Journal of Tourism and Heritage Research (2025), vol. 8, nº 2, pp. 112-147, Yangailo, T. "Sustainable Tourism and Economic Growth: The Role of Renewable Energy, Digital Connectivity, and Environmental Conservation Across Global Regions"

SUSTAINABLE TOURISM AND ECONOMIC GROWTH: THE ROLE OF RENEWABLE ENERGY, DIGITAL CONNECTIVITY, AND ENVIRONMENTAL CONSERVATION ACROSS GLOBAL REGIONS

Tryson Yangailo[1]

Abstract:

This study examines the relationships between economic growth, environmental sustainability, technological advancement, and tourism across global regions, focusing on patterns that affect sustainable development. Analyzing data from 2000 to 2023 through correlation, ANOVA, and regression models using jamovi, the study explores variables like foreign direct investment (FDI), renewable energy consumption, employment in services, and mobile phone subscriptions. The findings highlight regional disparities, with wealthier regions such as the European Union excelling in GDP per capita, FDI, and tourism, while developing regions like Sub-Saharan Africa and the Caribbean struggle with economic diversification and infrastructure. Sub-Saharan Africa shows higher renewable energy consumption due to limited access to non-renewable resources, while wealthier regions lag behind in renewable energy adoption despite their economic advantages. The study challenges the assumption that natural resource endowments automatically lead to sustainable practices, urging the need for targeted policies to promote renewable energy. It identifies FDI as crucial for tourism and economic growth, emphasizing its role in developing infrastructure. Employment in services is highlighted as a key predictor of GDP per capita, indicating the importance of service-oriented economies. The study also shows a bidirectional relationship between tourism and economic growth, with both driving and benefiting from each other. Innovatively, the study offers region-specific recommendations, supporting frameworks like the structural change hypothesis and the environmental Kuznets curve. It suggests tailored policies for each region to foster inclusive growth, reduce environmental degradation, and bridge regional inequalities, promoting long-term economic resilience.

Keywords: Sustainable Tourism, Foreign Direct Investment (FDI), Renewable Energy, Economic Growth, Regional Disparities

[1] University of Zambia. ytryson@yahoo.com

1. INTRODUCTION

Tourism plays a critical role in the economic success of many countries around the world and has been a widely studied area for decades (Naseem, 2021). As the third largest export industry in the world - behind fuel and chemicals, but ahead of food and automotive products - tourism contributes significantly to global trade and economic activity (Rasool et al., 2021). Over the past few decades, travel and tourism has been one of the fastest growing industries in the world, with tremendous growth potential, and has played an important role in the development and expansion of the economies of many nations (Yangailo, 2025), with millions of people around the world finding work in the sector, which has also helped many rural and urban areas to flourish.

In the context of African economies, the tourism sector serves as a key driver of economic development and structural transformation. By promoting economic diversification, tourism increases non-oil wealth and contributes to overall economic stability (Ekeocha et al., 2021). The sector's role in job creation, income generation, poverty alleviation, and mitigation of instability in global commodity markets cannot be overemphasized (Ekeocha et al., 2021). In addition, foreign direct investment (FDI) and tourism are widely recognized as critical components of economic growth in many countries (Sokhanvar & Jenkins, 2022).

In recent years, there has been growing scientific interest in the relationship between sustainable tourism development and economic growth (León-Gómez et al., 2021). Recognizing its economic potential, many national and regional development policies have prioritized tourism, particularly as a means of promoting growth in rural areas (Vazquez Vicente et al., 2021). For small island economies in particular, the travel and tourism sector plays a critical role in job creation and income generation (Fauzel, 2021). Given their heavy reliance on tourism revenues, these economies face significant risks in the event of a downturn in the sector (Fauzel, 2021). Tourism expansion requires significant resources, with FDI playing a critical role in providing the necessary capital, infrastructure, knowledge, and access to global marketing and distribution networks (Fauzel, 2021). Indeed, FDI is widely regarded as one of the most effective mechanisms for strengthening the tourism sector and ensuring its long-term sustainability (Fauzel, 2021).

Beyond its economic impact, tourism is deeply intertwined with cultural and environmental dimensions. Many cultures have historically maintained a strong relationship with forests and trees, often using forest and tree motifs to symbolize human-nature interactions (Aschenbrand & Michler, 2022). Since the nineteenth century, outdoor recreation and tourism have increased the popularity of forests, coinciding with the emergence of modern conservation efforts (Aschenbrand & Michler, 2022). By the twentieth century, tourism had become an integral part of forest conservation strategies, reflecting a growing appreciation for the grandeur of nature (Aschenbrand & Michler, 2022).

However, the development of forest tourism depends on adequate infrastructure and facilities, an area that remains underexplored in quantitative research (Zhang et al., 2022). To address this gap, a theoretical framework has been proposed that examines how perceptions of forest tourism infrastructure influence tourists' willingness to visit urban forest parks, based on perceived value theory (Zhang et al., 2022).

In addition, the relationship between economic development and environmental sustainability is often analyzed through the lens of the environmental Kuznets curve (EKC), which describes the dynamic interplay between income levels and environmental quality (Anwar et al., 2022). Understanding these dynamics is essential for promoting sustainable tourism development that balances economic growth with environmental conservation. Sustainable development has emerged as a critical global imperative that seeks to balance economic progress with environmental conservation and social equity. However, the pursuit of sustainability is complicated by significant regional disparities, where different socio-economic, environmental, and technological conditions lead to different pathways and outcomes. This study explores the complex interplay between economic drivers, technological advances, environmental sustainability, and human factors, with a particular focus on tourism, renewable energy, digital infrastructure, and automation.

The primary objectives of this study are to identify key drivers of sustainable development, assess the impact of tourism on economic and environmental outcomes, and examine how technological advances contribute to economic transformation and sustainability. Specifically, the study seeks to

1. Analyze the Role of Tourism in Economic Growth
2. Evaluate the Environmental Impact of Tourism
3. Assess the Role of Technology in Tourism Development
4. Address Regional Disparities in Tourism Development

By analyzing data from 2000 to 2023, this study aims to provide actionable insights for policymakers and stakeholders to promote balanced and inclusive growth through sustainable tourism practices.

This study is important for several reasons. First, it provides a comprehensive analysis of the role of tourism in driving economic growth and environmental sustainability, providing valuable insights for policymakers and stakeholders. By examining the relationships between tourism, GDP per capita, service employment, and renewable energy consumption, the study highlights how tourism can contribute to both economic development and environmental conservation.

Second, the study emphasizes the importance of foreign direct investment (FDI) and technological advances in strengthening the tourism sector, particularly in developing regions. It shows how FDI supports tourism infrastructure development and how digital infrastructure, such as mobile phone subscriptions , promotes economic transformation and connectivity. These findings underscore the critical role of investment and innovation in promoting sustainable tourism practices.

Third, the study highlights the need for region-specific strategies to address disparities in tourism development. By analyzing regional differences in tourism outcomes, the study identifies unique challenges and opportunities for different regions to ensure that all regions - developed and developing - can reap the economic and environmental benefits of tourism. For example, it provides tailored recommendations for sub-Saharan Africa, the Caribbean and other regions to build on their strengths and address specific constraints.

Finally, the study contributes to the growing body of literature on sustainable tourism by addressing key gaps in the field. Specifically, it advances quantitative research on forest tourism infrastructure by proposing a theoretical framework based on perceived value theory. It also explores the bidirectional relationship between tourism and economic growth, providing new insights into how tourism not only drives economic development, but also benefits from higher levels of economic growth. These contributions enrich the academic discourse on sustainable tourism and provide a foundation for future research.

2. LITERATURE REVIEW

2.1 Theoretical Perspectives on Sustainable Development

Several economic theories underpin sustainable development. Endogenous growth theory emphasizes the role of human capital and technological innovation in long-term economic growth, which is critical for sustainability. The structural change hypothesis suggests that economic development is accompanied by sectoral shifts, particularly from agriculture to industry and services, which affect both economic and environmental outcomes. The Environmental Kuznets Curve (EKC) proposes an inverted U-shaped relationship between economic growth and environmental degradation, where environmental quality initially declines but improves with higher income levels (Anwar et al., 2022). Recent studies such as Mohammed et al. (2024) have validated the EKC hypothesis in the EU-27, showing that while energy consumption increased, CO2 emissions decreased, with Germany showing the largest reduction. Similarly, Ahmad et al. (2021) found support for the EKC hypothesis in 11 developing countries, although the relationship varied across countries, highlighting the need for tailored environmental policies.

Leal and Marques (2022) further extended the EKC by emphasizing the importance of incorporating technological progress, climate finance, and energy transition into its framework, while Mahmood et al. (2023) highlighted the role of pollution proxies and regional data in validating the EKC hypothesis in China. Zhang (2021) examined the long-term relationship between CO2 emissions and income in China, the world's largest CO2 emitter, and found an N-shaped relationship between CO2 emissions and real GDP per capita, rather than the conventional U-shaped EKC. The study found that energy consumption has a positive impact on CO2 emissions, with a 1% increase in energy consumption leading to a 0.9% increase in emissions, while urbanization has a negative impact. These findings suggest that China will need significant policy and energy innovations to meet its emissions reduction targets, especially given its unique socio-economic and political context.

2.2 Tourism as a Catalyst for Sustainable Development

Tourism is a major driver of economic growth, infrastructure development, and job creation. It is the third largest export industry in the world, surpassing food and automotive products (Rasool et al., 2021). In small island economies and developing countries, tourism provides an important avenue for economic diversification, enhancing stability, creating jobs and reducing poverty (Ekeocha et al., 2021; Fauzel, 2021). However, the impact of tourism varies considerably across regions. For example, Raifu (2024) revisited the tourism-led growth hypothesis (TLGH) and found it to be valid despite structural breaks caused by events such as the global financial crisis and the Ebola outbreak. Similarly, Naseem (2021) found a strong correlation between tourism and economic growth in Saudi Arabia, while Ekeocha et

al. (2021) reported that Africa's underutilized tourism potential and economic constraints limit its impact. El Menyari (2021) examined the impact of international tourism and FDI on economic growth in Morocco and found a positive long-run relationship between tourist arrivals and economic growth. However, tourism-specific FDI had a negative impact, highlighting the need to align tourism strategies with broader sectoral plans to maximize benefits.

Beyond economic contributions, tourism plays a role in environmental sustainability. Historically, forest and conservation efforts have been closely linked to tourism, with initiatives aimed at preserving natural and cultural heritage (Aschenbrand & Michler, 2022). However, Zhuang et al. (2022) found that while tourism increases carbon emissions in Belt and Road Initiative (BRI) countries, technological innovation and foreign direct investment contribute to long-term emission reductions. Sheng Yin and Hussain (2021) also highlighted that tourism, along with FDI and economic growth, contributes to an increased ecological footprint in Southeast Asia, highlighting the need for green initiatives in the tourism sector.

2.3 Technological Innovation and Environmental Sustainability

Technological innovation plays a crucial role in promoting environmental sustainability. Zhuang et al. (2022) found that while tourism increases carbon emissions in BRI countries, technological innovation and foreign direct investment reduce emissions in the long run. Similarly, Yuan and Zhang (2024) found that technological innovation, human capital, and the use of renewable energy contribute significantly to sustainable economic growth in Asian economies. These studies highlight the need for investment in technological infrastructure to bridge regional disparities and promote sustainable growth. Ghosh and Parab (2021) further emphasize the importance of FDI and human capital in driving long-term productivity growth in India, while Akcigit and Ates (2021) highlight the role of knowledge diffusion and innovation in addressing declining economic dynamism in the United States.

