17.48482	15705.97	3.15E+10
Obs	80	80	80	80	80

Source: data processed

The Chow test compares the model between the Common Effect Model (CEM) and Fixed Effect Model (FEM). Table 2 shows the cross-section F-statistic is $0.000 < 0.05$; therefore, the selected model is the fixed-effects model (FEM). Hausman test which model is best between Fixed Effect Model (FEM) and Random Effect Model (REM). Decision making by looking at the probability value (p) for Cross-section Random. If the p value > 0.05 then the selected model is REM. But if $p < 0.05$ then the model chosen is FEM. Table 2 shows the probability of Cross-Section Random $0.000 < 0.05$. Therefore, after conducting the Chow and Hausman tests, the model selected for this study is FEM.

Table 2. Chow and Hausman Test Result

Chow Test			
Test Effect	Statistic	d.f.	Prob.
Cross-section F	272.787	(4.71)	0.000
Cross-section Chi-square	223.628	4	0.000
Hausman Test			
Test cross-section random effects	Chi-Sq. Statistic	d.f.	Prob
Cross-section random	1091.146	4	0.000

Source: data processed

Table 3 shows the the EPI variable has a regression coefficient of 0.946, indicating a positive relationship with a probability level of $0.000 < 0.05$. The results show EPI or environmental performance index has a positive and significant effect on the Sustainable Development Index in 5 ASEAN Countries. This is demonstrated by the positive regression coefficient, supported by the t-statistic test for H1, where the EPI indicator yields a significance value of $0.000 < 0.05$. If all other variables remain constant and the EPI variable increases by 1 percent, the SDI variable will increase by 0.946. This positive relationship aligns with sustainable development theory, which emphasizes that sound environmental performance can drive aggregate development success (Sun et al., 2023).

The ASEAN-5 countries in this study demonstrate high-quality environmental performance, as reflected in effective natural resource management and lower pollution levels (OECD, 2018; Wendling et al., 2026). According to Del-Aguila-Arcentales et al (2022) demonstrated that a country's environmental performance has a significant impact on the achievement of sustainable development, which is closely linked to the three pillars of the SDGs. However, improvements are needed in developing countries, which often have low EPI scores due to limitations in addressing challenges related to sanitation and deforestation. The positive correlation between environmental performance and sustainable development underscores the urgency for the five ASEAN countries to enhance their environmental protection and management strategies, as well as to transition toward a low-carbon and resource-efficient economy.

Eco-innovation and the adoption of environmentally friendly technologies in the tourism sector have proven to play a crucial role in improving environmental quality in ASEAN countries, although their effectiveness depends heavily on the level of economic development and the implementation of national policies (Wei & Lihua, 2023). ASEAN tourist destinations in Thailand, the implementation of low-carbon tourism initiatives such as the use of renewable energy in hotels and tourist areas, restrictions on fossil-fuel-powered vehicles, and the provision of eco-friendly transportation has been shown to reduce carbon emissions and improve resource efficiency (Bhaktikul et al., 2021). Additionally, green tourism certification schemes such as the ASEAN Green Hotel Standard have encouraged tourism service providers to reduce energy and water consumption, improve waste management efficiency, and expand the use of clean technologies (ASEAN, 2021). Contrast to Liu et al (2017) stated sustainability indicators, including the EPI and SDI, can show contradictory relationships because each indicator measures different dimensions of sustainability. That study explains that the EPI is more focused on achieving environmental quality from a short-term perspective, whereas other sustainable development indicators consider economic, social, and environmental dimensions over the long term. Consequently, an increase in the EPI score is not always accompanied by an improvement in sustainable development. This aligns with Wendling et al (2022) found that countries with high environmental sustainability scores generally enforce stricter environmental regulations and impose restrictions on the exploitation of natural resources.

