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Research article

Exploring the nexus between economic and environmental issues in the tourism sector at the country level. A replicable framework

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ABSTRACT

In recent years, the tourism activities take experienced a steady growth in demand, yet it causes ecological damages, such as waste production and carbon dioxide emissions. This paper provides a theoretical framework for testing the interactions among sustainable development and economic growth in the tourism context and demonstrates that sustainability depends on both environmental impacts and some relationships among different factors. In particular, considering some of the key indicators proposed by Agenda 2030 and integrated in the Sustainable Development Goals (SDGs), the authors focused on the direct influence of tourism to Gross Domestic Product (TGDP), Environmental Performance Indicator (EPI) score, and Carbon Footprint (CF) as indicators that were used together with GDP and Municipal Solid Waste (MSW) to test five hypotheses and analyze their interactions for a sample country. The results reveal the statistical significance among these indicators in the light of Sustainable Development Goals n. 8, n. 12, and n. 13. Finally, Municipal Solid Waste, the first visible human effect due to tourism, presents a strong interaction with Carbon Footprint.

1. Introduction

Nowadays, tourism is responsible for economic growth, physical and human capital accumulation, environmental impacts (e.g. emissions and production of waste), infrastructural transformations, technological push, and effects on host communities [1–3]. Specifically, the quick progress of the tourism business is increasing negative environmental consequences that often outweigh the social and/or economic benefits [4].

Under this perspective and considering its relevance for the sustainable tourism industry, this paper starts from the rapid increase in tourist demand compared with the diffusion of decarbonization technologies in the tourism sector. Indeed, given the continued growth and high intensity of carbon emissions in this sector, tourism is now dependable for a substantial share of these greenhouse gas emissions globally [5].

Moreover, recently, the issue of sustainable tourism has been emerging [6,7]. This kind of tourism is expected to achieve profitability, while still mitigating ecological, collective, and financial impacts [8]. Hence, it covers a strategic position in achieving the objectives of the 2030 Agenda towards SDGs [9]. From the economic point of view, universal tourism business, accounting for 10% of the Gross Domestic Product (GDP) and 10% of employment, is a powerful force for economic and social advance and cultural heritage

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defense [10], occasionally contributing to sustainable development through economic reallocation. Contrariwise, environmentally, tourism causes significant adverse effects like environmental pollution, boosted demand for fossil fuels, and energy concentration [11].

Accordingly, assumed the economic, environmental, and social significance of tourism growth, unsurprisingly, the UN contemplated this industry in the 2030 Agenda, the international reference framework based on the SDGs under UN resolution 70/1 [12]. These SDGs aim to internationally quantity the progress towards achieving long-term sustainable development, harmonizing economic, social, and environmental sustainability, and converging on inclusivity, shared prosperity, and responsibilities [13]. Within this global agreement (Agenda 2030), which includes 17 goals, 169 targets, and 230 indicators, the authors stressed (Fig. 1) the interactions between tourism and SDGs. Although tourism is particularly envisaged in SDGs n. 8, n. 12, and n. 13, it directly and indirectly affects all goals. For this reason, it is considered a driver for the accomplishment of the SDGs at a global level. Moreover, after conducting a scientific literature screening, which detected a gap of only four papers (see 2.1), it emerged that the quantity and intricacy of the multiple features involved in the analysis of the sustainability (economic, environmental, and social) of tourism do not facilitate the achievement of qualitatively detailed results [14]. Therefore, this study includes a systematic analysis process that combines qualitative and quantitative properties, observing the phenomenon at the country level and using different indicators for purpose and typology. From these perspectives, the purpose of this study consists to examine the application of a scientific and replicable approach at the country level for monitoring and improving tourism activities that affect the sustainable development. For this reason, a full set of indicators was selected with the aim to test their interaction with tourism and fill the gap underlined in Section 2.1. Through the use of statistical tools, the linkage between these indicators and tourism was evaluated to verify the (in)dependence between economic and environmental issues in the tourism sector.

Mainly, the authors used GDP (Gross Domestic Product), TGDP (Tourism Gross Domestic Product), MSW (Municipal Solid Waste), EPI (Environmental Performance Indicator) score, and CF (Carbon Footprint) as indicators. In particular, waste (in terms of MSW) symbolizes one of the most perceptible impacts that affects tourism industry and the ecosystem [15] and is responsible for the production of up to 2 billion tons of waste per day globally. Moreover, GDP and TGDP underline the economic development of a country, the EPI score synthesizes the environmental performance of a country, and CF focuses on the environmental GHG impact in the atmosphere.