2.4 Technological Advancements and Economic Transformation

Technological advances, particularly in digital infrastructure and automation, are reshaping sustainable development. The proliferation of mobile phone subscriptions and internet access has improved information dissemination, increased market efficiency, and facilitated sustainable business practices. Bamati and Raoofi (2020) found that high technology exports drive renewable energy adoption in developed countries, while GDP per capita plays a more consistent role in both developed and developing countries. Human factors are also critical to technology adoption. Sætren et al. (2016) highlighted how neglecting human factors analysis in automated drilling technology led to increased costs and safety risks, highlighting the importance of incorporating human expertise in technology design. Yuan and Zhang (2024) further demonstrated that technological innovation, human capital, and the use of renewable energy contribute significantly to sustainable economic growth in Asian economies, highlighting the need for investment in digital infrastructure and education.

2.5 Regional Disparities and Governance in Sustainable Development

Sustainable development outcomes vary widely across regions due to differences in the quality of governance, resource availability, and environmental conditions. Agyeman et al.

(2022) found that governance plays a critical role in mitigating CO2 emissions in Africa, suggesting that effective regulatory frameworks can offset the negative environmental impacts of tourism and FDI. Similarly, Zhang et al. (2022) reported that the decarbonization effect of the digital economy was strongest in eastern China, while other regions lagged behind due to insufficient technological investment. Osinubi et al. (2022) further emphasized the role of governance in increasing tourism demand in African countries, while Sou and Vinnicombe (2023) highlighted the indirect impact of governance on tourism demand through FDI.

The relationship between economic growth and environmental sustainability is complex and often mediated by technological innovation and policy interventions. Raihan et al. (2023) showed that while economic growth increased CO2 emissions in Indonesia, the adoption of renewable energy, technological innovation, and forest conservation significantly mitigated these emissions. The socio-economic impacts of tourism also vary across regions. Alcalá-Ordóñez and Segarra (2025) reviewed 57 studies and found that tourism reduces poverty and income inequality by creating employment opportunities and improving living conditions. However, disparities remain, with some regions benefiting more than others due to differences in infrastructure, governance and resource endowments.

2.6 Tourism and Economic Growth: A Bidirectional Relationship

Recent studies have examined the bidirectional relationship between tourism and economic growth. Pulido-Fernández et al. (2021) examined 143 countries and found that tourism not only drives economic development, but also benefits from higher levels of economic development. Similarly, Pata (2021) examined G10 countries and found that positive shocks to tourism development cause economic growth, while negative shocks show a bidirectional causal relationship. Enilov and Wang (2022) further highlighted the time-varying causality between international tourist arrivals and economic growth in 23 developing and developed countries, emphasizing the role of tourism as a leading indicator of future economic growth, especially in developing countries. Hajam et al. (2023) examined the relationship between tourism and the economy in India and found that both tourism receipts and expenditures have a positive impact on economic growth, with unidirectional causality from tourism expenditures to economic growth, supporting the tourism-led growth hypothesis. The study recommends the promotion of tourism to accelerate economic growth and suggests that future research should examine the relationship between tourism and the economy at a disaggregated sectoral level.

2.7 Sustainable Tourism Development and Community Engagement

Community engagement and sustainable tourism development are critical to long-term success. Munanura and Kline (2023) examined community support for tourism using the Value-Attitude-Behavior (VAB) approach and found that perceived tourism impacts strongly predicted support. Mihardja et al. (2023) explored the potential of Bali's Batur Geopark as a spiritual recreation destination, emphasizing the importance of community participation in disaster mitigation and forest conservation. Similarly, Kurowska et al. (2023) examined abandoned quarries in Poland and proposed their transformation into tourist attractions to enhance social and environmental benefits. De Siano and Canale (2022) introduced a novel "tourism pressure" indicator in Italy, showing that while tourism generally promotes growth,

excessive tourism pressure leads to detrimental effects on per capita income, highlighting the need to manage tourism to avoid conflicts with local populations.

2.8 Gaps in Literature Addressed

This study addresses several critical gaps in the existing literature on tourism and sustainable development.

First, there is limited quantitative research on the role of infrastructure in forest tourism development, despite growing recognition of the cultural and environmental dimensions of tourism. While previous studies have focused on the broader cultural and environmental benefits of tourism, the specific impact of infrastructure on forest tourism has not been extensively explored. This study fills this gap by proposing a theoretical framework based on the Perceived Value Theory (Zhang et al., 2022) that provides a quantitative approach to understanding how infrastructure influences tourists' willingness to visit urban forest parks.

Another gap addressed by this study is the bidirectional relationship between tourism and economic growth. While the tourism-led growth hypothesis (TLGH) is well documented, there is limited research examining how tourism not only drives economic development, but also benefits from higher levels of economic growth. This study contributes to the literature by exploring this reciprocal relationship, particularly in regions with developed infrastructure and economic stability, highlighting the complexities and potential benefits of tourism in driving long-term economic growth.

The study also addresses regional differences in tourism development, an area where previous research has been less detailed. The impact of tourism varies significantly across regions, largely due to differences in infrastructure, governance and resource availability. This study provides a comprehensive analysis of these disparities and offers region-specific recommendations aimed at promoting sustainable tourism development tailored to local conditions and challenges.

Finally, this research contributes to the understanding of the role of technology in sustainable tourism. While previous studies have focused on the economic and environmental impacts of tourism, the influence of digital infrastructure and technological innovation in enhancing tourism's contribution to sustainable development has received limited attention. This study explores how technological advances, particularly in digital infrastructure, can help bridge regional disparities and promote more sustainable tourism practices, providing new insights into how technology can support sustainable tourism in different contexts.

3. METHODOLOGY

3.1 Research Design

This study uses a quantitative approach to examine the relationships between economic, environmental, and technological variables across regions. The study focuses on identifying key patterns, regional disparities, and the factors influencing sustainable development. The analysis integrates correlation analysis, ANOVA, and multiple regression models to assess the relationships between different indicators and their implications for regional development. The methodology is designed to provide both theoretical insights and practical recommendations for policy makers.

3.2 Data Collection

The study uses secondary data from the World Bank database, which provides a comprehensive set of economic, environmental, and technological indicators. The variables selected for analysis include: economic indicators (GDP per capita, foreign direct investment (FDI), employment in services, international tourist arrivals, and travel services as a percentage of services exports); environmental indicators (forest cover, renewable energy consumption, and other sustainability-related measures); and technological indicators (mobile phone subscriptions as a proxy for technology adoption and digital infrastructure). The data cover the period 2000 to 2023, with a focus on analyzing regional disparities and trends in various indicators.

3.3 Variables

The study identifies two main dependent variables: GDP per capita and international tourist arrivals. The independent variables include FDI, employment in services, renewable energy consumption, forest cover, mobile phone subscriptions, and travel services (as a percentage of services exports). Control variables, such as region-specific dummy variables, are introduced to account for regional differences.

3.4 Sampling Strategy

The study includes data from several regions, categorized as follows: Sub-Saharan Africa, Caribbean Small States, Middle East and North Africa, Europe and Central Asia, European Union, East Asia and the Pacific, Latin America and the Caribbean, Central Europe and the Baltic States, Africa Eastern and Southern , and Africa Western and Central

These regions were selected based on their diverse economic, environmental, and technological characteristics to ensure a broad range of perspectives.

3.5 Data Analysis Techniques

The study uses Pearson's correlation coefficient to examine the strength and direction of relationships between variables. This analysis helps to understand the preliminary relationships between economic, environmental, and technological factors.

ANOVA (Analysis of Variance) is used to assess the statistical significance of regional differences in the variables of interest. This method makes it possible to examine how different regions compare in terms of their economic, environmental, and technological outcomes. Regions are treated as independent groups and the variance within and between these groups is analyzed.

Multiple linear regression is used to examine the drivers of international tourist arrivals and GDP per capita. The two main regression models aim to explain the variance in these dependent variables based on independent factors such as FDI, renewable energy consumption, and service employment.

For international tourism arrivals, the regression model is specified as:

$$\text{Tourism Arrivals}_i = \beta_0 + \beta_1 \text{Forest Area}_i + \beta_2 \text{Renewable Energy Consumption}_i + \beta_3 \text{FDI}_i + \beta_4 \text{Mobile Cellular Subscriptions}_i + \beta_5 \text{Region}_i + \epsilon_i$$

Where:

- β_0 is the intercept, representing the reference level (Sub-Saharan Africa),
- β_1 through β_4 are the coefficients for the predictors: forest area, renewable energy consumption, foreign direct investment, and mobile cellular subscriptions,
- β_5 is the coefficient for the regional dummy variables.

For GDP per capita, the regression model is specified as:

$$\text{GDP per capita}_i = \beta_0 + \beta_1 \text{Travel Services (Import)}_i + \beta_2 \text{Travel Services (Export)}_i + \beta_3 \text{Tourism Arrivals}_i + \beta_4 \text{Employment in Services}_i + \beta_5 \text{Region}_i + \epsilon_i$$

Where:

- β_0 is the intercept (Sub-Saharan Africa),
- β_1 and β_2 are the coefficients for the predictors: travel services as a percentage of imports and exports,
- β_3 is the coefficient for international tourism arrivals,
- β_4 is the coefficient for employment in services,
- β_5 accounts for regional dummy variables.

These regression models are tested for multicollinearity, homoscedasticity, and normality of the residuals to ensure the robustness of the results.

3.6 Statistical Software

The analysis is performed using Jamovi, an open-source statistical software chosen for its user-friendly interface and powerful capabilities for performing regression analysis, ANOVA, and correlation tests. Jamovi's integration with R allows for further customization of the analysis, ensuring that all statistical assumptions are met.

3.7 Data Validation and Reliability

Data reliability is ensured by sourcing data from credible organizations such as the World Bank and, where possible, cross-validating data with other independent databases. Missing or inconsistent data points are dealt with by using data imputation techniques or removing incomplete cases where necessary. The consistency of the indicators across years and regions is checked to ensure the robustness of the results.

3.8 Limitations

While the study provides valuable insights into regional disparities and the relationships among economic, environmental, and technological variables, there are several limitations. The study is cross-sectional in nature, which limits its ability to definitively assess long-term trends or causal relationships. Data availability is another limitation, as some regions may have incomplete or inconsistent data, which could affect the accuracy of the analysis. In addition, the study cannot account for all potential confounding factors, such as political stability or social influences, which may affect the relationships between variables.

3.9 Ethical Considerations

As this study uses secondary data, there are no direct ethical concerns regarding data collection. However, proper attribution is given to data sources, including the World Bank and other relevant institutions. The analysis is conducted in a manner that respects the privacy and integrity of the regions studied.

4. INTERPRETATION OF RESULTS

The results are interpreted in the context of existing economic, environmental, and development theories. Theoretical implications are drawn from established frameworks such as endogenous growth theory, the structural change hypothesis, and the environmental Kuznets curve. Practical implications are drawn to guide policymakers in designing region-specific strategies to promote sustainable development, address inequalities, and foster inclusive economic growth.

The findings provide a comprehensive framework for understanding the complex interactions among various economic, environmental, and technological factors, and offer actionable recommendations for promoting sustainable development in different regions.

