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Research article

Economic and environmental effects of sustainable tourism development: A meta-analysis

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ABSTRACT

Sustainable tourism development can influence growth together with environmental sustainability. However, existing studies report both positive and negative effect in direction and magnitude, which needed to generalized. For reporting generalized result through meta-analysis approach the results of 23 empirical studies derived from the Web of Science and Scopus databases that examine the relationship between sustainable tourism development with economy and environment outcomes were used. The results reveled that sustainable tourism positively enhances both economy and environment. Moreover, location of country and destination type significantly moderated the effect of sustainable tourism on economy whereas only location of country moderated the effect of sustainable tourism on environmental sustainability. The rest of the moderators such as sample size, development level, research period did not significantly influence the effect. In sum, this meta-analysis provided the generalized, robust and reliable effect and direction of sustainable tourism on economic and environmental factors. It also provides practical and theoretical implication for future research.

KEYWORDS

Sustainable tourism; economy; environment; meta-analysis; moderators

Introduction

Sustainable tourism is a multifaceted approach that balances economic growth together with environment conservation. Sustainable tourism fosters economic growth by generating revenue, creating jobs, and promoting local economies. For instance, destinations with sustainable tourism certifications experience a 20% increase in per capita tourist expenditure, highlighting the economic benefits of adopting sustainable practices (Xing, 2024). Similarly, sustainable tourism practices in Indonesia empowered local communities by creating jobs and fostering entrepreneurship (Vachhani, 2024). Additionally, in regions like Bali, Indonesia, sustainable tourism management was instrumental in ensuring that economic benefits are distributed equitably among local communities, thereby reducing poverty and improving living standards(Laksmi et al., 2024). Sustainable tourism contributes to long-term economic resilience by diversifying income sources, creating jobs and promoting rural livelihood. Similarly, the environmental dimension of sustainable tourism is important as it focus on sustainable tourism practices that target to reduce carbon footprints, conserve biodiversity, and promote eco-friendly infrastructure. For instance, adopting low-carbon transportation and energy-efficient accommodations as a sustainable tourism measure can lead to a 40% reduction in CO_2 emissions together with improved biodiversity indices by 25% through conservation efforts (Xing, 2024). Additionally, sustainable tourism assists to maintain ecological balance and support biodiversity by promoting and preserving the natural and cultural heritage (Sofronov, 2017). However, sustainable tourism faces several challenges such as overexploitation of natural resources and environmental degradation. For instance, in one unit increase in tourism, 0.26 unit increase in CO_2 emissions in the long run was illustrated in one of the study investigating the environmental impacts of tourism in Pakistan (Khan et al., 2020). This shows both positive and negative effect of sustainable tourism in environment.

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Additionally, Obradovic & Stojanovic (2022) illustrates that local communities have a positive attitude toward sustainable tourism development and tourism have the positive impact in economy and negative impact on environment. Similarly, Bhat & Mishra (2021) concluded that the high-income class have the positive attitude towards economic benefits and environmental costs as a result of sustainable tourism development. Frleta & Smolcic (2020) explored that respondent understand the extent of the economic and environmental impacts of tourism however there was statistically significant difference in the perception of different groups such as people employed in tourism, not employed in tourism and other than these two. Furthermore, Andrasari et al. (2024) found that while tourism significantly enhances economic growth in high-income countries, its impact on middle-income countries is relatively modest. Overall, these findings illustrate the variation in the relation of sustainable tourism to economy and environmental factors in terms of both intensity and direction. Therefore, the problem is how the sustainable tourism development affected by economic, and environmental factor in general. More importantly, what influence the relationship between these factors? In these regards, this study aims to quantitively summarize and review the existing literature that illustrates influence of sustainable tourism development to economic and environmental factor through meta-analytic approach so as to draw the general conclusion and test the moderators affecting their relations.

Literature review

Meta-analysis is used to generalize the findings and results of different study with similar dependent and independent variables. Additionally, it helps to identify the effect of potential moderators that influences outcomes (Gössling & Hall, 2019). Here, meta-analysis is effective tool to find the complex relationship and intensity between sustainable tourism, economic and environment effect.

Economic impact on sustainable tourism

Sustainable tourism has generally positive impact in economy, contributing to job creation, GDP growth and infrastructure development but intensity varies across different contexts (UNWTO, 2020). In contexts of developing countries, sustainable tourism is considered as major actor of employment and investment (Brida et al., 2020). Similarly, in countries with strong institutional framework and diversified economy, the effect size of tourism on GDP was higher (Sharpley, 2021). However, higher dependency in tourism can create economic instability due to volatility of tourism demand (Hall, 2020). Additionally, lack of good economic governance effect the overall economic sustainability of tourism which results the more benefit to external stakeholders rather than local communities (Brida et al., 2020). Further, for local communities such as homestay programs and nature-based tourism have enabled residents to benefit directly from tourism activities especially in rural areas that led to increased economic resilience and reduced outmigration (Ginanjar, 2023). Furthermore, studies reports illustrate that sustainable tourism contributes to inclusive economic development by empowering marginalized groups, particularly women and youth by engaging local people in tourism planning and operations and by providing greater economic participation and capacity building (Aqilah & Islam, 2024; Shamsoddini & Dehghani, 2023).Despite positive effect of sustainable tourism on economy there exists demerits too. The dominance of landowners, people with capital and political connections can benefit more leaving vulnerable group behind thus creating unequal distribution of income and benefits which may create social tension and reduce local people's trust on fairness of tourism development (Y. Wang & Tziamalis, 2023). Additionally, the seasonal nature of tourism can lead to yearly imbalance on income, employment opportunity and other economic activities which consequently effect the sustainability of livelihood of people depending on tourism (Rahman & Baddam, 2021). Sustainable tourism presents both opportunities and challenges for economic development. Several bodies of literatures illustrate the positive effect of sustainable tourism on economy, while some revels the negative effects. Demirović Bajrami et al. (2020), Stylidis et al. (2014), Aishah Zakaria et al. (2024), Hsu et al. (2020) and Uslu et al. (2020) are some studies that revels the positive effect of tourism on economy. Uslu et al. (2023), Baloch et al. (2023) and Nordin et al. (2020) illustrates the negative effect of tourism on economy. Due to this variation on effect size the meta-analysis was needed for generalization of results. These literatures imply the following hypothesis:

Hypothesis 1: There exists positive relationship between sustainable tourism and economic factors.