Methodologically, this research paper provides an empirical analysis and identifies the interactions between tourism and sustainability, consequently defining an introductory methodology to evaluate the responsibility of tourism in achieving the SDGs and their targets. The aims of this paper were the investigation of issues of environmental sustainability, with particular reference to the pressure created by tourism at the country level, and the building of a replicable framework to experiment the relationships amongst sustainable development and economic advance in the tourism context, allowing for the evaluation of the potential achievement of the UN SDGs.

The systematic process for measuring tourism sustainability was carried out using the following specific steps:

i) Observation of tourism phenomena at the country level;
ii) Analysis of the interactions test, which includes four indicators and the carbon dioxide emissions and five hypotheses;
iii) Inclusion of some SDGs in the interaction analysis.

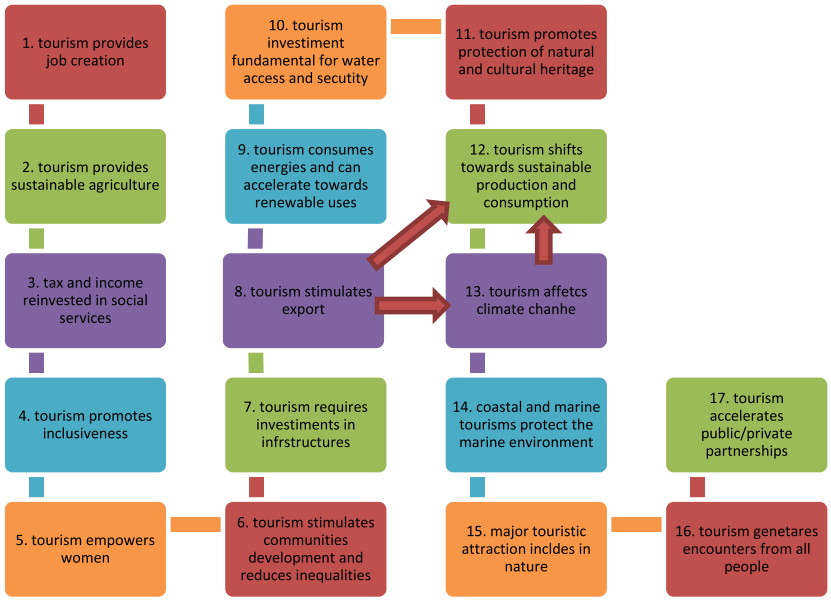


Fig. 1. The 17 UN SDGs translated into tourism issues.
Source: Authors' adaptation on data UNWTO [16,17].

In particular, this analysis can:

a) Demonstrate the dependence of environmental sustainability in a more impactfully sector, such as tourism on environmental impacts;
b) Highlight some relationships between different factors (e.g. economic, political, and social).

Thus, methodologically this research article adopts an empirical and replicable approach to analyze the interactions among the selected indicators (GDP, TGDP, municipal solid waste, and EPI score), CO_2 (carbon dioxide emissions), and tourism industry. The use of GDP and TGDP is suggested in 2015 by some scholars [3] and was included in SDG n. 8; in particular, indicator n. 8.9.1, which considers tourism-direct GDP as portion of total GDP. Lastly, considering that overviews of the SDGs already exist, especially for hotel and tourism companies, the authors aimed to expand specific knowledge on the use of indicators and SDGs by conducting an analysis at the country level.

In particular, this investigation purposes to explore the subsequent general research question:

RQ. "What is the linkage between economic and environmental issues in tourism?".

2. Literature review and theoretical framework

2.1. Gaps in literature and research needs

With the aim of identifying appropriate papers, the scholars conducted Boolean explorations using Scopus database by combining several keywords with "AND" operator to further generate more relevant outcomes. In particular, the search queries included these five keywords (country, level, tourism, sustainability, and SDG). After this screening, only six papers emerged. Amongst these, one paper was published in 2017 and five were published in 2020. This selection of documents comprised four articles and two book chapters, which covered, in particular, scientific areas including emerging Environmental Sciences (with six papers), Social Sciences (four), Business, Management, and Accounting (three), Economics, Econometrics, and Finance (two), and Energy (two).