4.1 Correlation Analysis

The correlation matrix presented in Table 1 provides insight into the relationships between different economic, environmental and technological variables. The correlation between forest cover (% of land area) and renewable energy consumption (% of total final energy consumption) is weak and not statistically significant ($r = -0.045$, $p = 0.491$). This suggests that countries with larger forest areas do not necessarily consume more renewable energy, suggesting that forest cover alone does not drive the adoption of renewable energy. Net FDI inflows show a strong positive correlation with GDP per capita ($r = 0.599$, $p < .001$), indicating that higher levels of FDI are associated with higher economic output per person. This is consistent with economic theory, as FDI often brings capital, technology, and know-how that can raise productivity and income levels.

Employment in services is strongly positively correlated with GDP per capita ($r = 0.728$, $p < .001$). This reflects the structural transformation of economies, where higher-income countries tend to have a larger share of employment in services than in agriculture or industry. Mobile phone subscriptions (per 100 people) are positively correlated with GDP per capita ($r = 0.577$, $p < .001$) and employment in services ($r = 0.564$, $p < .001$). This suggests that higher levels of technology adoption, as reflected in mobile phone subscriptions , are associated with economic development and a shift towards service-oriented economies.

Table 1. Correlation Matrix of Economic, Environmental, and Technological Variables

		Forest area (% of land area)		Renewable energy consumption (% of total final energy consumption)		Foreign direct investment, net inflows (BoP, current US$)		GDP per capita (current US$)		Employment in services (% of total employment) (modeled ILO estimate)		Mobile cellular subscriptions (per 100 people)		Travel services (% of service imports, BoP)		Travel services (% of service exports, BoP)		International tourism, number of arrivals	
Forest area (% of land area)	Pearson's r	—																	
	df	—																	
	p-value	—																	
Renewable energy consumption (% of total final energy consumption)	Pearson's r	-0.045		—															
	df	238		—															
	p-value	0.491		—															
Foreign direct investment, net inflows (BoP, current US$)	Pearson's r	0.021		-0.329	***	—													
	df	238		238		—													
	p-value	0.742		< .001		—													
GDP per capita (current US$)	Pearson's r	0.154	*	-0.523	***	0.599	***	—											
	df	238		238		238		—											
	p-value	0.017		< .001		< .001		—											
Employment in services (% of total employment) (modeled ILO estimate)	Pearson's r	0.415	***	-0.663	***	0.332	***	0.728	***	—									
	df	238		238		238		238		—									
	p-value	< .001		< .001		< .001		< .001		—									
Mobile cellular	Pearson's r	0.071		-0.4	***	0.422	***	0.577	***	0.564	**	—							

subscriptions (per 100 people)					70			*		*		*								
		df		238		238		238		238		238		—						
		p-value		0.270		<.001		<.001		<.001		<.001		—						
Travel services (% of service imports, BoP)		Pearson's r		0.139	*	-0.005		0.272	***	0.102		0.028		0.046		—				
		df		238		238		238		238		238		238		—				
		p-value		0.031		0.940		<.001		0.114		0.672		0.480		—				
Travel services (% of service exports, BoP)		Pearson's r		0.649	***	0.302	***	-0.224	***	-0.225	***	-0.088		-0.133	*	0.143	*	—		
		df		238		238		238		238		238		238		238		—		
		p-value		<.001		<.001		<.001		<.001		0.176		0.040		0.026		—		
International tourism, number of arrivals		Pearson's r		0.042		-0.321	***	0.755	***	0.675	***	0.409	***	0.383	***	0.381	***	-0.196	**	—
		df		238		238		238		238		238		238		238		238		—
		p-value		0.515		<.001		<.001		<.001		<.001		<.001		<.001		0.002		—

Note. * p < .05, ** p < .01, *** p < .001

Travel services (% of service exports) have a strong positive correlation with forest area ($r = 0.649$, $p < .001$), suggesting that countries with larger forest areas may benefit from tourism related to natural attractions. However, travel services (% of service exports) is negatively correlated with FDI ($r = -0.224$, $p < .001$) and GDP per capita ($r = -0.225$, $p < .001$), suggesting that wealthier countries or those with higher FDI may rely less on tourism as a share of their service exports.The number of international tourist arrivals is strongly positively correlated with FDI ($r = 0.755$, $p < .001$) and GDP per capita ($r = 0.675$, $p < .001$). This highlights the role of economic stability and investment in attracting tourists, as wealthier countries and those with higher FDI may have better infrastructure and amenities for tourism.

Several important patterns emerge from the correlation matrix. First, economic development, as measured by GDP per capita, is closely related to employment in services, mobile phone subscriptions, and international tourism. This underscores the importance of technological progress and structural economic changes in driving growth. Second, the negative correlations between renewable energy consumption and variables such as GDP per capita ($r = -0.523$, $p < .001$) and employment in services ($r = -0.663$, $p < .001$) suggest that wealthier, service-oriented economies may still rely heavily on non-renewable energy sources, highlighting a potential area for policy intervention.

The strong positive correlation between FDI and international tourism ($r = 0.755$, $p < .001$) suggests that foreign investment can play a crucial role in developing tourism infrastructure, which in turn can boost economic growth. However, the negative correlation between travel services (% of services exports) and GDP per capita ($r = -0.225$, $p < .001$) suggests that as countries develop, they can diversify their economies away from dependence on tourism.

Overall, the matrix provides valuable insights into the interplay between environmental, economic and technological factors. Policymakers can use these findings to design strategies that promote sustainable development, such as incentivizing the adoption of renewable energy in high-income countries or using FDI to improve tourism infrastructure in developing countries.

4.2 ANOVA

The results of the one-way ANOVA in Table 2 show statistically significant differences ($p < .001$) between the regions for all the variables analyzed, including forest area, renewable energy consumption, foreign direct investment (FDI), GDP per capita, service employment, mobile phone subscriptions, and international tourist arrivals. The use of non-equal variance Welch's ANOVA was necessary because the homogeneity of variances assumption was violated, as confirmed by Levene's test in Table 5. The high F-values for each variable, such as 411.7 for forest area and 488.8 for employment in services, suggest that regional groupings have a significant impact on these variables. This implies that geographic and economic factors significantly influence environmental, economic and technological indicators across regions.

Table 2. One-Way ANOVA (Welch's)

	F	df1	df2	p
Forest area (% of land area)	411.7	9	84.9	< .001
Renewable energy consumption (% of total final energy consumption)	100.0	9	86.0	< .001
Foreign direct investment, net inflows (BoP, current US$)	64.4	9	84.7	< .001
GDP per capita (current US$)	179.0	9	91.1	< .001
Employment in services (% of total employment) (modeled ILO estimate)	488.8	9	93.3	< .001
Mobile cellular subscriptions (per 100 people)	11.5	9	93.6	< .001
International tourism, number of arrivals	57.9	9	90.1	< .001

Table 3 provides descriptive statistics for each variable across regions, highlighting significant differences. For example, the Caribbean small states have the highest average forest cover (87.18%), while the Middle East and North Africa region has the lowest (1.91%). This stark contrast reflects differences in natural resource endowments and land use policies. Renewable energy consumption is highest in Sub-Saharan Africa (61.30%) and Africa Western and Central (69.51%), likely due to limited access to non-renewable energy sources and reliance on traditional biomass. In contrast, the Middle East and North Africa (1.72%) and Europe and Central Asia (9.32%) have the lowest use of renewable energy, possibly due to their reliance on fossil fuels. GDP per capita is highest in the European Union (31,523) and lowest in Sub-Saharan Africa (31,523) and the Caribbean (1,385), reflecting the economic

divide between developed and developing regions. Employment in services is highest in the small Caribbean states (68.79%) and the European Union (67.72%), indicating a shift towards service-oriented economies, while sub-Saharan Africa (34.20%) and Africa Eastern and Southern (29.66%) lag behind, suggesting a reliance on agriculture and the informal sector. Mobile phone subscriptions are highest in Europe and Central Asia (104.15%) and the European Union (103.91%), reflecting advanced technological infrastructure, while Sub-Saharan Africa (47.46%) and Africa Eastern and Southern (42.76%) have the lowest penetration, indicating limited access to technology. International tourism arrivals are dominated by Europe and Central Asia (761 million) and the European Union (626 million), reflecting their well-developed tourism industries, while Africa Western and Central (6.04 million) has the lowest arrivals, highlighting underdeveloped tourism infrastructure.

Table 3. Descriptive of Variables

	Region	N	Mean	SD	SE
Forest area (% of land area)	Sub-Saharan Africa	24	27.59	6.218	1.2693
	Africa Eastern and Southern	24	32.97	7.858	1.6040
	Africa Western and Central	24	19.74	4.246	0.8668
	Caribbean small states	24	87.18	18.575	3.7915
	Central Europe and the Baltics	24	32.36	6.927	1.4139
	East Asia & Pacific	24	25.61	5.467	1.1160
	Europe & Central Asia	24	36.69	7.817	1.5957
	European Union	24	37.52	8.013	1.6357
	Latin America & Caribbean	24	46.07	9.905	2.0218
	Middle East & North Africa	24	1.91	0.412	0.0842
Renewable energy consumption (% of total final energy consumption)	Sub-Saharan Africa	24	61.30	23.708	4.8394
	Africa Eastern and Southern	24	55.21	21.364	4.3610
	Africa Western and Central	24	69.51	26.962	5.5036
	Caribbean small states	24	14.09	6.186	1.2626
	Central Europe and the Baltics	24	12.36	5.672	1.1578
	East Asia & Pacific	24	13.64	6.034	1.2317
	Europe & Central Asia	24	9.32	4.256	0.8689
	European Union	24	12.32	6.040	1.2329
	Latin America & Caribbean	24	25.47	9.913	2.0234

Table 3. Descriptive of Variables

	Region	N	Mean	SD	SE
	Middle East & North Africa	24	1.72	0.736	0.1502
Foreign direct investment, net inflows (BoP, current US$)	Sub-Saharan Africa	24	2.75e+10	1.45e+10	2.97e0+9
	Africa Eastern and Southern	24	1.66e+10	1.04e+10	2.12e0+9
	Africa Western and Central	24	1.09e+10	5.81e0+9	1.19e0+9
	Caribbean small states	24	1.82e0+9	6.78e0+8	1.38e0+8
	Central Europe and the Baltics	24	6.31e+10	5.82e+10	1.19e+10
	East Asia & Pacific	24	4.45e+11	2.06e+11	4.21e+10
	Europe & Central Asia	24	7.22e+11	5.07e+11	1.03e+11
	European Union	24	5.57e+11	3.48e+11	7.11e+10
	Latin America & Caribbean	24	1.90e+11	7.76e+10	1.58e+10
	Middle East & North Africa	24	6.49e+10	4.40e+10	8.99e0+9
GDP per capita (current US$)	Sub-Saharan Africa	24	1385.24	405.038	82.6780
	Africa Eastern and Southern	24	1339.28	349.187	71.2774
	Africa Western and Central	24	1452.90	498.052	101.6644
	Caribbean small states	24	10519.31	2576.255	525.8758
	Central Europe and the Baltics	24	12533.74	4888.557	997.8726
	East Asia & Pacific	24	8222.16	3175.248	648.1448
	Europe & Central Asia	24	22497.59	5121.566	1045.4352
	European Union	24	31523.36	6723.110	1372.3491
	Latin America & Caribbean	24	7777.48	2339.118	477.4704
	Middle East & North Africa	24	6432.95	2040.635	416.5429
Employment in services (% of total employment) (modeled ILO estimate)	Sub-Saharan Africa	24	34.20	3.450	0.7043
	Africa Eastern and Southern	24	29.66	3.474	0.7090
	Africa Western and Central	24	40.38	3.543	0.7232
	Caribbean small states	24	68.79	1.971	0.4023