Environmental impact of sustainable tourism

Further, the environmental impact of sustainable tourism is highly debated, as it depends on the intensity of tourism activities and the regulatory environment. A study of environmental sustainability in tourism found that destinations with stringent environmental policies experience lower rates of biodiversity loss and

pollution (Weaver, 2020). Conversely, mass tourism without adequate environmental controls leads to habitat destruction, increased carbon emissions, deforestation, disruption of wildlife and resource depletion (Buckley, 2021; Mushkudiani et al., 2023). The effect direction was often negative in high-intensity tourism regions but can be mitigated by sustainability initiatives such as eco-certification programs and green infrastructure (Hall & Lew, 2019). Studies also indicated that technological innovations in tourism, such as smart energy management and waste reduction practices, can enhance environmental sustainability (Gössling, 2020). Similarly, body of literatures highlighted how sustainable tourism contribute to biodiversity preservation, protection of natural resources, and improved waste and water management (Kumar et al., 2023; PATIL & Pattanshetti, 2024). Local communities, when engaged in tourism planning and operations, often act as caretaker of the environment, ensuring that natural assets are preserved for both ecological and economic purposes (Xing, 2024). Similarly, the tourism lead economic growth shows significant increase in carbon emission which negatively affect environment (Lee & Brahmasrene, 2016). Sustainable tourism can be the engine for environment protection while developing by mitigating the negative effect of environment through community awareness, engagement and technological intervention. Studies illustrated both positive and negative effects of sustainable tourism on the environment. Demirović Bajrami et al. (2020), Stylidis et al. (2014), Hsu et al. (2020), Hassan et al. (2022), and Thi Thanh Nguyen et al. (2024) shows the positive effect of sustainable tourism development on environment. However, Baloch et al. (2023), Truong et al. (2020), Vu et al. (2020), and Lee & Brahmasrene (2016) shows the negative effect of sustainable tourism on environment. Further, Nordin et al. (2020), Qiu et al. (2018), and Bhat & Mishra (2021) shows both positive and negative relationships. These variations of effects found in different literatures imply the following hypothesis:

Hypothesis 2: There exists positive relationship between sustainable tourism and environmental factors.

Potential moderators

In Meta-analysis, the moderators explain their influence in relationships between dependent and independent variables, i.e. sustainable tourism and its economic, and environmental outcomes. Study period can be one potential moderator since it can explain weather changes in awareness and enriched regulatory measures with time moderates the effect of sustainable development with economy and environment or not (Sharpley, 2021). Similarly, sample size may moderate the effect between variables. Study with larger sample sizes generally generate more reliable results whereas small sample size may overestimate tourism's economic benefits and underestimating its negative environmental effects (Brida et al., 2020). Likewise, the geographical context and economic status of country may moderate the effect by exploring stronger economic benefits but weaker environmental protection in developing countries whereas with more stringent regulatory framework developed countries shows mitigated negative environmental effects (UNEP, 2020). Similarly, the effect may vary as per the tourist destinations. Urban destinations may face over-tourism and cultural commodification, whereas rural destinations face infrastructure and local participation related challenges (Higham & Miller, 2020). Additionally, the effects of tourism one these sustainability parameters are context dependents (Del Chiappa et al., 2016; Hussain et al., 2015; Uslu et al., 2023). To define the context, the development level of country defined by UN and Human Development Index (HDI) were considered. Further, the commonly used moderators such as research time, sample size, tourism destination type and location of study by several studies were also considered (Gursoy et al., 2019; Zhang, 2021). These empirical studies result illustrated that the relationship between sustainable tourism and its economic and environmental dimensions were complex and moderated by various factors. These relations point toward the following hypothesis:

Hypothesis 3: Country economic status moderates the association between Tourism and economy
Hypothesis 4: Country economic status moderates the association between Tourism and environment
Hypothesis 5: The Human Development Index moderates the association between Tourism and economy
Hypothesis 6: The Human Development Index moderates the association between Tourism and environment
Hypothesis 7: Research time moderates the association between Tourism and economy
Hypothesis 8: Research time moderates the association between Tourism and environment
Hypothesis 9: Sample size moderates the association between Tourism and economy
Hypothesis 10: Sample size moderates the association between Tourism and Environment
Hypothesis 11: Research location moderates the relationship between Tourism and economy
Hypothesis 12: Research location moderates the relationship between Tourism and environment
Hypothesis 13: Tourism destination type moderates the association between Tourism and economy
Hypothesis 14: Tourism destination type moderates the association between Tourism and environment

Theoretical framework

Sustainable tourism development was essential for United Nations Sustainable Development Goals (SDGs) since, it emphasizes economic viability and environmental protection, aiming to mitigate the adverse effects of tourism while enhancing its benefits. For instance, sustainable tourism promotes employment of local communities and economic growth which aligns to goal 8 that states decent work and economic growth, sustainable consumption and production of goal 12 are some key aspects of SDGs that highlight the sustainable tourism development (United Nations, 2015). Similarly, Ecological Modernization Theory suggest that economic growth and environment protection can coexist, reveling the importance of sustainable tourism practice to avoid ecological damage which encourages to adopt environmental friendly practices and enhancing social awareness of tourism environmental impacts (Mol et al., 2013). Likewise, the complicated Adaptation System Theory advocated for balance development of tourism and environmental protection (Z. W. Wang, 2020). These theories underscore the effect of tourism development in environment and suggest to conserve environment in tourism destinations.