In particular, in 2020 some scholars [18] investigated which SDGs amongst 17 are most contemplated in the sustainability programs of hotel companies, focusing on Costa Rica. From a methodological point of view, their study is founded mainly on subordinate evidence from the websites of two companies considered, integrating with the studies on punctual aspects on specific SDGs and other material such as news articles. Finally, specific hotel evidence was scrutinized using studies on the progress of the SDGs and some frameworks suggested by the United Nations (UN) and the United Nations World Tourism Organization (UNWTO). It turns out that the sustainability programs of these two companies align more closely with SDGs 11, 12, and 13. Instead, another research group [19] carried out a comparison between two main Spanish urban destinations, Madrid and Barcelona, using some SDGs indicators. The analysis focused on the impacts of real estate values and average domestic income on tourism in a neighborhood-level methodology. Moreover, in 2020 [20] it was used a cluster analysis, selecting some targets, to distinguish appropriate clusters of countries that are influenced by tourism. Specifically, the results highlighted the subsistence of a positive connection between tourism development and life quality, and amongst level of sustainable performance and tourism concentration. Conversely, another study [21] assessed spatio-temporal variations in the Okavango Delta to assess the impacts of land use changes and sustainability. Although this chapter emerged in the bibliographic search, after careful analysis, in this study it was excluded from the sample considered because it was not consistent with the topics of our study. Methodologically, other scholars analyzed the connection concerning sustainability and tourism competitiveness and the transformations recorded by these parameters in different geographical areas [21]. The Travel and Tourism Competitiveness Index (TTCI), developed by the World Economic Forum, was considered to quantity the competitiveness of tourism. Furthermore, these authors proposed a synthetic indicator (Imα) to measure tourism competitiveness. Instead, the Sustainable Development Index (SDI) was used to analyze sustainability data [22]. Lastly, the study carried out in 2017 does not fall within the selected sample because, after careful analysis, it emerged that it was based on Sustainable Consumption and Production as objective 12 of the SDGs and not directly on tourism [23]. In conclusion, only four studies were suitable for inclusion in the analysis presented, and there was a strong lack of studies that adopted the same methodology as this study in terms of investigating the SDGs at the country level with the selected indicators.

2.2. Theoretical framework

Sustainable tourism has been discussed and measured by means of sustainable development indicators [24]. Moreover, analyzing some key indicators, it was apparent that owing to the intensification in disposable income in emerging economies, tourism has realized dramatic growth despite the global economic crisis [25].

Generally, the relevance in implementing original businesses in tourism and stimulating socially responsible, sustainable, and accessible tourism for inclusive growth emerges [26]. However, a few years after the UN 2030 Agenda Declaration for Sustainable Development, considering that tourism is responsible for more than 10% of the world's GDP, there are no clearly applicable sustainable management standards to contribute to reaching the SDGs [27].

Actually, tourism provides considerably to global GDP, although it has some negative properties related to environmental, economic, and socio-cultural elements [28]. Generally, since 2015, the year of the publication of the 2030 Agenda, only three analyses in the current literature has considered key indicators to assess a country's potential to implement SDGs and determine in what way they

are achieving the goals n. 8.9.1 and n. 12.b.1 in the tourism sector. Two publications used a local observation scale: the firstly [29] highlighted that in Wolong District, particularly Nanyang town in China, tourism contributed to encouraging economic growth (SDG indicator n. 8.9.1) by growing tourism GDP from 1.9% to 7.1% in the period 1996–2006. Conversely, in 2019 other scholars [30] stressed that the Montenegrin Ministries of Finance and Sustainable Development and Tourism only announced the use of SDG indicator no. 8.9.1.

Additional study focuses at national level included findings consistent with the theoretical foundations of economic growth: on the one hand, confirming the negative effect on population and well-being, and on the other, exposing a positive impact of technological improvement in the prospect of green growth in the tourism sector [31].

Moreover, at the country level, analyzing tourism development by using a sample of 139 countries, it emerged that the territorial diffusion of tourism can cause environmental impacts and pollution. Therefore, tourism is responsible of high environmental costs related to the impacts generated in host destinations and countries. In fact, the connection amongst tourism and environmental sustainability is not one way: the expansion of tourism generates environmental degradation of the destination [32].

Other authors have highlighted, at the country level, the scarcity of a univocal methodology for evaluating the impact of the development of entrepreneurial innovation in the tourism sector regarding the macro indicators of the countries, mainly in terms of achieving sustainability goals [26].

Precisely, amongst the advanced continents, Europe covers the most important tourism market and likes a rich tradition and unique cultural heritage that attracts around 41% of international tourism incomes, ranking in first position worldwide among areas concerned with a direct contribution of tourism to GDP. Despite this ranking, tourism is not yet a priority in Europe, especially sustainability issues [33]. Conversely, analyzing sustainable tourism in developing countries, such as Vietnam, with particular concern for the reduction in global emissions under the Paris Agreement on Climate Change signed in 2015, it emerges that the reduction depends on the development policies adopted by emerging economies [34].