Table 3. Descriptive of Variables

	Region	N	Mean	SD	SE
Mobile cellular subscriptions (per 100 people)	Central Europe and the Baltics	24	55.53	3.734	0.7623
	East Asia & Pacific	24	41.44	5.609	1.1449
	Europe & Central Asia	24	64.42	3.243	0.6619
	European Union	24	67.72	3.303	0.6743
	Latin America & Caribbean	24	63.01	2.342	0.4780
	Middle East & North Africa	24	55.09	2.870	0.5858
	Sub-Saharan Africa	24	47.46	31.363	6.4019
	Africa Eastern and Southern	24	42.76	27.420	5.5970
	Africa Western and Central	24	54.33	37.184	7.5901
	Caribbean small states	24	72.24	39.414	8.0453
	Central Europe and the Baltics	24	98.78	39.856	8.1356
	East Asia & Pacific	24	78.70	41.901	8.5530
	Europe & Central Asia	24	104.15	31.195	6.3677
	European Union	24	103.91	31.456	6.4210
	Latin America & Caribbean	24	81.40	37.195	7.5925
	Middle East & North Africa	24	74.74	40.855	8.3396
International tourism, number of arrivals	Sub-Saharan Africa	24	3.14e0+7	1.82e0+7	3.71e0+6
	Africa Eastern and Southern	24	2.33e0+7	1.33e0+7	2.71e0+6
	Africa Western and Central	24	6.04e0+6	4.68e0+6	956020.9528
	Caribbean small states	24	1.24e0+7	6.19e0+6	1.26e0+6
	Central Europe and the Baltics	24	1.92e0+8	9.55e0+7	1.95e0+7
	East Asia & Pacific	24	2.60e0+8	1.50e0+8	3.06e0+7
	Europe & Central Asia	24	7.61e0+8	3.72e0+8	7.59e0+7
	European Union	24	6.26e0+8	3.02e0+8	6.17e0+7
	Latin America & Caribbean	24	1.41e0+8	6.64e0+7	1.35e0+7
	Middle East & North Africa	24	7.80e0+7	5.86e0+7	1.20e0+7

4.2.1 Assumption Checks

The results of the Shapiro-Wilk test in Table 4 indicate that the assumption of normality is violated for all variables, as evidenced by low W values and p-values less than .001

Table 4. Normality Test (Shapiro-Wilk)

	W	p
Forest area (% of land area)	0.338	< .001
Renewable energy consumption (% of total final energy consumption)	0.586	< .001
Foreign direct investment, net inflows (BoP, current US$)	0.702	< .001
GDP per capita (current US$)	0.901	< .001
Employment in services (% of total employment) (modeled ILO estimate)	0.976	< .001
Mobile cellular subscriptions (per 100 people)	0.892	< .001
International tourism, number of arrivals	0.683	< .001

Note. A low p-value suggests a violation of the assumption of normality

For example, forest area has a W value of 0.338 and renewable energy consumption has a W value of 0.586. This violation of normality justifies the use of nonparametric tests, such as Welch's ANOVA and Games-Howell post-hoc tests, which do not rely on the assumption of normally distributed data.

Levene's test in Table 5 shows significant differences in variances for most variables ($p < .001$), except for forest area ($p = 0.201$) and mobile phone subscriptions ($p = 0.053$). This indicates that the assumption of equal variances is violated for renewable energy consumption, FDI, GDP per capita, employment in services, and international tourist arrivals. The violation of this assumption further supports the use of Welch's ANOVA and Games-Howell post-hoc tests, which are robust to unequal variances.

Table 5. Homogeneity of Variances Test (Levene's)

	F	df1	df2	p
Forest area (% of land area)	1.37	9	230	0.201
Renewable energy consumption (% of total final energy consumption)	7.36	9	230	< .001
Foreign direct investment, net inflows (BoP, current US$)	21.04	9	230	< .001
GDP per capita (current US$)	15.53	9	230	< .001
Employment in services (% of total employment) (modeled ILO estimate)	6.90	9	230	< .001
Mobile cellular subscriptions (per 100 people)	1.90	9	230	0.053
International tourism, number of arrivals	15.81	9	230	< .001

4.2.2 Post Hoc Tests

The Games-Howell post-hoc tests in Table 6 through 12 provide detailed insights into specific regional differences. For example, in Table 5, the Caribbean small states have significantly more forest area than all other regions ($p < .001$), while the Middle East and North Africa have

significantly less forest area ($p < .001$). This reflects the Caribbean's emphasis on conservation and the Middle East's arid climate.

Table 6. Games-Howell Post-Hoc Test – Forest area (% of land area)

		Sub-Saharan Africa	Africa Eastern and Southern	Africa Western and Central	Caribbean small states	Central Europe and the Baltics	East Asia & Pacific	Europe & Central Asia	European Union	Latin America & Caribbean	Middle East & North Africa
Sub-Saharan Africa	Mean difference	—	-5.39	7.85	-59.6	-4.768	1.98	-9.10	-9.927	-18.49	25.7
	p-value	—	0.234	< .001	< .001	0.291	0.973	0.002	< .001	< .001	< .001
Africa Eastern and Southern	Mean difference		—	13.23	-54.2	0.617	7.37	-3.71	-4.541	-13.10	31.1
	p-value		—	< .001	< .001	1.000	0.017	0.821	0.615	< .001	< .001
Africa Western and Central	Mean difference			—	-67.4	-12.613	-5.87	-16.94	-17.772	-26.33	17.8
	p-value			—	< .001	< .001	0.005	< .001	< .001	< .001	< .001
Caribbean small states	Mean difference				—	54.826	61.57	50.49	49.667	41.11	85.3
	p-value				—	< .001	< .001	< .001	< .001	< .001	< .001
Central Europe and the Baltics	Mean difference					—	6.75	-4.33	-5.158	-13.72	30.4
	p-value					—	0.017	0.582	0.358	< .001	< .001
East Asia & Pacific	Mean difference						—	-11.08	-11.906	-20.46	23.7
	p-value						—	< .001	< .001	< .001	< .001
Europe & Central Asia	Mean difference							—	-0.827	-9.39	34.8
	p-value							—	1.000	0.022	< .001
European Union	Mean difference								—	-8.56	35.6
	p-value								—	0.055	< .001
Latin America & Caribbean	Mean difference									—	44.2
	p-value									—	< .001
Middle East & North Africa	Mean difference										—
	p-value										—

In Table 7, Sub-Saharan Africa and Africa Western and Central have significantly higher renewable energy consumption than other regions ($p < .001$), while the Middle East and North Africa and Europe and Central Asia have the lowest consumption ($p < .001$). This suggests that wealthier regions rely more on non-renewable energy sources, while developing regions rely on renewable energy due to limited access to fossil fuels.

Table 7. Games-Howell Post-Hoc Test – Renewable energy consumption (% of total final energy consumption)

		Sub-Saharan Africa	Africa Eastern and Southern	Africa Western and Central	Caribbean small states	Central Europe and the Baltics	East Asia & Pacific	Europe & Central Asia	European Union	Latin America & Caribbean	Middle East & North Africa
Sub-Saharan Africa	Mean difference	—	6.09	-8.21	47.2	48.94	47.658	51.98	48.9769	35.8	59.58
	p-value	—	0.994	0.980	< .001	< .001	< .001	< .001	< .001	< .001	< .001
Africa Eastern and Southern	Mean difference		—	-14.31	41.1	42.85	41.564	45.89	42.8836	29.7	53.48
	p-value		—	0.579	< .001	< .001	< .001	< .001	< .001	< .001	< .001
Africa Western and Central	Mean difference			—	55.4	57.15	55.872	60.19	57.1909	44.0	67.79
	p-value			—	< .001	< .001	< .001	< .001	< .001	< .001	< .001
Caribbean small states	Mean difference				—	1.73	0.446	4.77	1.7655	-11.4	12.37
	p-value				—	0.990	1.000	0.087	0.991	< .001	< .001
Central Europe and the Baltics	Mean difference					—	-1.281	3.04	0.0386	-13.1	10.64
	p-value					—	0.999	0.536	1.000	< .001	< .001
East Asia & Pacific	Mean difference						—	4.32	1.3193	-11.8	11.92
	p-value						—	0.148	0.999	< .001	< .001
Europe & Central Asia	Mean difference							—	-3.0041	-16.1	7.60
	p-value							—	0.609	< .001	< .001
European Union	Mean difference								—	-13.1	10.60
	p-value								—	< .001	< .001
Latin America & Caribbean	Mean difference									—	23.74
	p-value									—	< .001
Middle East & North Africa	Mean difference										—
	p-value										—

In Table 8, Europe and Central Asia and the European Union attract significantly more FDI than other regions ($p < .001$), while Sub-Saharan Africa and Africa Western and Central have significantly lower FDI inflows ($p < .001$). This reflects the attractiveness of developed economies to foreign investors and the challenges that developing regions face in attracting investment.

Table 8. Games-Howell Post-Hoc Test – Foreign direct investment, net inflows (BoP, current US$)

		Sub-Saharan Africa	Africa Eastern and Southern	Africa Western and Central	Caribbean small states	Central Europe and the Baltics	East Asia & Pacific	Europe & Central Asia	European Union	Latin America & Caribbean	Middle East & North Africa
Sub-Saharan Africa	Mean difference	—	1.09e+10	1.66e+10	2.57e+10	-3.56e−10	-4.18e−11	-6.95e−11	-5.30e−11	-1.63e−11	-3.74e−10
	p-value	—	0.113	< .001	< .001	0.153	< .001	< .001	< .001	< .001	0.014
Africa	Mean		—	5.68e0	1.48e+	-	-	-	-	-	-

Eastern and Southern		difference					+9		10		4.65e−10		4.29e−11		7.05e−11		5.41e−11		1.74e−11		4.83e−10	
		p-value				—	0.389		< .001		0.021		< .001		< .001		< .001		< .001		< .001	
Africa Western and Central		Mean difference					—		9.09e0+9		-5.22e−10		-4.34e−11		-7.11e−11		-5.46e−11		-1.79e−11		-5.40e−10	
		p-value					—		< .001		0.007		< .001		< .001		< .001		< .001		< .001	
Caribbean small states		Mean difference							—		-6.13e−10		-4.43e−11		-7.20e−11		-5.55e−11		-1.89e−11		-6.31e−10	
		p-value							—		0.001		< .001		< .001		< .001		< .001		< .001	
Central Europe and the Baltics		Mean difference									—		-3.82e−11		-6.59e−11		-4.94e−11		-1.27e−11		-1.80e0-9	
		p-value									—		< .001		< .001		< .001		< .001		1.000	
East Asia & Pacific		Mean difference											—		-2.77e−11		-1.12e−11		2.55e+11		3.80e+11	
		p-value											—		0.319		0.933		< .001		< .001	
Europe & Central Asia		Mean difference													—		1.65e+11		5.32e+11		6.57e+11	
		p-value													—		0.945		0.001		< .001	
European Union		Mean difference															—		3.67e+11		4.92e+11	
		p-value															—		0.001		< .001	
Latin America & Caribbean		Mean difference																	—		1.25e+11	
		p-value																	—		< .001	
Middle East & North Africa		Mean difference																			—	
		p-value																			—	

In Table 9, the European Union and Europe and Central Asia have significantly higher GDP per capita than all other regions ($p < .001$), while Sub-Saharan Africa and Africa Eastern and Southern have the lowest GDP per capita ($p < .001$). This highlights the economic divide between developed and developing regions.