Conceptual framework

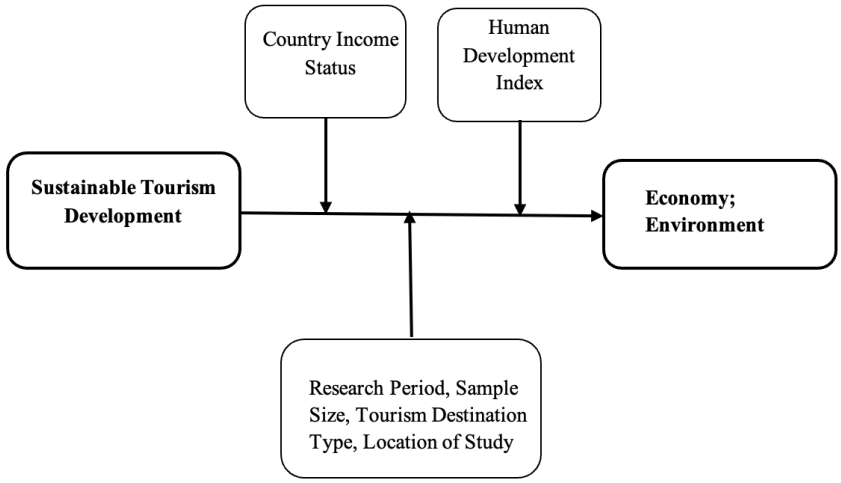

Figure 1 Conceptual framework

Methodology

To find the effect of sustainable tourism development on economy and environment, a meta-analysis approach was used where literature related to the related topics were selected from 1st January, 2015 to 23rd July, 2025 period of time. Studies listed in Google Scholar, Scopus and major search journal database such as ScienceDirect, Taylor and Francis, Sage, Springer, Wiley and others were used for meta-analysis purpose. The keywords used for search are “effect of tourism on economy”, “effect of tourism on environment” and “impact of tourism on economy and environment”.

Table 1 Details of studies collected for meta-analysis

S. N.	Citation	Title	Published Year	Journal	Quarter	Cited by	Statistical Method
1	(Baloch et al., 2023)	Impact of tourism development upon environmental sustainability: a suggested framework for sustainable ecotourism	2022	Environmental Science and Pollution Research	Q1	369	Linear Regression
2	(Uslu et al., 2023)	Determinants of Residents’ Support for Sustainable Tourism Development: An Empirical Study in Midyat, Turkey	2023	Sustainability	Q1	6	Structural Equation Modeling
3	(Demirović Bajrami et al., 2020)	Determinants of Residents’ Support for Sustainable Tourism Development: Implications for Rural Communities	2020	Sustainability	Q1	68	Least Square Regression
4	(Stylidis et al., 2014)	Residents' support for tourism development: The role of residents' place image and perceived tourism impacts	2014	Tourism Management	Q1	1054	Linear Regression
5	(Qiu et al., 2018)	Analyzing the Economic Sustainability of Tourism Development: Evidence from Hong Kong	2018	Journal of Hospitality & Tourism Research	Q1	53	ANOVA
6	(Truong et al., 2020)	Hierarchical Variance Analysis: A Quantitative Approach for Relevant Factor Exploration and Confirmation of Perceived Tourism Impacts	2020	International Journal of Environmental Research and Public Health	Q2	5	Linear Regression
7	(Aishah Zakaria et al., 2024)	Tourism development impacts, cultural intelligence and community support for future development	2023	Tourism and Hospitality Management	Q3	3	PLS-SEM
8	(Obradović & Stojanović, 2022)	Measuring residents’ attitude toward sustainable tourism development: a case study of the Gradac River gorge, Valjevo (Serbia)	2020	Tourism Recreation Research	Q1	26	ANOVA test and T Test

S. N.	Citation	Title	Published Year	Journal	Quarter	Cited by	Statistical Method
9	(Bhat & Mishra, 2021)	Demographic characteristics and residents' attitude towards tourism development: A case of Kashmir region	2020	Journal of Public Affairs	Q1	7	Multiple linear regressions
10	(Soldić Frleta & Smolčić Jurdana, 2020)	Insights into differences in residents' attitudes: Tourism impacts and support for future development	2019	Tourism	Q3	17	ANOVA; Regression Analysis
11	(VU et al., 2020)	Factors Affecting Sustainable Tourism Development in Ba Ria-Vung Tau, Vietnam	2020	Journal of Asian Finance, Economics and Business	Q2	38	Regression Analysis
12	(Hsu et al., 2020)	Measuring sustainable tourism attitude scale (SUS-TAS) in an Eastern island context	2019	Tourism Management Perspectives	Q1	66	CFA; Correlations
13	(Uslu et al., 2020)	Socio-cultural, Economic, and Environmental Effects of Tourism from the Point of View of the Local Community	2020	Journal of Tourism and Services	Q2	82	Structural Equation Modeling
14	(Nazirullah et al., 2023)	The Influence of Socio-Cultural and Economic Impact on Tourism Support: A Mediating Role of Community Value	2023	Planning Malaysia Journal	Q2	4	Structural Equation Modeling
15	(Hassan et al., 2022)	Impact of Rural Tourism Development on Residents' Satisfaction with the Local Environment, Socio-Economy and Quality of Life in Al-hsa Region, Saudi Arabia	2022	International Journal of Environmental Research and Public Health	Q2	49	Linear Regression
16	(Thi Thanh Nguyen et al., 2024)	How Responsible Tourism Behavioral Intentions Influence Tour Choices: Effects of Economic, Socio Cultural, and Environmental Responsibility	2022	International Journal of Hospitality & Tourism Administration	Q2	11	Structural Equation Modeling
17	(Lee & Brahmasrene, 2016)	Tourism effects on the environment and economic sustainability of sub-Saharan Africa	2015	International Journal of Sustainable Development and World Ecology	Q1	41	Panel Regression
18	(Nordin et al., 2020)	Impact of Tourism Development on the Quality of Life: A case study of Perhentian Island, Malaysia	2019	African Journal of Hospitality, Tourism and Leisure	Q3	10	Multiple Regression Analysis
19	(Hussain et al., 2015)	Sustainable tourism and resulting resident satisfaction at Jammu and Kashmir, India	2015	Worldwide Hospitality and Tourism Themes	Q1	77	Linear Regression
20	(Del Chiappa et al., 2016)	Attitudes Toward Responsible Tourism and Behavioral Change to Practice it: A Demand-Side Perspective in the Context of Italy	2016	Journal of Quality Assurance in Hospitality & Tourism	Q2	27	ANOVA
21	(Muresan et al., 2016)	Local Residents' Attitude towards Sustainable Rural Tourism Development	2015	Sustainability	Q1	217	Correlation
22	(Gao et al., 2024)	Stakeholder Perceptions of Sustainable Tourism Development: A Case Study in Haikou, China	2024	Sustainability	Q1	4	Structural Equation Modeling
23	(Basak et al., 2021)	Understanding sustainable homestay tourism as a driving factor of tourist's satisfaction through structural equation modelling: A case of Darjeeling Himalayan region, India	2021	Current Research in Environmental Sustainability	Q1	45	Structural Equation Modeling