Table 3. Result of Fixed Effect Model

Variable	FEM
Cons	-0.135 (-0.029)
<i>EPI</i>	0.946*** (17.754)
<i>TTDI</i>	1.148** (2.169)
<i>REC</i>	-0.066*** (-3.046)
<i>GDP</i>	-0.0002*** (-5.813)

Source: data processed

Table 3 shows the TTDI has a positive effect on the Sustainable Development Index in five ASEAN countries. If all other variables remain constant and the TTDI variable increases by 1 percent, the SDI variable will increase by 1.147997. According to Rodríguez-Díaz & Pulido-Fernández (2019) stated that improvements in tourism competitiveness, as represented by the TTDI, are closely linked to the achievement of sustainable development, based on cross-country data. The study's findings reveal that the dimensions within the TTDI such as environmental sustainability, the quality of tourism infrastructure and human resources, and institutional pressure to improve environmental governance to maintain a destination's appeal contribute significantly to the achievement of sustainable development. Countries with high levels of tourism competitiveness tend to demonstrate better sustainable development performance in integrating economic growth in the tourism sector with environmental protection and sustainable resource management.

High tourism competitiveness contributes to sustainable development through job creation, increased income for local communities, and economic diversification (Dogru et al., 2019). ASEAN countries, such as Vietnam, evidence shows that investment in competitive tourism infrastructure

can significantly boost the appeal to international tourists, thereby driving economic growth that extends across the entire region (Nguyen, 2021). This aligns with the concept of pro-poor tourism, which emphasizes that tourism competitiveness can reduce income disparities a key component of the SDGs (Scheyvens & Cheer, 2022). Furthermore, countries with high TTDI scores tend to adopt stricter tourism regulations and promote the development of ecotourism as a long-term competitiveness strategy (Ridderstaat et al., 2014). In ASEAN countries, regional competitive pressures are driving member states to adopt higher environmental sustainability standards to maintain their competitive positions (Goffi et al., 2019). Thus, better environmental regulations and tourism competitiveness reinforce one another in achieving sustainable development goals, particularly SDG 8 (Decent Work and Economic Growth). Some studies have found that short-term increases in tourism competitiveness can place pressure on natural resources and social infrastructure, particularly in destinations that lack adequate management capacity (Koens et al., 2018). These differing findings stem from variations in the observation periods, the composition of the sample countries, and the proxies used to measure sustainable development. This study utilizes panel data from five ASEAN countries with relatively strong SDG policy commitments, allowing the positive effects of TTDI on sustainable development to be identified more clearly compared to samples of countries with greater institutional differences. Furthermore, this study also indicates that an increase in competitiveness.

REC variables has a negative effect on the Sustainable Development Index in the five ASEAN countries. This indicates that if all other variables remain constant and the REC variable increases by 1 percent, the SDI will decrease by -3.046041. Although these results contradict the general paradigm, this short-term negative impact is strongly supported by the literature on the global energy transition. The transition to clean energy requires very high initial capital investment costs as well as significant restructuring of industry operational costs, which in the short term can reduce economic efficiency and divert budget allocations from other social programs. The positive impacts of investments in renewable energy consumption generally only accumulate and turn positive on the SDI dimension in the long term (Güney, 2021; Zheng et al., 2023). The results of this study contradict to Chen et al (2025) found that an increase in renewable energy consumption significantly boosts tourism activity and reduces carbon emissions as well as healthcare costs resulting from environmental pollution. The transition to clean energy not only supports the growth of the tourism sector but also improves environmental quality, thereby enabling sustainable economic development. As further explained in the findings of Tverijonaite et al (2024) that increased utilization of renewable energy can mitigate climate change, which is part of SDG 13 (climate action).

The findings indicates the relationship between renewable energy consumption and sustainable development is contextual and depends on a country's level of energy infrastructure development and its very high operational costs. A study from Aboul-Atta & Rashed (2021) stated the transition to renewable energy in countries with a high sustainable development index is actually proceeding slowly because these countries already have fossil fuel power plants and well-developed energy infrastructure networks, so the shift to renewable energy is not a primary need. Furthermore, supported by the findings of Li et al (2023) used panel data from 125 countries, the study found that the development of renewable energy can hinder economic growth, particularly in developing countries. This may occur because the high costs of the energy transition have not yet been offset by long-term economic benefits. The findings suggested the contribution of renewable energy to sustainable development will be more effective if accompanied by the transformation of the tourism sector toward environmentally friendly practices. The relationship between renewable energy and the tourism sector is mediated by the use of clean energy in the accommodation, transportation, and tourism destination infrastructure sectors (Tverijonaite et al., 2024; Warren & Becken, 2017; Suliswanto et al., 2026). According to Azam et al (2018) argued the increase in the number of tourists in Malaysia has contributed to rising carbon emissions. This situation is caused by the dominant use of fossil fuels to meet electricity, transportation, and other tourism-related needs. Although the use of renewable energy continues to increase, its contribution to the national energy mix remains relatively low, making it unable to offset the rising energy demand resulting from the growth of the tourism sector. Therefore, it can be concluded that the negative impact identified in this study does not indicate that renewable energy hinders sustainable development; rather, its effectiveness is significantly influenced by infrastructure readiness, operational costs, the maturity level of the energy transition, and the tourism sector's capacity to adopt clean energy (Khasanah & Kurniawan, 2025; Vhina & Fazaalloh, 2026).