Table 9. Games-Howell Post-Hoc Test – GDP per capita (current US$)

		Sub-Saharan Africa	Africa Eastern and Southern	Africa Western and Central	Caribbean small states	Central Europe and the Baltics	East Asia & Pacific	Europe & Central Asia	European Union	Latin America & Caribbean	Middle East & North Africa
Sub-Saharan Africa	Mean difference	—	46.0	-67.7	-9134	-11148	-6837	-21112	-30138	-6392	-5048
	p-value	—	1.000	1.000	< .001	< .001	< .001	< .001	< .001	< .001	< .001
Africa Eastern and Southern	Mean difference		—	-113.6	-9180	-11194	-6883	-21158	-30184	-6438	-5094
	p-value		—	0.995	< .001	< .001	< .001	< .001	< .001	< .001	< .001
Africa Western and Central	Mean difference			—	-9066	-11081	-6769	-21045	-30070	-6325	-4980
	p-value			—	< .001	< .001	< .001	< .001	< .001	< .001	< .001
Caribbean small states	Mean difference				—	-2014	2297	-11978	-21004	2742	4086
	p-value				—	0.739	0.185	< .001	< .001	0.012	< .001
Central Europe and the Baltics	Mean difference					—	4312	-9964	-18990	4756	6101
	p-value					—	0.025	< .001	< .001	0.005	< .001
East Asia & Pacific	Mean difference						—	-14275	-23301	445	1789
	p-value						—	< .001	< .001	1.000	0.398
Europe & Central Asia	Mean difference							—	-9026	14720	16065
	p-value							—	< .001	< .001	< .001
European	Mean								—	23746	25090

Union		difference																						
		p-value																						
Latin America & Caribbean		Mean difference																						
		p-value																						
Middle East & North Africa		Mean difference																						
		p-value																						

In Table 10, the Caribbean small states and the European Union have significantly higher employment in services than other regions ($p < .001$), while Sub-Saharan Africa and Africa Eastern and Southern have the lowest employment in services ($p < .001$). This reflects the structural transformation of economies, with wealthier regions shifting toward service-oriented industries.

Table 10. Games-Howell Post-Hoc Test – Employment in services (% of total employment) (modeled ILO estimate)

		Sub-Saharan Africa	**Africa Eastern and Southern**	**Africa Western and Central**	**Caribbean small states**	**Central Europe and the Baltics**	**East Asia & Pacific**	**Europe & Central Asia**	**European Union**	**Latin America & Caribbean**	**Middle East & North Africa**
Sub-Saharan Africa	Mean difference	—	4.54	-6.18	-34.6	-21.3	-7.24	-30.22	-33.52	-28.81	-20.889
	p-value	—	0.002	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
Africa Eastern and Southern	Mean difference		—	-10.72	-39.1	-25.9	-11.78	-34.76	-38.06	-33.35	-25.426
	p-value		—	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
Africa Western and Central	Mean difference			—	-28.4	-15.1	-1.06	-24.04	-27.33	-22.63	-14.704
	p-value			—	<.001	<.001	0.998	<.001	<.001	<.001	<.001
Caribbean small states	Mean difference				—	13.3	27.35	4.37	1.07	5.78	13.698
	p-value				—	<.001	<.001	<.001	0.931	<.001	<.001
Central Europe and the Baltics	Mean difference					—	14.09	-8.89	-12.19	-7.48	0.438
	p-value					—	<.001	<.001	<.001	<.001	1.000
East Asia & Pacific	Mean difference						—	-22.98	-26.28	-21.57	-13.647
	p-value						—	<.001	<.001	<.001	<.001
Europe & Central Asia	Mean difference							—	-3.30	1.41	9.331
	p-value							—	0.032	0.774	<.001
European Union	Mean difference								—	4.71	12.629
	p-value								—	<.001	<.001
Latin America & Caribbean	Mean difference									—	7.921
	p-value									—	<.001
Middle East & North Africa	Mean difference										—
	p-value										—

In Table 11, Europe and Central Asia and the European Union have significantly higher mobile penetration than other regions ($p < .001$), while Sub-Saharan Africa and Africa Eastern and Southern have the lowest mobile penetration ($p < .001$).

Table 11. Games-Howell Post-Hoc Test – Mobile cellular subscriptions (per 100 people)

		Sub-Saharan Africa	Africa Eastern and Southern	Africa Western and Central	Caribbean small states	Central Europe and the Baltics	East Asia & Pacific	Europe & Central Asia	European Union	Latin America & Caribbean	Middle East & North Africa
Sub-Saharan Africa	Mean difference	—	4.70	-6.87	-24.8	-51.3	-31.24	-56.69	-56.455	-33.94	-27.29
	p-value	—	1.000	0.999	0.345	< .001	0.130	< .001	< .001	0.040	0.251
Africa Eastern and Southern	Mean difference		—	-11.56	-29.5	-56.0	-35.94	-61.39	-61.152	-38.63	-31.98
	p-value		—	0.964	0.110	< .001	0.033	< .001	< .001	0.006	0.074
Africa Western and Central	Mean difference			—	-17.9	-44.5	-24.37	-49.82	-49.587	-27.07	-20.42
	p-value			—	0.832	0.008	0.516	< .001	< .001	0.285	0.725
Caribbean small states	Mean difference				—	-26.5	-6.46	-31.91	-31.670	-9.15	-2.50
	p-value				—	0.397	1.000	0.085	0.092	0.998	1.000
Central Europe and the Baltics	Mean difference					—	20.08	-5.37	-5.134	17.38	24.04
	p-value					—	0.789	1.000	1.000	0.859	0.561
East Asia & Pacific	Mean difference						—	-25.45	-25.213	-2.70	3.96
	p-value						—	0.359	0.376	1.000	1.000
Europe & Central Asia	Mean difference							—	0.237	22.75	29.41
	p-value							—	1.000	0.411	0.168
European Union	Mean difference								—	22.52	29.17
	p-value								—	0.431	0.179
Latin America & Caribbean	Mean difference									—	6.65
	p-value									—	1.000
Middle East & North Africa	Mean difference										—
	p-value										—

In Table 12, Europe and Central Asia and the European Union have significantly higher international tourism arrivals than other regions ($p < .001$), while Africa West and Central has the lowest number of arrivals ($p < .001$). This reflects the well-developed tourism infrastructure in wealthier regions and the underdeveloped tourism sector in poorer regions.

Table 12. Games-Howell Post-Hoc Test – International tourism, number of arrivals

		Sub-Saharan Africa	Africa Eastern and Southern	Africa Western and Central	Caribbean small states	Central Europe and the Baltics	East Asia & Pacific	Europe & Central Asia	European Union	Latin America & Caribbean	Middle East & North Africa
Sub-Saharan Africa	Mean difference	—	8.10e+6	2.54e+7	1.90e+7	-1.61e−8	-2.29e−8	-7.29e−8	-5.94e−8	-1.10e−8	-4.66e−7
	p-value	—	0.754	< .001	0.001	< .001	< .001	< .001	< .001	< .001	0.026
Africa Eastern and Southern	Mean difference		—	1.73e+7	1.09e+7	-1.69e−8	-2.37e−8	-7.38e−8	-6.03e−8	-1.18e−8	-5.47e−7
	p-value		—	< .001	0.027	< .001	< .001	< .001	< .001	< .001	0.005
Africa Western and Central	Mean difference			—	-6.39e−6	-1.86e−8	-2.54e−8	-7.55e−8	-6.20e−8	-1.35e−8	-7.19e−7
	p-value			—	0.008	< .001	< .001	< .001	< .001	< .001	< .001
Caribbean small	Mean differen				—	-1.80e	-2.48e	-7.48e	-6.13e	-1.29e	-6.56e

states		ce										−8		−8		−8		−8		−8		−7	
		p-value									—	< .001		< .001		< .001		< .001		< .001		< .001	
Central Europe and the Baltics		Mean difference										—		-6.77e−7		-5.69e−8		-4.34e−8		5.12e+7		1.14e+8	
		p-value										—		0.691		< .001		< .001		0.500		< .001	
East Asia & Pacific		Mean difference												—		-5.01e−8		-3.66e−8		1.19e+8		1.82e+8	
		p-value												—		< .001		< .001		0.035		< .001	
Europe & Central Asia		Mean difference														—		1.35e+8		6.20e+8		6.83e+8	
		p-value														—		0.927		< .001		< .001	
European Union		Mean difference																—		4.85e+8		5.48e+8	
		p-value																—		< .001		< .001	
Latin America & Caribbean		Mean difference																		—		6.31e+7	
		p-value																		—		0.033	
Middle East & North Africa		Mean difference																				—	
		p-value																				—	

The analysis reveals significant regional disparities in environmental, economic, and technological indicators. Wealthier regions such as the European Union and Europe and Central Asia dominate in GDP per capita, FDI, mobile phone subscriptions, and international tourism, reflecting their advanced economies and infrastructure. In contrast, Sub-Saharan Africa and Africa Western and Central lag in these areas but lead in renewable energy consumption, likely due to lower industrialization and reliance on traditional energy sources. The small states of the Caribbean stand out for their high forest cover and employment in services, suggesting a focus on conservation and service-oriented economies. However, their lower GDP per capita and FDI inflows point to challenges in economic development.

Policymakers can use these findings to address regional disparities and promote sustainable development. Wealthier regions should focus on increasing renewable energy consumption to meet sustainability goals, while developing regions such as Sub-Saharan Africa need targeted investments in infrastructure, technology, and tourism to spur economic growth. The Middle East and North Africa should prioritize environmental protection and economic diversification to reduce dependence on non-renewable resources. Overall, the analysis underscores the importance of region-specific strategies to address disparities and promote sustainable development, ensuring that each region can capitalize on its unique strengths while addressing its specific challenges.

4.3 Regression Analysis

4.3.1 International tourism, number of arrivals

The linear regression model in Table 13 shows a good fit for predicting international tourist arrivals. The model's R value of 0.877 indicates a high degree of correlation between the predictors and the dependent variable (international tourist arrivals). The R^2 value of 0.769 indicates that approximately 76.9% of the variance in international tourist arrivals is explained by the predictors included in the model. The adjusted R^2 value of 0.756 takes into account the number of predictors and confirms the robustness of the model. The overall model is statistically significant, as indicated by the F-value of 57.9 and a p-value of less than

0.001. This implies that the predictors collectively have a significant impact on international tourist arrivals.

Table 13. Model Fit Measures

				Overall Model Test			
Model	**R**	**R^2**	**Adjusted R^2**	**F**	**df1**	**df2**	**p**
1	0.877	0.769	0.756	57.9	13	226	< .001

The coefficients in Table 14 provide insight into the direction and magnitude of the impact of each predictor on international tourism arrivals. The intercept, representing the reference level (Sub-Saharan Africa), is statistically significant (p = 0.019), indicating that Sub-Saharan Africa has a baseline level of tourism arrivals that is significantly different from zero, holding all other predictors constant.

The coefficient on forest area is positive (2.15e+6) but not statistically significant (p = 0.085). This suggests that while forest area may have a weak positive relationship with tourist arrivals, this relationship is not robust enough to be conclusive. In contrast, renewable energy consumption has a positive and statistically significant coefficient (1.64e+6, p = 0.037), indicating that higher renewable energy consumption is associated with increased tourism arrivals. This may reflect the attractiveness of sustainable practices to tourists.

Foreign direct investment (FDI) has a strongly positive and statistically significant coefficient (2.81e-4, p < .001), indicating that higher FDI inflows are associated with significantly higher tourism arrivals. This probably reflects the role of FDI in developing tourism infrastructure and promoting international travel. On the other hand, the coefficient for mobile phone subscriptions is not statistically significant (p = 0.748), suggesting that mobile phone subscriptions does not significantly affect tourism arrivals in this model.