For systematic selection of literatures, the Prisma Model was utilized. At first stage, the studies that illustrated the effect of sustainable tourism on economy and/or environment were included and others were excluded. In second stage, literatures that used quantitative studies and the study that contains the data suitable to calculate effect size were considered. Finally, studies that employed chi-square test, t-test, z test, ANOVA, correlation test, regression test or/and structural equation modeling as statistical method were included for final studies. The required data for meta-analysis was collected from the selected 23 studies. The p-value, standard error and effect sizes were calculated from the data presented in individual studies. To conduct meta-regression, moderator analysis and heterogeneity test, the sample size, research year, research area, destination type, dependent variables, independent variables, correlation coefficient, t-statistics, p-values, F-values and regression coefficients were collected from the selected literatures. The collected data were coded with consultation with the scholar.

Effect size calculation

The effect size was calculated using the correlation coefficient and beta coefficient wherever applicable. The equations used for effect size calculations are listed below.

Effect size based on correlations

Correlation coefficient itself serve as effect size index, to compute r, the variance of r is approximately,

1. $V_r = \frac{(1-r^2)^2}{n-1}$ **……Equation i**

Where, n is sample size.

(Borenstein, 2009, pp. 41–45)

Effect size based on beta-coefficient

"First, when reporting regression coefficient β only and β= (0.5, 0.5), β is converted to r with as follows:

2. r =0.98*β+0.05*λ……. Equation ii,

Where if $\beta \geq 0$, $\lambda = 1$; if $\beta < 0$, $\lambda = 0$ and

Second, if |β|≥0.5 and t-statistics were reported, r can be calculated using following equation:

3. $r = \frac{t}{\sqrt{t^2 + N - 3}}$ ……..…**Equation iii**

Where, N denotes the sample size, t denotes t value."
(Zhang, 2021, p. 315)

Moderators and their coding

Table 2 shows the potential moderators based on the literatures and theories stated in literature review section. The research period, sample size, country income status, HDI, tourism destination type and the location as context were used as moderators. The description of these moderators and category were presented in the same table. Each category was coded into different codes as shown in table for moderator analysis.

Table 2 Potential moderators and its coding

Moderators	Descriptions	Category
Research Period	Time of research conducted	Pre 2020, 1; Post 2020, 2
Sample Size	Number of observations in each study	Less than 500,1; 500 to 1000, 2; above 1000, 3
Country Income Status	UN list	High, 1; Upper Middle, 2; Lower Middle, 3; Low,4
HDI	HDI ranking	Very High HDI, 1; High HDI ,2; Medium HDI, 3; Low HDI, 4
Tourism Destination Type	Rural or Urban	Mixed, 1; Rural, 2; Urban, 3
Location	Continents where it locates	Asia, 1; Other than Asia, 2

Data analysis

R studio and its add-ins was used for data analysis purpose. The meta-regression was conducted to test the relation between the variables and their directions. The forest plot, funnel plot and Galbraith Plot were presented to check the validity and reliability of the documents and to test heterogeneity of results. The moderator analysis was conducted to see how moderators influences the relationship between the tested variables. The sensitivity analysis was conducted to find the robustness of result and to identify the outlier if present. Finally, the meta-analysis result was analyzed to make more universal conclusion of the relationship between variables.

Results

Effect of sustainable tourism on economy

The effect of sustainable tourism on economy was analyzed through meta-analysis, sensitivity analysis and heterogeneity tests. The results of the heterogeneity tests and meta-analysis are presented in below sections:

Publication bias test, heterogeneity test and Forest plot

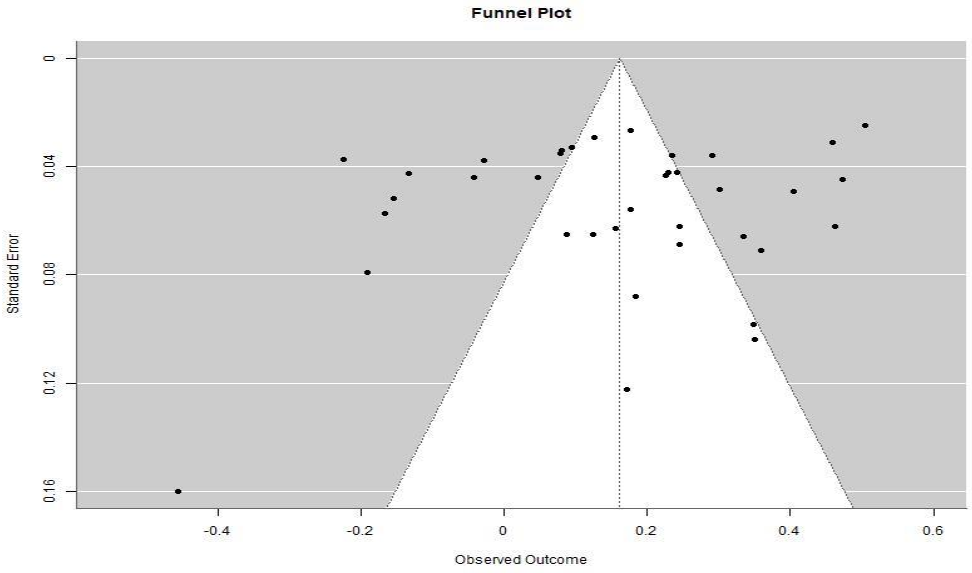

Figure 1: Funnel plot

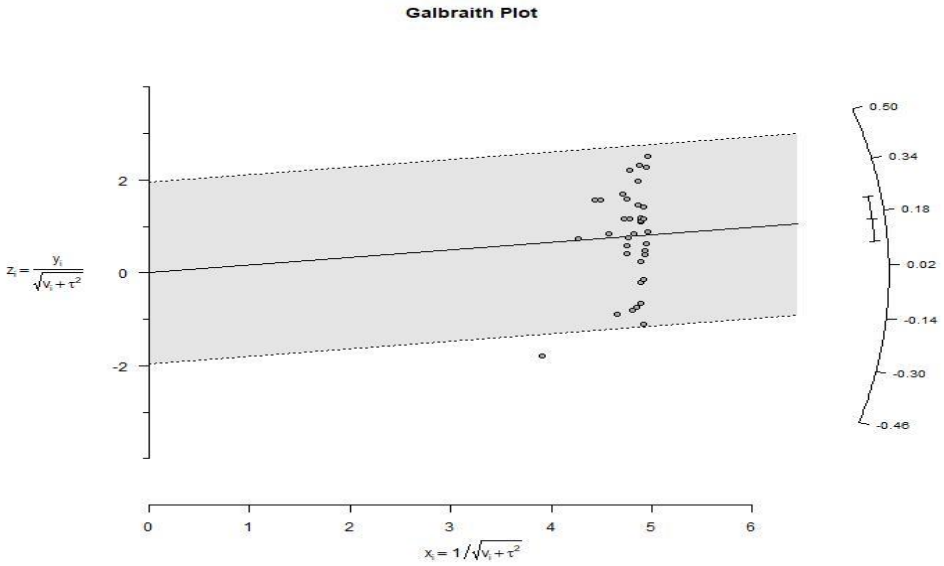

Figure 2 Galbraith plot

Funnel plot as shown in figure 2 demonstrates an approximately symmetrical distribution of effect sizes around the mean, implying an absence of publication bias, which was further supported by the Egger's regression test (z = –1.05, p = 0.29) and Galbraith Plot shown in Figure 3 by depicting the standardized effect sizes within expected confidence limits, with most data points clustering along the regression line which shows the presence of heterogeneity across studies. Additionally, the Forest Plot as illustrated in figure 4 visually summarizes individual and pooled effect sizes, where the majority of studies showed positive coefficients which supports the overall positive effect of the sustainable tourism development.

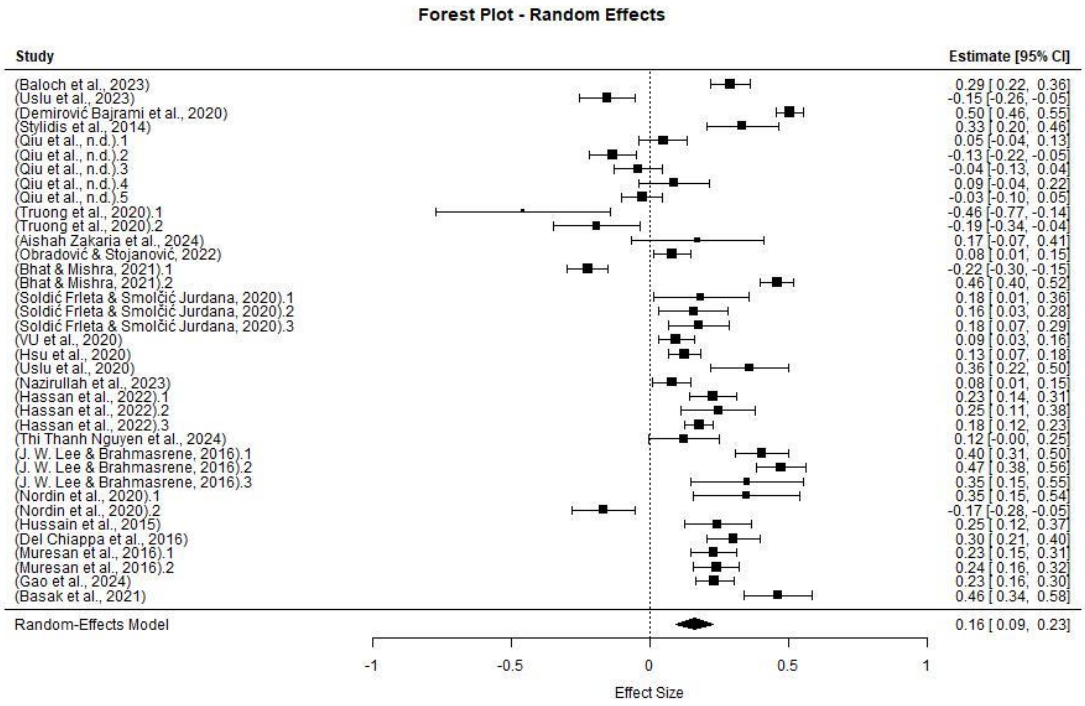

Figure 3 Forest plot

Meta-regression

Table 3 shows the meta-regression result with a statistically significant positive pooled effect size ($r = 0.162$, $p < 0.001$), accepting the hypothesis 1. The 95% confidence interval (0.095 to 0.229) reinforced the reliability of this finding, confirming that the true population effect was moderately positive. However, the substantial heterogeneity statistics ($Q = 756.8$, $df = 36$, $p < 0.001$; $I^2 = 95.2\%$) revealed significant variation among studies, suggesting the effect of moderator.