Therefore, one of the missions of the SDGs is to encourage the economic, social, and sustainable development of non-perfectly balanced countries, such as Romania and other Eastern European regions, for decreasing their economic and social disparities which also affect tourism [35]. The authors investigated the influence of tourism on municipal waste (or vice versa) because the tourism sector generates a large amount of it [36,37]. In some regions, municipal waste management from tourism can double that of produced by residents, and yet some countries provide specific regulations and indicators aiming to monitor the level of environmental sustainability achieved.

Then, for providing a multi-indicator analysis (Fig. 2) concerning both the economic development and environmental impacts of tourism industry, the authors set a replicable methodological path and, according to the literature mentioned above, a research question (RQ1).

RQ1. "What is the linkage between economic and environmental issues in tourism?". The authors developed five hypotheses.

In particular, the interactions test, displayed in Fig. 3, analyzes the sustainable development of tourism using economic and environmental indicators. This interaction was tested through the statistical measures of linear interaction and correlation, which were organized into five hypotheses. This test provides some new insight because it statistically tests these relationships at the country level.

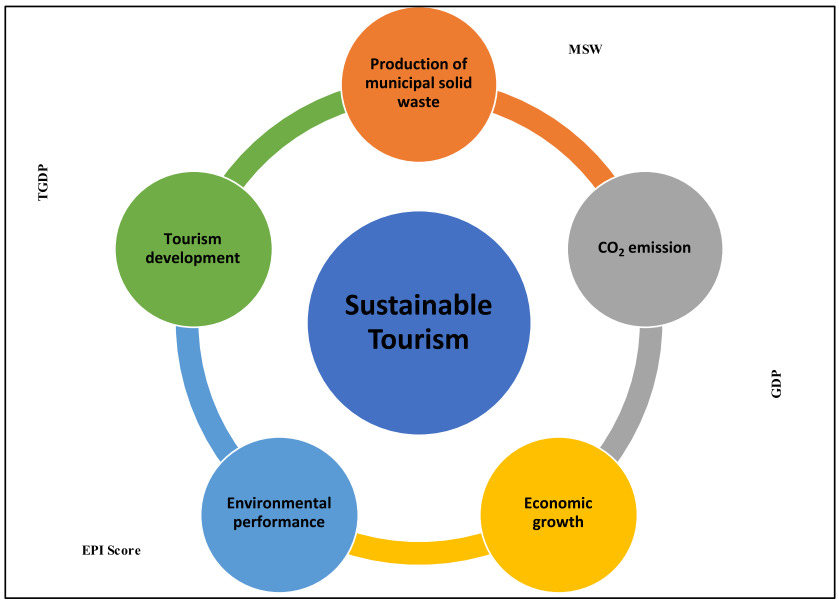


Fig. 2. Framework of interactions among tourism, environment, and development.
Source: Authors' elaboration.

In 2016, it has been analyzed the correlation amongst the disposal of MSW and the increase in environmental impacts in the tourism industry [2]. They found that the per capita production of solid waste depends on the economic position and living canons of the people who stay in different categories of hotels [2]. Therefore, the economic development generated by tourism (TGDP) also affects the emissions released into the environment. This study was the basis for H1.

H1. There is a nexus between economic growth for tourism and environmental impact.

A few years later, however, it has been analyzed the interaction between CF reduction potential and waste management in the tourism industry. It occurred that the tourists' contribution to the global annual production of waste does not support general variations to the collection system of recyclable materials for tourism purposes only, but the same rules must be considered for any economic activity [37,38]. From this study, the authors built H2.

H2. There is a linkage between the production of waste and environmental impact.

The relationship between MSW and EPI scores has been presented in a review analysis in 2019 [39]. In fact, with regard to the UN SDGs, governments must declare their environmental performance in pollution programs. The EPI is one of the most recognized environmental performance metric that has been applied in several studies. For the first time, it was evaluated the EPI with the production rate of MSW [39]. For these reasons, the authors followed H3.

H3. There is an interaction between the production of waste and environmental performance.

Furthermore, in 2019, it was observed the nexus between environmental impacts and economic development [40]. The authors, using an annual time set of environmental impact indicators and GDP per capita, tested the connection between environmental impacts and economic growth. Starting from this study, the authors proposed H4 focusing on tourism.

H4. Tourism development affects the quality of the environment.

Finally, at general level, the authors tested the dependence between GDP and TGDP as suggested in literature [3].