The regional coefficients compare each region to the reference level (Sub-Saharan Africa). Regions such as Central Europe and the Baltics, East Asia and the Pacific, Europe and Central Asia, the European Union, and the Middle East and North Africa have significantly higher tourist arrivals than Sub-Saharan Africa (p < .001 for all). For example, Europe and Central Asia has the highest coefficient (5.95e+8), indicating that this region attracts significantly more tourists than Sub-Saharan Africa. Similarly, the European Union has a strong positive coefficient (5.00e+8), reflecting its well-developed tourism industry. The Middle East and North Africa has a positive coefficient (1.87e+8), indicating that this region also outperforms Sub-Saharan Africa in attracting tourists.

Table 14. Model Coefficients - International tourism, number of arrivals

Predictor	Estimate	SE	t	p	Stand. Estimate
Intercept [a]	-1.41e−8	5.97e+7	-2.360	0.019	
Forest area (% of land area)	2.15e+6	1.24e+6	1.732	0.085	0.1608
Renewable energy consumption (% of total final energy consumption)	1.64e+6	781686	2.103	0.037	0.1488
Foreign direct investment, net inflows (BoP, current US$)	2.81e-4	4.97e-5	5.655	< .001	0.3020
Mobile cellular subscriptions (per 100 people)	94191	293372	0.321	0.748	0.0129
Region:					
Africa Eastern and Southern – Sub-Saharan Africa	-6.16e−6	4.42e+7	-0.139	0.889	-0.0204
Africa Western and Central – Sub-Saharan Africa	-1.80e−7	4.53e+7	-0.398	0.691	-0.0597
Caribbean small states – Sub-Saharan Africa	-6.47e−7	1.03e+8	-0.627	0.531	-0.2144
Central Europe and the Baltics – Sub-Saharan Africa	2.16e+8	5.83e+7	3.709	< .001	0.7166
East Asia & Pacific – Sub-Saharan Africa	1.91e+8	5.85e+7	3.265	0.001	0.6329
Europe & Central Asia – Sub-Saharan Africa	5.95e+8	6.80e+7	8.749	< .001	1.9716
European Union – Sub-Saharan Africa	5.00e+8	6.39e+7	7.816	< .001	1.6552
Latin America & Caribbean – Sub-Saharan Africa	7.99e+7	5.94e+7	1.346	0.180	0.2648
Middle East & North Africa – Sub-Saharan Africa	1.87e+8	6.16e+7	3.027	0.003	0.6184
[a] Represents reference level					

On the other hand, regions such as Africa Eastern and Southern, Africa Western and Central, and the Caribbean Small States do not show statistically significant differences compared to Sub-Saharan Africa ($p > 0.05$). This suggests that these regions have similar levels of tourist arrivals to Sub-Saharan Africa, despite differences in other predictors.

In short, the regression analysis highlights the importance of economic and regional factors in driving international tourism arrivals (Table 14). Foreign direct investment emerges as a key driver, probably due to its role in developing tourism infrastructure and promoting international travel. Renewable energy consumption also plays a significant role, possibly reflecting the growing preference for sustainable tourism destinations. Regional differences are particularly pronounced, with wealthier and more developed regions such as Europe and Central Asia and the European Union attracting significantly more tourists than Sub-Saharan Africa.

Policymakers can use these findings to develop targeted strategies to promote tourism. For example, developing regions such as sub-Saharan Africa could focus on attracting foreign direct investment to improve tourism infrastructure and promote sustainable practices to increase their attractiveness to international tourists. Wealthier regions should continue to invest in sustainability and innovation to maintain their competitive advantage in the global tourism market. Overall, the analysis highlights the interplay between economic development, sustainability and regional characteristics in shaping international tourism trends.

4.3.2 GDP per capita (current US$)

The linear regression model presented in Table 15 shows an exceptionally good fit for predicting GDP per capita, as indicated by an R value of 0.971 and an R^2 value of 0.943. This means that about 94.3 percent of the variance in GDP per capita is explained by the predictors included in the model. The adjusted R^2 value of 0.939 further confirms the robustness of the model given the number of predictors. The overall model is statistically significant, with an F-value of 286 and a p-value of less than 0.001, indicating that the predictors collectively have a highly significant impact on GDP per capita. This strong model fit suggests that the selected variables are highly effective in explaining differences in GDP per capita across regions.

Table 15. Model Fit Measures

				Overall Model Test			
Model	**R**	**R^2**	**Adjusted R^2**	**F**	**df1**	**df2**	**p**
1	0.971	0.943	0.939	286	13	226	< .001

In Table 16, the model coefficients provide detailed insights into the direction and magnitude of the impact of each predictor on GDP per capita. The intercept, which represents the reference level (Sub-Saharan Africa), is statistically significant ($p < .001$), indicating that Sub-Saharan Africa has a baseline GDP per capita that is significantly different from zero, holding all other predictors constant. Among the predictors, employment in services stands out as the most significant, with a strong positive coefficient of 674.393 ($p < .001$). This suggests that a higher percentage of employment in services is associated with significantly higher GDP per capita, reflecting the economic benefits of transitioning to a service-oriented economy. In contrast, travel services as a percentage of service imports has a marginally significant negative coefficient (-54.611, $p = 0.056$), suggesting that reliance on imported travel services may slightly hinder GDP per capita, possibly due to capital outflows. Travel services as a percentage of service exports and international tourist arrivals do not show

statistically significant relationships with GDP per capita, suggesting that these factors have minimal influence in this model.

Table 16. Model Coefficients - GDP per capita (current US$)

Predictor	Estimate	SE	t	p
Intercept [a]	-20742.242	2054.4	-10.0965	< .001
Travel services (% of service imports, BoP)	-54.611	28.4	-1.9228	0.056
Travel services (% of service exports, BoP)	0.940	13.2	0.0713	0.943
International tourism, number of arrivals	-1.48e−6	1.05e-6	-1.4058	0.161
Employment in services (% of total employment) (modeled ILO estimate)	674.393	49.2	13.7182	< .001
Region:				
Africa Eastern and Southern – Sub-Saharan Africa	2945.443	744.9	3.9543	< .001
Africa Western and Central – Sub-Saharan Africa	-4147.306	786.7	-5.2721	< .001
Caribbean small states – Sub-Saharan Africa	-14284.720	1878.8	-7.6032	< .001
Central Europe and the Baltics – Sub-Saharan Africa	-2617.875	1319.4	-1.9841	0.048
East Asia & Pacific – Sub-Saharan Africa	2764.617	891.3	3.1017	0.002
Europe & Central Asia – Sub-Saharan Africa	2115.457	1833.4	1.1539	0.250
European Union – Sub-Saharan Africa	8591.904	1903.7	4.5132	< .001
Latin America & Caribbean – Sub-Saharan Africa	-12597.918	1626.4	-7.7460	< .001
Middle East & North Africa – Sub-Saharan Africa	-9266.779	1275.6	-7.2645	< .001
[a] Represents reference level				

Regional comparisons reveal significant differences in GDP per capita between the regions compared to Sub-Saharan Africa. For example, Africa Eastern and Southern and East Asia and the Pacific have significantly higher GDP per capita (coefficients = 2945.443 and 2764.617, respectively, $p < 0.001$ and $p = 0.002$), while Africa Western and Central, Small Caribbean States, Latin America and the Caribbean, and the Middle East and North Africa have significantly lower GDP per capita (coefficients = -4147.306, -14284.720, -12597.918, and -9266.779, respectively, $p < 0.001$). The European Union also has a significantly higher GDP per capita than Sub-Saharan Africa (coefficient = 8591.904, $p < .001$), reflecting its advanced economic development. Central Europe and the Baltics, on the other hand, have only slightly lower GDP per capita than Sub-Saharan Africa (coefficient = -2617.875, $p = 0.048$). These regional differences highlight the uneven distribution of economic development and the challenges that less developed regions face in achieving higher income levels.

The analysis underscores the critical role of services employment in driving GDP per capita, and highlights the importance of economic diversification and the transition to service-oriented economies. For developing regions, such as Sub-Saharan Africa, promoting employment opportunities in high-value service sectors could be a key strategy for boosting economic growth. In addition, the marginally significant negative relationship between travel services as a share of service imports and GDP per capita suggests that reducing reliance on imported travel services and developing domestic tourism industries could help retain economic value within countries. Wealthier regions, such as the European Union and East Asia and the Pacific, should continue to innovate and invest in sustainable economic practices to maintain their competitive advantage. Overall, the findings highlight the need for region-specific strategies to address disparities and promote inclusive economic growth, ensuring that all regions can capitalize on their unique strengths while addressing their specific challenges.

5. DISCUSSION

The results of the study provide a comprehensive understanding of the relationships between economic, environmental, and technological variables across regions. These insights are critical for policymakers and stakeholders seeking to promote sustainable development and address regional disparities. The study reveals significant patterns and relationships that have both theoretical and practical implications, providing a roadmap for region-specific strategies to promote inclusive growth and sustainability.

The correlation analysis highlighted several important relationships. In particular, the weak and statistically insignificant correlation between forest cover and renewable energy consumption suggests that forest-rich countries do not inherently prioritize the adoption of renewable energy. This challenges the assumption that natural resource endowments automatically drive sustainable practices and underscores the need for targeted policies to incentivize renewable energy use. The strong positive correlation between FDI and GDP per capita is consistent with economic theories such as endogenous growth theory, which emphasize the role of foreign investment in raising productivity and income levels through capital infusion, technology transfer, and improved human capital. Similarly, the positive relationship between services employment and GDP per capita reflects the structural transformation of economies as higher-income countries shift from agriculture and industry to service-oriented sectors. This supports the structural change hypothesis, which posits that economic development is characterized by a shift from primary industries to services and technology-driven sectors.

The negative correlations between renewable energy consumption and GDP per capita, as well as employment in services, suggest that wealthier, service-oriented economies may still rely heavily on non-renewable energy sources. This finding is consistent with the environmental Kuznets curve hypothesis, which suggests that environmental sustainability does not automatically improve with economic growth, but requires deliberate policy interventions. Technology adoption, as measured by mobile phone subscriptions, was positively associated with GDP per capita and service sector employment, highlighting the role of digital infrastructure in economic transformation. In addition, international tourism arrivals were strongly correlated with FDI and GDP per capita, suggesting that investment in infrastructure and economic stability play a critical role in attracting tourists. However, the negative correlation between travel services (% of service exports) and GDP per capita suggests that as countries develop, they diversify their economies away from dependence on tourism.

The ANOVA results revealed significant regional differences across all variables, reflecting the impact of geographic and economic factors on environmental, economic and technological indicators. For example, the Caribbean small states have the highest forest cover, while the Middle East and North Africa have the lowest. This stark contrast highlights the need for region-specific conservation strategies. Similarly, sub-Saharan Africa and West and Central Africa have the highest consumption of renewable energy, likely due to limited access to non-renewable energy sources, while the Middle East and Europe and Central Asia have the lowest, reflecting their dependence on fossil fuels. This disparity underscores the need for wealthier regions to transition to renewable energy to meet sustainability goals.