Table 3 Meta regression results

Model	Number of estimates	Obs.	Point estimates	Lower limit	Upper limit	Z value	P value	Q value	Df (Q)	P value (Q)	I^2
Random	37	20032	0.162	0.095	0.229	4.719	0	756.8	36	0	95.2

Sensitivity analysis

Annex 1(Table 7) revealed the results of sensitivity analysis conducting by omitting the individual observation respectively. The results showed that the sequential omission of individual observations did not significantly change the pooled effect size, which remained stable and statistically significant ($p < 0.01$), while heterogeneity measures remained consistently high ($I^2 \approx 95\%$). This illustrates that the observed heterogeneity was due to contextual variation rather than sampling bias.

Moderation analysis

The moderator analysis shown in table 4 explored influence of moderators on effect size. The results reveled that location of study significantly moderates the effect size (QM = 7.644, p < 0.05). Further, the Asia categorical variable and other than Asia categorical variable both influence positively and significantly on the effect size, while higher coefficient in other than Asia category was reported. Similarly, the moderator destination types also significantly influence the effect size (QM = 12.075, p < 0.05). The categorical variable mixed destinations illustrate the significant strongest positive influence whereas urban destinations exhibit a significant negative influence and rural was found non-significant. Therefore, the hypothesis 11 and hypothesis 13 were accepted. However, the moderators sample size, study period, development status and HDI has no influence in effect of sustainable tourism on economy. The categorical variable small sample size of moderator sample size, post 2020 of moderator study period, high on moderator development status and high HDI on HDI moderators were significant though the moderator variables were insignificant. This may be due to chance or there may be other various causes which needed rigorous research to explore. Hence, the hypothesis 7, hypothesis 9, hypothesis 3 and hypothesis 5 were rejected.

Table 4 Moderation analysis

Moderator	Level	Effect Size (CI 95%)		Test of null (2-Tail)		Heterogeneity		
		Estimate	SE	z-value	p-value	QM	QE	I^2
Sample Size	Large	-0.005	0.088	-0.06	0.952	4.267	630.35*	94.69
	Medium	0.203	0.109	1.854	0.064			
	Small	0.192	0.098	1.968	0.049			
Study Period	Post 2020	0.151	0.05	3.019	0.003	0.095	738.86*	95.32
	Pre 2020	0.021	0.07	0.307	0.758			
Study Country	Asia	0.102	0.038	2.662	0.008	7.644*	594.92*	94.2
	Other than Asia	0.185	0.067	2.765	0.006			
Destination Type	Mixed	0.298	0.071	4.208	0	12.075*	593.94*	93.78
	Rural	-0.091	0.083	-1.095	0.273			
	Urban	-0.281	0.089	-3.162	0.002			
Development Status	High	0.144	0.051	2.83	0.005	3.56	689.09*	94.95
	Lower Middle	-0.074	0.09	-0.83	0.407			
	Upper Middle	0.097	0.077	1.256	0.209			
HDI	High HDI	0.191	0.072	2.64	0.008	0.383	737.79*	95.32
	Medium HDI	0.001	0.127	0.01	0.992			
	Very High HDI	-0.045	0.084	-0.535	0.593			

Notes: QM represents Test of Moderators and QE represents Residual Heterogeneity; * represents p-value<0.05

Effect of sustainable tourism on environment

Using a combination of meta-analysis, sensitivity analysis, and heterogeneity testing, this part illustrated the impact of sustainable tourism on environmental sustainability. The findings from the meta-analysis and heterogeneity assessments were presented below.

Publication bias test, Heterogeneity test and Forest Plot

Funnel plot shown in Figure 5 illustrated a symmetrical distribution of effect sizes, confirming the absence of systematic publication bias, this finding was statistically supported by the Egger's regression test ($z = 0.7371$, $p = 0.4611$). Additionally, the points aligning within the limit of Galbraith Plot of Figure 6 revels that the result of environmental estimates were heterogeneous and the heterogeneity are due to contextual factors. Further, figure 7 illustrates the Forest Plot that graphically presented the individual and pooled environmental effect sizes where most of the studies shows positive effect size with overall effect size positioned on right side or reference line which revealed that sustainable tourism generally has positive effect on environment.