Table 3 shows GDP as control variables has a negative and significant effect on the Sustainable Development Index in the 5 ASEAN Countries. This implies that, holding other variables constant, an increase in GDP reduces the SDI by -0.0002. This suggests that economic growth across the five ASEAN countries is not yet fully aligned with the achievement of sustainable development goals, as every increase in GDP has a negative impact on sustainable development, even though the magnitude of this effect is relatively small. This situation can occur in the tourism sector, which is the largest contributor to GDP growth. The ecological economy which is part of conventional economic growth still relies on the exploitation of natural resources, massive fossil fuel consumption, and high carbon emissions. The decline in the SDI alongside rising GDP highlights the importance of shifting the focus from the quantity of economic growth toward the quality of development to avoid degrading the environment (Hickel & Kallis, 2020; Juwita et al., 2021). According to Aini (2024) that tourism makes a significant positive contribution to GDP and employment in Southeast Asia, however, there remains a gap in achieving environmentally sustainable goals. Increased tourism in a country leads to higher carbon emissions, particularly in nations with high growth in tourist arrivals, such as Indonesia, Thailand, and Vietnam. Dai (2025) explained on the Southeast Asian region, the region's economic expansion still relies on industrial activities and has not yet adopted environmentally friendly practices. Consequently, GDP growth has not yet fully yielded positive impacts on the dimensions of sustainable development.

5. Conclusion

This study examines the relationship between green tourism, proxied by the Environmental Performance Index (EPI), the Travel and Tourism Development Index (TTDI), and Renewable Energy Consumption (REC) and Gross Domestic Product (GDP) as a control variable, all of which influence the Sustainable Development Index (SDI). The results of the panel data regression show that the effects of each variable on the SDI do not move in the same direction, as sustainable development achievements across the five ASEAN countries are influenced by more complex interplay between environmental, economic, and social dimensions. Statistically, the EPI and TTDI have positive and significant effects on the SDI. These findings indicate that good environmental performance and tourism development can contribute to sustainable development achievements. Conversely, the results show that REC, as the main variable, and GDP, as the control variable, have a negative and significant impact on the SDI. The impact of REC reflects the long-term benefits of the renewable energy transition, while in the short term it will create pressures, such as high investment costs and restructuring expenses. Meanwhile, the negative impact of GDP indicates that economic growth in the ASEAN region which is largely supported by the tourism sector still relies on conventional growth patterns that are not fully aligned with the principles of environmental sustainability.

The implications of the study are a). The positive effect of the EPI highlights the importance of environmental conservation and management strategies, including the transition toward a low-carbon economy through eco-innovation and green tourism certification schemes, such as the ASEAN Green Hotel Standard; b). The positive effect of the TTDI highlights the importance of enhancing travel and tourism development such as improving tourism competitiveness through infrastructure upgrades and destination governance without neglecting environmental management capacity, so that tourism growth does not place undue pressure on natural resources; c). The negative effect of the REC underscores the need for fiscal policy support and investment incentives to accelerate the renewable energy transition and promote the integration of clean energy into the accommodation, transportation, and tourism destination infrastructure sectors and; d). The impact of GDP highlights the need for a shift in focus that also prioritizes the quality of environmentally sustainable development, particularly in countries with high tourism sector growth, such as Indonesia, Thailand, and Vietnam. Therefore, aligning environmental policies, strengthening tourism competitiveness, accelerating the energy transition, and reorienting economic growth are critical for the five ASEAN countries to achieve optimal sustainable development outcomes.

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