H5. There is an interaction between economic development and economic growth of tourism.

These five hypotheses can be considered experimental elements to evaluate the level of sustainability achieved by tourism at country level. To this end, the methodological and empirical path carried out in the present research article aims to present a widespread analysis (Fig. 3) to recognize and define the interactions between the aforementioned indicators, tourism activities, and environmental impacts. The outcomes of this type of analysis make it possible to observe the achievement or otherwise of the SDGs from an interdependent perspective.

Thus, the authors present a multi-indicator analysis with the aim to provide statistical evidence (positive or negative) and significance between economic development and environmental indicators in light of the issues pertaining to sustainable tourism.

The novelty of this paper consists of the development of an innovative framework for analyzing carbon emissions in the tourism context under the guidance of the UN SDGs. In particular, this new analytical framework can be applied effectively and successfully to all areas to be observed and for every level, from macro-meso to micro observation. Furthermore, this framework can provide for the replacement of some indicators with others, among the different ones included in the SDG targets or built on the basis of the phenomenon observed. Mainly, this study includes a country-level observation and provides a comparison to other pilot cases based on tourist destination analysis. Under these perspectives, this study has been compared with a case study of Pahalgam [2]. Moreover, the sample countries analyzed by the authors consisted of developed and developing countries and not only the seven largest economically advanced states on the planet (e.g. the G7 countries) as proposed in literature [40] or only developing countries as well [39]. The

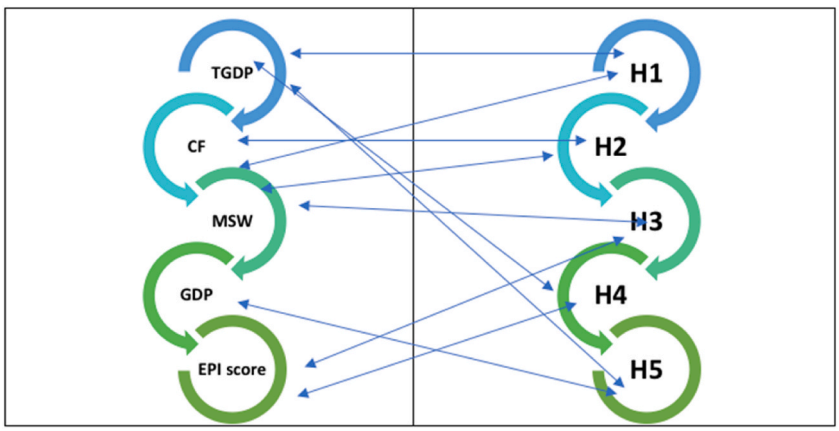


Fig. 3. Interaction test amongst indicators and hypotheses.
Source: Authors' elaboration.

Table 1
Key indicators used at the country level for SDGs and environmental monitoring in tourism.

Countries	Monitoring area (km^2)	Municipality	Visitors overnight	Accommodation	Room/beds	Tourist attraction	% of contribution to GDP State	Main key monitoring areas in addition to the UNWTO mandatory indicators related to environmental impact
Yucatan (Mexico)	3.95E+04	1.06E+02	2.25E+05	5.86E+00	1.57E+04 beds	6.00E+00	11.1	Climate change, energy, water and **solid waste management**, wastewater treatment
São Paolo (Brazil)	2.48E+05	9.00E+00	3.37 E+05	2.33E+03	1.25E+05 beds	x	8.7	Climate change, energy, water and **solid waste management**
Biscay (Spain)	2.22E+03	x	1.93 E+06	7.44E+00	1.55E+04 beds	x	x	NA
Málaga (Spain)	3.95E+02	x	2.60 E+06	x	x	1.14E+02	x	Climate change, cruise ship impacts
Bogotà (Colombia)	1,76E+03	x	7.74E+05	2.48E+03	3.20E+04 beds	x	x	Climate change, sewage, energy, and water management
Yukon (Canada)	4.83E+04	x	4.91E+05	x	x		5	Natural environment
Barcelona (Spain)	7.69E+03	x	1.94E+07	x	x	x	x	Air pollution, climate change, energy, water management, marketing for sustainable tourism, and sustainable and environmental management
Mallorca (Spain)	3.34E+00	x	2.31 E+07	1.80E+03	3.045E+04 beds	x	x	Biodiversity, safeguarding of nature
Canary Islands (Spain)	7.50E+03	x	1.56E+07	1.31E+04	x	x	3.50E+01	Energy, wastewater and **solid waste management**, climate change, natural capital, protected areas, and fragile ecosystems,
Azores (Portugal)	x	x	x	x	x	x	x	Energy, water management, **solid waste**, and wastewater (sewage) management
Algarve (Portugal)	x	x	x	x	x	x	x	Energy, water and **solid waste management**, wastewater (sewage)
Thompson Okanagan (Canada)	7.16E+04	1.20E+02	1.55E+06	x	x	x	x	Energy, water and waste management, climate change, land use, and sustainable tourism practices
South West Australia	x	x	3.13E+06	x	x	x	x	Energy, water and **solid waste management**
Antigua Guatemala	7.80E+01	x	1.19E+06	1.98E+00	2.87E+03 rooms	x	x	CO_2 of tourism events, garbage, and water consumption
Navarre (Spain)	1.04E+04	x	1.45E+05	4.00E+01	x	6.00E+00	3.00E+00	Impact of emissions, spatial deconcentration, reforestation, and the evolution of the ecosystem
Buenos Aires (Argentina)	2.00E+00	x	x	5.69E+00	8.89E+05 rooms			NA
Alentejo (Portugal)	3.16E+04	x	1.50E+06	2.33E+03	x	x	6.90E+00	Energy and water, **solid waste** and wastewater management