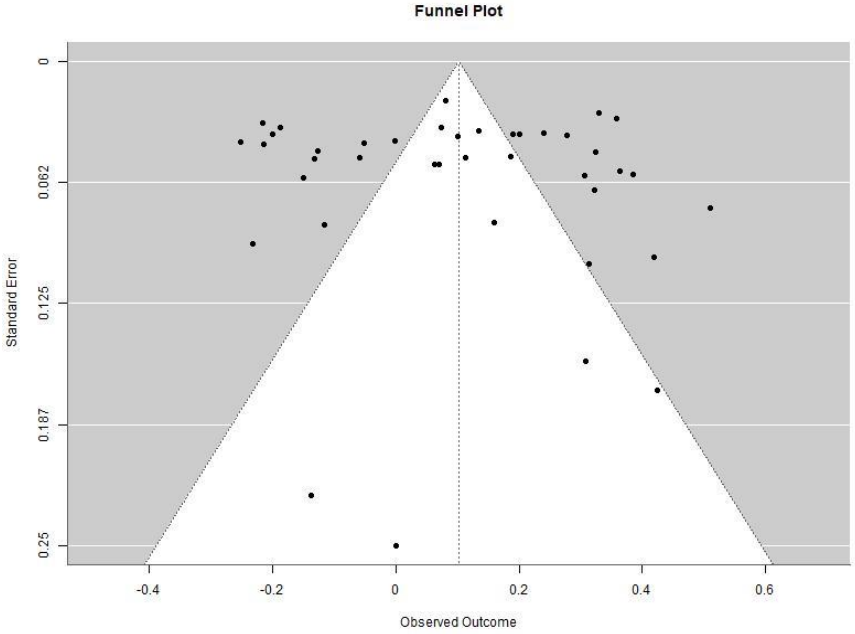

Figure 4 Funnel plot

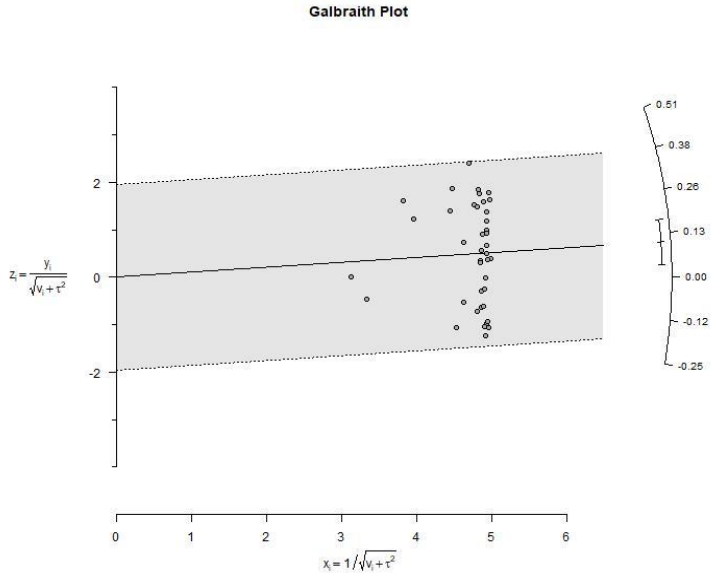

Figure 5 Galbraith plot

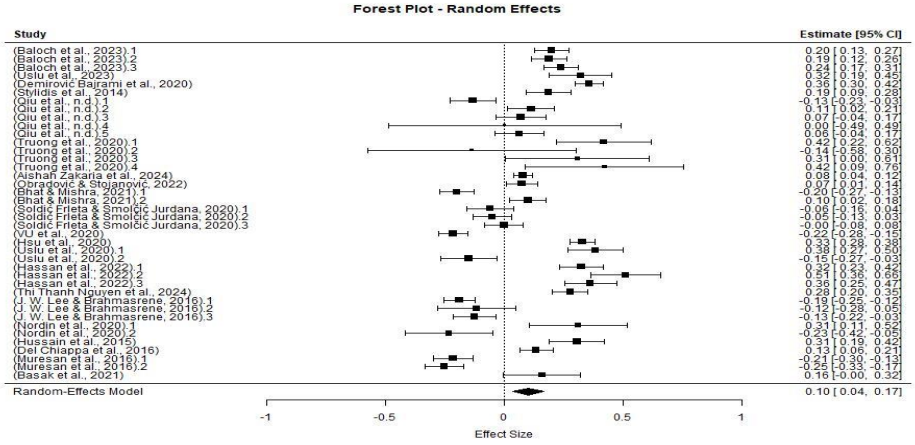

Figure 6 Forest plot

Meta-regression

Table 5 illustrated the meta-regression results to show the relationship between sustainable tourism and environment. Results revealed the statistically significant overall effect of sustainable tourism on environmental sustainability (r = 0.148, p < 0.01). However, the high heterogeneity was observed (Q = 690.34, df = 33, p < 0.001; I^2 = 94.12%) which signify the considerable variability among studies. The presence of this significant heterogeneity caters for the sensitivity analysis to check the robustness of results and moderator analysis for more reliable results on effect of sustainable tourism on environmental sustainability.

Table 5: Meta regression results

Model	Number of estimates	Obs.	Point estimates	Lower limit	Upper limit	Z value	P value	Q value	Df Q.	P value (Q)	I^2
Random	40	21774	0.102	0.037	0.168	3.06	0.002	814.7	39	0	95.2

Sensitivity analysis

Annex 1 (Table 8) shows the sensitivity analysis results for environmental outcomes conducting by sequential omission of individual effect sizes. The sensitivity results reveled the high degree of robustness of results since, the pooled estimate remained within a narrow range (0.137–0.156) and are statistically significant throughout. Similarly, the presence of stable heterogeneity ($Q \approx 670–710$; $I^2 \approx 94\%$) implied that the observed variability was due to structural and contextual diversity rather than model instability.

Moderation analysis

Table 6 shows the moderator analysis which explored the effect of different categorical moderators in the relation of sustainable tourism and environment. The result revealed that study country i.e. location of study significantly moderates the effect of sustainable tourism on environment. similarly, the study results of Asian countries illustrate a strong and statistically significant positive association (r = 0.164, p < 0.001), however studies from countries other than Asia regions reveal a significant negative association (r = –0.179, p = 0.009). Here hypothesis 12 was accepted. However, the sample size, study period, destination type, development status, and HDI moderators did not significantly influence the effect between tourism and environment, as a consequence the hypothesis 4, hypothesis 6, hypothesis 8, hypothesis 10 and hypothesis 14 were rejected.

Table 6 Moderator analysis

Moderator	Level	Effect Size (CI 95%)		Test of null (2-Tail)		Heterogeneity		
		Estimate	SE	z-value	p-value	QM	QE	I^2
Sample Size	Large	0.091	0.096	0.949	0.343	2.043	781.21*	95.44
	Medium	-0.063	0.116	-0.545	0.586			
	Small	0.05	0.106	0.476	0.634			
Study Period	Post 2020	0.133	0.052	2.552	0.011	0.616	814.67*	95.57
	Pre 2020	-0.055	0.07	-0.785	0.433			
Study Country	Asia	0.164	0.04	4.094	0	6.89*	744.44*	94.82
	Other than Asia	-0.179	0.068	-2.625	0.009			
Destination Type	Mixed	0.055	0.077	0.71	0.478	0.501	781.56*	95.63
	Rural	0.064	0.092	0.69	0.49			
	Urban	0.057	0.101	0.563	0.573			
Development Status	High	0.088	0.055	1.59	0.112	1.069	814.30*	95.56
	Lower Middle	0.068	0.084	0.804	0.421			
	Upper Middle	-0.022	0.086	-0.253	0.801			
HDI	High HDI	0.051	0.072	0.709	0.478	0.874	722.27*	95.68
	Low HDI	0.149	0.229	0.652	0.514			
	Medium HDI	0.08	0.115	0.699	0.485			
	Very High HDI	0.062	0.086	0.725	0.468			