The economic divide between developed and developing regions is evident in GDP per capita, with the European Union and Europe and Central Asia dominating and Sub-Saharan Africa and the Caribbean lagging behind. This highlights the challenges that developing regions face in achieving higher income levels and the need for targeted investment in infrastructure and technology. Employment in services follows a similar pattern, with small Caribbean states and the European Union leading the way, while sub-Saharan Africa and Africa Eastern and Southern lag behind. This reflects the structural transformation of economies and the need for developing regions to promote service-oriented sectors. The digital divide is also pronounced, with Europe and Central Asia and the European Union having the highest mobile phone subscriptions , and Sub-Saharan Africa and Africa Eastern and Southern having the lowest. This underscores the importance of investing in technology infrastructure to bridge gaps in access and connectivity.

The regression models provided deeper insights into the drivers of international tourism arrivals and GDP per capita, providing actionable recommendations for policymakers. For international tourism arrivals, the regression model explained 76.9% of the variance, with FDI emerging as the most significant predictor. This highlights the critical role of FDI in developing tourism infrastructure and promoting international travel. Renewable energy consumption also had a positive and statistically significant impact, suggesting that countries with higher renewable energy use are more attractive to tourists, likely due to the growing preference for sustainable tourism destinations. Regional differences were pronounced, with Europe and Central Asia and the European Union having significantly higher tourist arrivals than Sub-Saharan Africa. This reflects the well-developed tourism infrastructure and economic stability in these regions. Developing regions, such as sub-Saharan Africa, should focus on attracting foreign direct investment to improve tourism infrastructure and promote sustainable practices. Wealthier regions should continue to invest in sustainability to maintain their competitive advantage in the global tourism market.

For GDP per capita, the regression model showed an exceptionally good fit, explaining 94.3% of the variance. Employment in services was the most significant predictor, underscoring the economic benefits of transitioning to a service-oriented economy. Travel services as a percentage of service imports had a marginally significant negative coefficient, suggesting that reliance on imported travel services may be somewhat detrimental to GDP per capita, possibly due to capital outflows. Regional disparities were evident, with the European Union and East Asia and the Pacific having significantly higher GDP per capita than Sub-Saharan Africa. In contrast, regions such as West and Central Africa, small Caribbean states and Latin America and the Caribbean had significantly lower GDP per capita. Developing regions should promote employment in high-value service sectors to drive economic growth. Reducing dependence on imported travel services and developing domestic tourism industries could also help retain economic value within countries.

5.1 Comparative Analysis with Existing Literature

The findings of this study are consistent with and extend existing research on sustainable development, tourism, and economic growth. For example, the role of FDI in driving economic growth and tourism infrastructure development is well documented (Sokhanvar & Jenkins, 2022; Fauzel, 2021). Similarly, the structural transformation of economies from agriculture to services is a key theme in the literature (Ekeocha et al., 2021; Rasool et al.,

2021). The study's emphasis on the need for targeted policies to promote renewable energy adoption and bridge regional disparities resonates with the environmental Kuznets curve hypothesis and the broader sustainable development discourse (Anwar et al., 2022; Leal & Marques, 2022).

The study also contributes to the growing body of research on the bidirectional relationship between tourism and economic growth (Pulido-Fernández et al., 2021; Pata, 2021). The findings suggest that while tourism can drive economic development, it also benefits from higher levels of economic development, particularly in regions with well-developed infrastructure and economic stability. This underscores the importance of aligning tourism strategies with broader economic and environmental goals to maximize long-term benefits.

5.2 Theoretical and Practical Implications

The results have important theoretical and practical implications. From a theoretical perspective, the results are consistent with several economic and development theories. The positive correlation between FDI and GDP per capita supports endogenous growth theory, which emphasizes the role of investment in human capital and technology as key drivers of long-term economic growth. The observed structural transformation in wealthier economies, as reflected in the strong relationship between services employment and GDP per capita, supports the structural change hypothesis, which posits that economic development is characterized by a shift from primary industries to services and technology-driven sectors. The negative correlation between renewable energy consumption and GDP per capita challenges traditional assumptions about the sustainability of high-income economies and is consistent with the environmental Kuznets curve hypothesis, which suggests that environmental sustainability does not automatically improve with economic growth, but requires deliberate policy interventions.

From a practical perspective, the findings highlight the importance of targeted policies to address regional disparities and promote sustainable development. Wealthier regions, such as Europe and Central Asia and the European Union, should focus on increasing renewable energy consumption and investing in sustainable economic practices to achieve sustainability goals. Developing regions, such as sub-Saharan Africa and the Caribbean, need targeted investments in infrastructure, technology and tourism to stimulate economic growth. The Middle East and North Africa should prioritize environmental protection and economic diversification to reduce dependence on non-renewable resources. Overall, the analysis underscores the importance of tailored strategies to ensure that each region can capitalize on its unique strengths while addressing its specific challenges, thereby promoting a fairer and more sustainable global economy.

5.3 Region-Specific Recommendations

Sub-Saharan Africa: The region's low GDP per capita and employment in services reflect the challenges of transitioning from agricultural to service-oriented economies. To address this, policymakers should promote economic diversification by investing in high-value service sectors and improving access to digital infrastructure. Attracting foreign direct investment to develop tourism infrastructure and promote sustainable practices can also help increase international tourist arrivals and boost economic growth.

Caribbean Small States: The region's high forest cover and service sector employment reflect a focus on conservation and service-oriented economies. Leveraging natural attractions to promote ecotourism and sustainable tourism practices can spur economic growth. In addition, investments in renewable energy can reduce dependence on non-renewable energy sources and promote sustainable development.

Middle East and North Africa: The region's low levels of forest cover and renewable energy consumption reflect its reliance on fossil fuels and arid climate. Prioritizing environmental protection and economic diversification can reduce dependence on non-renewable resources. Investing in renewable energy technologies, such as solar and wind power, can promote sustainable development and align with global sustainability goals.

Europe and Central Asia: The region's high GDP per capita and tourist arrivals reflect its advanced economic development and well-developed tourism infrastructure. To maintain its competitive advantage, the region should continue to invest in sustainability and innovation. Promoting the use of renewable energy and sustainable tourism practices can help achieve sustainability goals and attract environmentally conscious tourists.

European Union: The region's high GDP per capita and employment in services reflect its advanced economic development and structural transformation. Focusing on increasing renewable energy consumption and investing in sustainable economic practices can help maintain its competitive advantage. Continued innovation in technology and services will also be crucial for long-term growth.

East Asia and the Pacific: The region's high GDP per capita and tourist arrivals reflect its economic development and well-developed tourism infrastructure. Promoting sustainable tourism practices and investing in renewable energy technologies can enhance the region's attractiveness to international tourists and support sustainable development.

Latin America and the Caribbean: The region's low GDP per capita and tourism arrivals reflect economic development challenges and underdeveloped tourism infrastructure. Attracting foreign direct investment to develop tourism infrastructure and promote sustainable practices can increase international tourist arrivals. In addition, promoting economic diversification by investing in high-value service sectors can foster inclusive growth.

Central Europe and the Baltic States: The region's moderate GDP per capita and relatively high mobile penetration suggest a balanced economic structure. However, further investment in renewable energy and digital infrastructure can improve its competitiveness. Policies should focus on promoting innovation and sustainable practices to maintain economic stability.

Africa Eastern and Southern: The region's low GDP per capita and employment in services highlight the need for economic diversification. Investments in education, digital infrastructure and high-value services can drive growth. In addition, promoting renewable energy and sustainable tourism can improve economic and environmental outcomes.

Africa Western and Central: The region's reliance on renewable energy and low GDP per capita suggest untapped potential for economic growth. Policies should focus on improving infrastructure, attracting foreign direct investment, and promoting sustainable tourism to drive development.

6. CONCLUSION

This study provides a comprehensive analysis of the complex relationships between economic growth, environmental sustainability, technological advancement and tourism in different regions of the world. Examining data from 2000 to 2023, the study highlights significant regional disparities and underscores the need for tailored policies to address unique challenges while promoting inclusive and sustainable development. The findings reveal several key patterns and offer actionable insights for policymakers, underscoring the importance of balancing economic progress with environmental protection and technological innovation.

One of the key findings is the bidirectional relationship between tourism and economic growth. Tourism serves as a critical driver of economic development, particularly in developing regions, by creating jobs, generating income and attracting foreign direct investment (FDI). At the same time, tourism benefits from higher levels of economic growth, as wealthier regions with robust infrastructure and economic stability are better positioned to attract international tourists. This reciprocal relationship highlights the importance of aligning tourism strategies with broader economic and environmental goals. For example, foreign direct investment is a key factor in developing tourism infrastructure, which in turn boosts international tourist arrivals and economic growth. Similarly, renewable energy consumption has a positive impact on tourism, reflecting the growing global preference for sustainable destinations. These findings suggest that developing regions, such as sub-Saharan Africa and small Caribbean states, should focus on attracting FDI and promoting sustainable practices to strengthen their tourism sectors and drive economic growth.

The study also sheds light on the environmental dimensions of economic development. The weak correlation between forest cover and renewable energy consumption challenges the assumption that natural resource endowments automatically drive sustainable practices. Instead, the results suggest that targeted policy interventions are needed to incentivize the adoption of renewable energy, particularly in wealthier regions that still rely heavily on non-renewable energy sources. This is consistent with the Environmental Kuznets Curve (EKC) hypothesis, which posits that environmental sustainability does not automatically improve with economic growth, but requires targeted efforts to balance economic progress with environmental protection. Wealthier regions, such as the European Union and Europe and Central Asia, should prioritize increasing renewable energy consumption and investing in sustainable economic practices to achieve global sustainability goals.

Technological advances, particularly in digital infrastructure, play a critical role in economic transformation and sustainable development. The study finds that mobile phone subscriptions is positively correlated with GDP per capita and service sector employment, highlighting the importance of digital connectivity in driving economic growth. However, technology adoption alone does not have a significant impact on tourism arrivals, suggesting that other factors such as infrastructure and economic stability are more critical in attracting tourists. This underscores the need for developing regions to invest in both technology infrastructure and broader economic development to bridge the digital divide and promote inclusive growth.

The regional disparities identified in the study further emphasize the importance of region-specific strategies to address unique challenges and leverage strengths. For example:

- **Sub-Saharan Africa** faces significant challenges in transitioning from agricultural to service-oriented economies, necessitating investments in education, digital infrastructure, and high-value service sectors.
- The **Caribbean Small States**, with their high forest cover and service-oriented economies, should focus on promoting ecotourism and sustainable tourism practices to drive economic growth.
- The **Middle East and North Africa** must prioritize environmental protection and economic diversification to reduce dependence on fossil fuels and promote renewable energy technologies.
- **Europe and Central Asia** and the **European Union**, with their advanced economies and well-developed tourism infrastructure, should continue to innovate and invest in sustainability to maintain their competitive advantages in the global tourism market.
- **East Asia and the Pacific** should leverage their economic development and tourism infrastructure to promote sustainable tourism practices and invest in renewable energy technologies.
- **Latin America and the Caribbean** need to attract FDI to develop tourism infrastructure and promote sustainable practices while reducing reliance on imported travel services.
- **Central Europe and the Baltic States**, with their moderate GDP per capita and relatively high mobile penetration, should focus on promoting innovation and sustainable practices to maintain economic stability.
- **Africa Eastern and Southern** and **Africa Western and Central** should prioritize investments in education, digital infrastructure, and renewable energy to drive economic growth and reduce reliance on non-renewable resources.