(*continued on next page*)

Table 1 (*continued*)

Countries	Monitoring area (km^2)	Municipality	Visitors overnight	Accommodation	Room/beds	Tourist attraction	% of contribution to GDP State	Main key monitoring areas in addition to the UNWTO mandatory indicators related to environmental impact
South Tyrol (Italy)	7.40E+03	x	7.00E+06	1.02E+04	7.33E+04 rooms	x	x	Biodiversity, nature protection, and climate change
Pangandaran (Indonesia)	2.04E+04	x	4.38E+05	4.50E+01	x	2.00E+00	x	**Solid waste management**
Sanur (Indonesia)	1.06E+04	x	7.59E+05	1.36E+00	5.20E+03 beds	4.00E+00	x	Water and **solid waste management**, and sewage treatment
Toba (Indonesia)	8.53E+04	x	3.78E+05	1.17E+00	3.50E+03 beds	4.00E+00	x	Energy, water and waste management
Lombok (Indonesia)	1.10E+03	x	2.21E+06	9.41E+00	1.21E+04 rooms	3.00E+00	x	NA
Sleman (Indonesia)	5.75E+02	x	x	x	x	4.00E+00	x	Liquid, solid waste management, sustainability standards, reduction of GHG, environmentally friendly transportation, and bio-mass energy produced from livestock
Sonoma (California, USA)	4.60E+03	x	7.00E+06	x	x	4.00E+00	x	Impacts of agricultural tourism, water scarcity, climate change
Adriatic Coast (Croatia)	2.47E+01		1.68E+07	7.11E+00	5.69E+04 beds	x	x	Energy, water, and waste control
Guanajuato (México)	3.06E+04	x	3.07E+07	9.59E+00	2.99E+04 beds	2.00E+00	x	Environment
Aegean Islands (Greece)	x	x	x	x	x	x	x	NA

*NA: not available.

*: in the column "Main key monitoring areas in addition to the UNWTO mandatory indicators related to environmental impact" in bold the topics considered by the authors in the current study.
Source: Authors' elaboration based on UNWTOINSTO platform [46].

empirical observation based on previously literature dealt with several kinds of indicators and interactions among them, without focusing only on GDP and TGDP [3], only on CF and MSW [38], or only on GDP and EPI score [39] as in Ansari et al. (2020).

3. Materials and methods

This paper aims to investigate the potential interactions among economic and environmental issues in tourism activities using some key indicators, such as GDP, TGDP, MSW, EPI score, and CF, to satisfy RQ1.

This methodological and empirical study proposes a replicable and simple technique using statistical analysis for testing five hypotheses, from H1 to H5, included at the end of Section 2. In this section, the authors firstly present the indicators set; secondly, the study area and the data used are discussed; and thirdly, the source of extraction and finally the dataset built through the analysis of clusters observed with reference to the above-mentioned SDGs are presented.

3.1. Indicators

As previously mentioned, the set of indicators, including some SDGs, considered by the authors of this paper were GDP, TGDP, MSW, EPI score, and CF.

In particular, concerning economic development, the authors used:

a) GDP: the GDP measures the added value created through the production/delivery in a country per year (Total, USD/capita) [41].
b) Tourism Direct GDP (commonly called TGDP): TGDP corresponds to that part of the GDP (% of GDP) generated by the tourism sector and its related industries. This indicator is a specific marker of the tourism economic development [42].