Notes: QM represents Test of Moderators and QE represents Residual Heterogeneity; * represents p<0.05

Discussions

The findings of this meta-analysis provided a generalized conclusion on the effect of sustainable tourism to economic and environmental factors across diverse global contexts. The meta-regression results revealed that tourism has a statistically significant positive economic effect (r = 0.162, p < 0.001), align with the finding of Gursoy et al. (2019), thereby supported hypothesis 1. According to Lipsey and Wilson (2001)**,** a correlation coefficient of $r \leq 0.10$ indicates a weak relationship, values between 0.10 and 0.40 represent a moderate relationship, and $r \geq 0.40$ reflects a strong correlation. Here, the correlation coefficient 0.162 suggested the moderate positive relationship between tourism and economy. This finding aligned with previous research indicating that sustainable tourism promotes local employment, revenue generation, and entrepreneurial opportunities (Aishah Zakaria et al., 2024; Baloch et al., 2023). However, the high heterogeneity was seen in results which may be due to variation in institutional capacity, destination characteristics, and regional policy environments of different contexts. The moderation analysis results reveled that moderator location of study and tourism destination type significantly moderates the relationship between tourism and the economy. Similarly, regional variations were observed where non-Asian countries

exhibit slightly stronger economic effects than Asian countries. This variation may be due to more developed tourism infrastructure and institutional support in non-Asian countries. Further, in destination type moderator, mixed destinations reveled the strongest economic gains which suggested the balanced tourism development across diverse settings promotes more inclusive and sustainable economic growth. Moreover, the diversified destinations encompassing both urban and rural elements offer broader and more inclusive economic benefits, likely due to spillover effects between urban commercial centers and rural community enterprises. However, the negative effect observed in purely urban contexts may be due to over-concentration of tourism benefits, higher operational costs, and limited community-level engagement.

Similarly, the statistically significant moderate positive effect of sustainable tourism and environment was observed ($r = 0.148$, $p < 0.01$), accepting hypothesis 2. This reveled that sustainable tourism practices have positive effect on environment and can contribute to environmental sustainability. This finding was similar to the findings of prior research which indicates sustainable tourism management can help in environmental conservation, resource efficiency, and ecological balance (Gössling & Hall, 2019). The moderate overall pooled effect size suggested that with effective governance and regulation, sustainable tourism can lead to environmental improvements (Mol et al., 2013; UNEP, 2020). Similarly, location of study significantly moderates the moderate the relationship between tourism and environment, however other moderators such as sample size, study period, destination type, development status, and HDI did not influence the effect of tourism on environment. Further, the regional moderator a positive and significant effect in results of Asian countries studies, however non-Asian regions with negative effects. This results may be due to constant adoption of eco-friendly tourism by developing country whereas developed country may face environmental challenges due to mature tourism industry. The overall results revealed that the contextual and temporal factors critically shaped tourism and environment relations.

This results provide practical insight on the relationship between sustainable tourism, economy and environmental outcomes. The universal generalized result on this study provide actionable insights for policymakers, planners, and tourism managers. The study results indicate that sustainable tourism enhances economic growth, especially in developing regions, by stimulating local entrepreneurship, employment, and investment diversification. Governments should emphasize small and medium scale community enterprises and promote inclusive participation in tourism decision-making to foster sustainable tourism. Moreover, the environmental findings suggested the necessity for effective regulatory frameworks, eco-certification programs, and integration of green technology to mitigate tourism's ecological footprint. Thus, the government policy efforts should concentrate on balancing economic growth with environmental sustainability through effective regulatory measures, continuous monitoring, participatory governance, and education-driven awareness initiatives. From a theoretical perspective, this study contributes positively to inclusive growth and environmental conservation, thus supporting the Sustainable Development Approach advocated by the United Nations. Similarly, the moderator analysis such as HDI, development status, and destination type advances the theoretical understanding that the relation between sustainable tourism with economy and environment outcomes was context specific. Further, this study emphasized that sustainable tourism's effects were not universally homogeneous but vary depending on governance structures, human capital, and cultural adaptability. Moreover, this finding aligns and further emphasize suggestions in the literature (Cooper, 2017; Paul & Barari, 2022) for integrated sustainability models that account for cross-sectoral and multi-level influences.

Conclusion and recommendation

From this meta-analysis it was concluded that there existed moderate positive relation between sustainable tourism with economy and environmental outcomes in general. However, the relations were not uniform; they vary across geographical, and developmental contexts, illustrating the dynamic nature of sustainability in tourism systems. Further, the analysis revealed that contextual moderators, such as destination type and regional characteristics, explain some of the observed variability, suggesting that the effectiveness of sustainable tourism depends on adaptive governance, institutional maturity, and local engagement. However, the unexplained variability needed further studies incorporating the other moderators that may influence the effect. Additionally, this study provided outputs that suggests sustainable tourism as a strategic mechanism for achieving balanced growth while maintaining environmental sustainability, both growth and green can be achieved simultaneously. Further study was needed to expand the database by incorporating a larger number of empirical studies, including both quantitative and qualitative case studies, to enhance the robustness and generalizability of results. Additionally, future meta-analyses should also integrate micro-level and longitudinal datasets to capture dynamic changes in tourism's impacts on sustainable development dimensions, including income inequality, cultural integrity, and environmental sustainability. Further, future study should explore new moderating variables, such as educational attainment, population dynamics,

governance quality, and economic structure, which may explain residual heterogeneity among studies. Finally, the cross-disciplinary collaborations that link economic, social, and environmental perspectives was encouraged for ensuring that tourism development policies align more closely with the United Nations Sustainable Development Goals (SDGs) and contribute effectively to equitable and resilient global progress. The analysis depends on secondary data from published studies, which may contain reporting bias or methodological inconsistencies. Similarly, the limited number of studies in specific regions restricts the generalizability of findings. Additionally, the meta-analysis could not fully capture qualitative dimensions of sustainability, such as perceptions of cultural authenticity or social justice.

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