The study provides actionable recommendations for policymakers. For example, FDI and renewable energy consumption emerge as important drivers of tourism growth, suggesting that regions should focus on attracting foreign investment to improve tourism infrastructure and adopt sustainable practices. Similarly, employment in services is identified as a key predictor of GDP per capita, highlighting the importance of promoting service-oriented sectors to stimulate economic growth. These findings are consistent with the existing literature on sustainable development, tourism and economic growth, confirming the importance of FDI in driving infrastructure development and tourism, the structural transformation of economies towards services, and the need for targeted policies to bridge regional disparities in renewable energy adoption and technology access.

In conclusion, this study highlights the importance of region-specific strategies to promote sustainable development. While wealthier regions should continue to invest in renewable energy and innovation, developing regions need to prioritize infrastructure, technology and economic diversification to promote inclusive growth. By addressing these regional differences and promoting tailored policies, countries can better position themselves to meet sustainability goals and ensure long-term economic resilience. The findings provide a roadmap for policymakers to design policies that foster economic transformation, reduce environmental degradation, and bridge regional disparities, ultimately ensuring a more

equitable and sustainable future for all regions, including Central Europe and the Baltic States, Africa Eastern and Southern , and Africa Western and Central

REFERENCES

Agyeman, F. O., Zhiqiang, M., Li, M., Sampene, A. K., Dapaah, M. F., Kedjanyi, E. A. G., ... & Heydari, M. (2022). Probing the effect of governance of tourism development, economic growth, and foreign direct investment on carbon dioxide emissions in Africa: The African experience. *Energies*, *15*(13), 4530. https://doi.org/10.3390/en15134530

Ahmad, M., Muslija, A., & Satrovic, E. (2021). Does economic prosperity lead to environmental sustainability in developing economies? Environmental Kuznets curve theory. *Environmental Science and Pollution Research*, *28*(18), 22588-22601.

Akcigit, U., & Ates, S. T. (2021). Ten facts on declining business dynamism and lessons from endogenous growth theory. *American Economic Journal: Macroeconomics*, *13*(1), 257-298.

Alcalá-Ordóñez, A., & Segarra, V. (2025). Tourism and economic development: A literature review to highlight main empirical findings. *Tourism Economics*, *31*(1), 76-103. https://doi.org/10.1177/13548166231219638

Anwar, M. A., Zhang, Q., Asmi, F., Hussain, N., Plantinga, A., Zafar, M. W., & Sinha, A. (2022). Global perspectives on environmental Kuznets curve: A bibliometric review. *Gondwana Research*, *103*, 135-145. https://doi.org/10.1016/j.gr.2021.11.010

Aschenbrand, E., & Michler, T. (2022). Exploring connections between tourism and forest conservation. In *Wald in der Vielfalt möglicher Perspektiven: Von der Pluralität lebensweltlicher Bezüge und wissenschaftlicher Thematisierungen* (pp. 257-277). Wiesbaden: Springer Fachmedien Wiesbaden.

Bamati, N., & Raoofi, A. (2020). Development level and the impact of technological factor on renewable energy production. *Renewable Energy*, *151*, 946-955. https://doi.org/10.1016/j.renene.2019.11.098

De Siano, R., & Canale, R. R. (2022). Controversial effects of tourism on economic growth: A spatial analysis on Italian provincial data. *Land Use Policy*, *117*, 106081. https://doi.org/10.1016/j.landusepol.2022.106081

Ekeocha, D. O., Ogbuabor, J. E., Orji, A., & Kalu, U. I. (2021). International tourism and economic growth in Africa: A post-global financial crisis analysis. *Tourism Management Perspectives*, *40*, 100896. https://doi.org/10.1016/j.tmp.2021.100896

El Menyari, Y. (2021). Effect of tourism FDI and international tourism to the economic growth in Morocco: Evidence from ARDL bound testing approach. *Journal of Policy Research in Tourism, Leisure and Events*, *13*(2), 222-242. https://doi.org/10.1080/19407963.2020.1771567

Enilov, M., & Wang, Y. (2022). Tourism and economic growth: Multi-country evidence from mixed-frequency Granger causality tests. *Tourism Economics*, *28*(5), 1216-1239. https://doi.org/10.1177/1354816621990155

Fauzel, S. (2021). FDI and tourism futures: a dynamic investigation for a panel of small island economies. *Journal of Tourism Futures*, *7*(1), 98-110. https://doi.org/10.1108/JTF-05-2018-0026

Ghosh, T., & Parab, P. M. (2021). Assessing India's productivity trends and endogenous growth: New evidence from technology, human capital and foreign direct investment. *Economic Modelling*, *97*, 182-195. https://doi.org/10.1016/j.econmod.2021.02.003

Hajam, A. G., Perween, S., & Malik, M. A. (2023). Re-visiting the causal relationship between tourism and economic growth in India: specific to general modelling approach. *Journal of Hospitality and Tourism Insights*, *7*(1), 95-120. https://doi.org/10.1108/JHTI-09-2022-0459

Kurowska, E. E., Czerniak, A., & Bańkowski, J. (2023). The rationale for restoration of abandoned quarries in forests of the Ślęża Massif (Poland) in the context of sustainable tourism and forest environment protection. *Forests*, *14*(7), 1386. https://doi.org/10.3390/f14071386

Leal, P. H., & Marques, A. C. (2022). The evolution of the environmental Kuznets curve hypothesis assessment: A literature review under a critical analysis perspective. *Heliyon*, *8*(11).

León-Gómez, A., Ruiz-Palomo, D., Fernández-Gámez, M. A., & García-Revilla, M. R. (2021). Sustainable tourism development and economic growth: Bibliometric review and analysis. *Sustainability*, *13*(4), 2270. https://doi.org/10.3390/su13042270

Mahmood, H., Furqan, M., Hassan, M. S., & Rej, S. (2023). The environmental Kuznets Curve (EKC) hypothesis in China: A review. *Sustainability*, *15*(7), 6110. https://doi.org/10.3390/su15076110

Mihardja, E. J., Alisjahbana, S., Agustini, P. M., Sari, D. A. P., & Pardede, T. S. (2023). Forest wellness tourism destination branding for supporting disaster mitigation: A case of Batur UNESCO Global Geopark, Bali. *International Journal of Geoheritage and Parks*, *11*(1), 169-181. https://doi.org/10.1016/j.ijgeop.2023.01.003

Mohammed, S., Gill, A. R., Ghosal, K., Al-Dalahmeh, M., Alsafadi, K., Szabó, S., ... & Harsanyi, E. (2024). Assessment of the environmental kuznets curve within EU-27: Steps toward environmental sustainability (1990–2019). *Environmental Science and Ecotechnology*, *18*, 100312. https://doi.org/10.1016/j.ese.2023.100312

Munanura, I. E., & Kline, J. D. (2023). Residents' support for tourism: The role of tourism impact attitudes, forest value orientations, and quality of life in Oregon, United States. *Tourism Planning & Development*, *20*(4), 566-582. https://doi.org/10.1080/21568316.2021.2012713

Naseem, S. (2021). The role of tourism in economic growth: Empirical evidence from Saudi Arabia. *Economies*, *9*(3), 117. https://doi.org/10.3390/economies9030117

Osinubi, T. T., Ajide, F. M., & Osinubi, O. B. (2022). Governance, FDI and tourism in top 10 tourist destinations in Africa. *Transnational Corporations Review*, *14*(2), 140-152. https://doi.org/10.1080/19186444.2022.2040345

Pata, U. K. (2021). Tourism and economic growth in g10 countries: Evidence from an asymmetric panel causality test. *Tourism: An International Interdisciplinary Journal*, *69*(1), 112-126. https://doi.org/10.37741/t.69.1.8

Pulido-Fernández, J. I., & Cárdenas-García, P. J. (2021). Analyzing the bidirectional relationship between tourism growth and economic development. *Journal of Travel Research*, *60*(3), 583-602. https://doi.org/10.1177/0047287520922316

Raifu, I. A. (2024). Is the tourism-led-growth hypothesis valid in the presence of structural breaks? Evidence from DKW's panel structural break method. *Tourism: An International Interdisciplinary Journal*, *72*(2), 270-274.

Raihan, A., Pavel, M. I., Muhtasim, D. A., Farhana, S., Faruk, O., & Paul, A. (2023). The role of renewable energy use, technological innovation, and forest cover toward green development: Evidence from Indonesia. *Innovation and Green Development*, *2*(1), 100035. https://doi.org/10.1016/j.igd.2023.100035

Rasool, H., Maqbool, S., & Tarique, M. (2021). The relationship between tourism and economic growth among BRICS countries: a panel cointegration analysis. *Future Business Journal*, *7*(1), 1.

Sætren, G. B., Hogenboom, S., & Laumann, K. (2016). A study of a technological development process: Human factors—the forgotten factors?. *Cognition, Technology & Work*, *18*, 595-611.

Sheng Yin, X., & Hussain, J. (2021). The implication of technological innovation and tourism development on FDI-growth-environment nexus in Association of Southeast Asian countries: a simultaneity modeling analysis. *Energy Sources, Part B: Economics, Planning, and Policy*, *16*(9), 878-902. https://doi.org/10.1080/15567249.2021.1971801

Sokhanvar, A. (2022). The role of tourism and FDI in the economic growth of EU11 countries. *Tourism and hospitality management*, *28*(2), 343-359. https://doi.org/10.20867/thm.28.2.5

Sokhanvar, A., & Jenkins, G. P. (2022). FDI, tourism, and accelerating the rate of economic growth in Spain. *The Journal of International Trade & Economic Development*, *31*(4), 493-510. https://doi.org/10.1080/09638199.2021.1988135

Sokhanvar, A., & Jenkins, G. P. (2022). Impact of foreign direct investment and international tourism on long-run economic growth of Estonia. *Journal of Economic Studies*, *49*(2), 364-378. https://doi.org/10.1108/JES-11-2020-0543

Sou, J. P. U., & Vinnicombe, T. (2023). Does governance quality matter for FDI-led tourism development? A supply-side perspective. *Tourism Economics*, *29*(2), 392-408. https://doi.org/10.1177/1354816621105281

Vazquez Vicente, G., Martín Barroso, V., & Blanco Jimenez, F. J. (2021). Sustainable tourism, economic growth and employment—The case of the wine routes of Spain. *Sustainability*, *13*(13), 7164. https://doi.org/10.3390/su13137164

Yangailo, T. (2025). The Challenges of Tourism Growth in Eastern and Southern African Countries. *Journal of Tourism and Heritage Research*, *8*(1), 45-58.

Yuan, F., & Zhang, P. (2024). Are natural resources, sustainable growth and entrepreneurship matter endogenous growth theory? The strategic role of technical progress. *Resources Policy*, *96*, 105189. https://doi.org/10.1016/j.resourpol.2024.105189

Zhang, J. (2021). Environmental Kuznets curve hypothesis on CO2 emissions: evidence for China. *Journal of Risk and Financial Management*, *14*(3), 93. https://doi.org/10.3390/jrfm14030093

Zhang, J., Lyu, Y., Li, Y., & Geng, Y. (2022). Digital economy: An innovation driving factor for low-carbon development. *Environmental Impact Assessment Review*, *96*, 106821. https://doi.org/10.1016/j.eiar.2022.106821

Zhang, L., Wu, C., & Hao, Y. (2022). Effect of the development level of facilities for forest tourism on tourists' willingness to visit urban forest parks. *Forests*, *13*(7), 1005. https://doi.org/10.3390/f13071005

Zhuang, Y., Yang, S., Razzaq, A., & Khan, Z. (2022). Environmental impact of infrastructure-led Chinese outward FDI, tourism development and technology innovation: a regional country analysis. *Journal of Environmental Planning and Management*, *66*(2), 367-399. https://doi.org/10.1080/09640568.2021.1989672