Environmentally, the authors used the following indicators to test tourism:

a) MSW indicator (kilograms per capita): MSW is defined as the amount of waste collected and treated at municipalities. This amount includes domestic waste, bulky waste, trade and craft waste, and office waste, and excludes waste from networks, urban sewage treatment, and construction and demolition activities [43].
b) EPI score: theorized by Yale and Columbia Universities, the EPI score focuses on environmental sustainability achieved by 180 countries and provides a quantitative score (between 1 and 100) on environmental performance [44]. This value numerically quantifies a country's environmental performance and complements the goals of the UN.
c) Lastly, CF estimates the total quantity of greenhouse gases emitted during the production/provision of a transformation service (tons per capita) to make policymakers aware of the level of environmental (un)sustainability of cities [45].

3.2. Country-level observation and data source

In order to identify the area of focus and collect the required information in the datasets, the authors queried several sources.

First of all, consulting the UNWTOISTO (UN Network of Tourism Observatories Monitoring Sustainable Tourism Development, platform) [46], the authors retrieved the list of tourist destinations (see Table 1) that declared their adopted policies on sustainable tourism. Specifically, these 27 tourist destinations declared their key monitoring of environment and sustainability areas in addition to the UNWTO mandatory indicators present in the 17 SDGs established in the UN Agenda 2023. A strong interest in solid waste management, energy and water management, climate change, and carrying capacity emerged from the results of the authors' review. Among these results, the authors focused on the tourism destinations and related countries that consider MSW as one of the most important key factors that characterize their public policies toward sustainability. These destinations are Yucatan in Mexico, South West in Australia, Antigua in Guatemala, Alentejo in Portugal, and Pangandaran in Indonesia (Fig. 4).

For example, Mexico recently banned admission, use, consumption, marketing and distribution of products that cause waste in tourist spaces [47]. Recently, Australia declared a goal of reducing total waste generated per person by at least 10% by 2030 [48]. Guatemala published the regulation for the waste management with the aim to protect healthiness and reduce pollution [49].

Moreover, Portugal published several strategic objectives for waste management: reduction in waste production, promotion of resource efficiency, contribution to a circular economy, reduction in environmental impacts, and sustainable adoption of a waste management plan [50].

Lastly, the Indonesian government is optimizing end-of-life MSW solutions with source segregation, a clear waste policy, adjustment of local budgets to cover management costs, improved waste collection, and application of an advanced MSW system [51].

Generally, these reference countries declared MSW management as a key factor in their tourism policies - in addition to the mandatory UNWTO factors presented in the UN SDGs - to achieve better sustainability at three levels: economic, social, and environmental. Through this initial screening, the authors built the sample countries (Mexico, Australia, Guatemala, Portugal, Indonesia, and Australia) used for observing the interactions declared in RQ1.

Secondly, for a comparison with other indicators, the scholars assessed the sustainability level accomplished by the sample countries using the EPI index and then evaluated the impact on the environment using the CF indicator.

Consequently, the authors used Mexico, Australia, Guatemala, Portugal, and Indonesia for tests H3 and H4 and only Australia, identified within the sample countries, for tests H1, H2, and H3. It must be stated that the authors focus on Australia in order to present a replicable analysis at the country level, considering that it presents a high rate of tourism and few inhabitants (about 26 million).

For synthesis requirements, the sample of countries composed of Mexico, Australia, Guatemala, Portugal, and Indonesia was named “sample countries” and the research focus on Australia was defined as the "Australian pilot case".

Finally, the data used to achieve the objective of this study refer to five indicators and present the economic and environmental conditions in the sample area investigated as follows:

(a) The amount of MSW produced for sample countries and the pilot case of Australia;
(b) The GDP produced for the pilot case of Australia;
(c) The TGDP produced by the sample countries and by the pilot case of Australia;
(d) The level of environmental performance achieved by the sample countries and measured by the EPI score;
(e) The amount of carbon emissions produced in the pilot case of Australia was measured using the CF indicator.

3.3. Clusters selected, datasets, and interaction analysis

Considering the indicators described above, the authors built an interaction analysis in order to test the hypotheses (H1 to H5) with the aim of answering RQ1 (Table 2).

The five hypotheses were elaborated using a literature review to provide theoretical references, on the one hand, and the relationships among SDGs, on the other hand.

Therefore, as shown in Table 2, H1 tested the interaction between TGDP and CF with the aim of verifying the relationship between tourism expansion and environmental impact. However, some authors confirmed that potential variation in GDP can be affected by economic development, tourism, and sustainability, especially in terms of carbon dioxide emissions [53].

Conversely, H2 verified the nexus between the production of MSW (including the MSW produced by tourism) and environmental impact measured in terms of greenhouse gas emissions. In this case, both hypotheses concern the observation of the pilot case in Australia.

Then, H3 and H4 were tested in the sample countries to investigate the effects, firstly, among MSW and environmental performance and, secondly, among TGDP and environmental quality. For both hypotheses, environmental and quality performance were measured using the EPI score index.

Then, H5 considered the interaction between economic development and tourism growth observing the pilot case of Australia as a local cluster.

Moreover, according to the SDGs, the goals related to tourism referenced in this study (Table 2) are:

(1) SDG 8 emphases the promotion of inclusive and sustainable economic growth, work, and employment, while indicator 8.9.1 defines the direct GDP of tourism as a proportion of total GDP and the rate of growth. This indicator, therefore, suggests a useful evaluation of the interactions between SDGs goals and GDP and TGDP [54].
(2) SDG 12 pushes toward responsible consumption and production, inviting countries to apply standard accounting tools for observing economic and environmental aspects [55].
(3) SDG 13 is titled “Climate action”, which is relevant because tourism both affects and is affected by climate change. Hence, all tourism practitioners (companies, public and private, institutions, and tourists) are responsible for climate change. For this

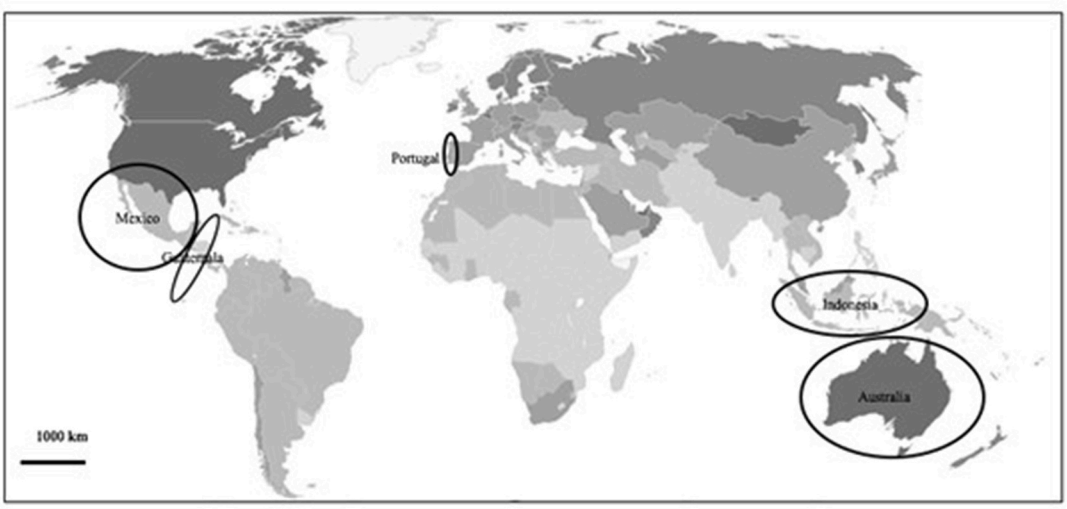


Fig. 4. Geographical location of the sample investigated*.
* The different shades of the countries highlight the per capita impact on the environment (the darker the color, the bigger the impact).
Source: Authors’ adaption based on GFN [52].

reason, among the measures adaptable, the carbon footprint reduction in transport and accommodation sectors leads tourism to be a low-carbon activity [56].

For each hypothesis, the authors built a scatter diagram, and depending on the output generated, the correlation between the two variables was verified, one of which is always independent and the other dependent.

As mentioned above, the authors used two kinds of observations: a sample of countries and a local cluster (Australia).

In terms of data, the authors used several sources: OECD platform [41–43] with the aim to collect GDP, TGDP, and MSW data; Global Footprint Network (GFN) [52]; and World Bank [57] to determine CO_2 emissions. Conversely, the authors retrieved EPI score data from Yale [44].

The period of referring data was the short range of 2015–2020 because 2015 represents the year the Agenda 2030 and the SDGs elaborated by the UN came into force.

Then, the authors used two datasets as shown in Tables 3 and 4.

Statistically, this study included a descriptive analysis of the indicators used and a short section about the regression analysis. Under these perspectives, the scholars did not carry out complex tests; however, they tested some key indicators with the aim of verifying the hypotheses selected and offering a replicable and non-complex framework to stakeholders and scholars.

In particular, with the aim to test the five hypotheses from H1 to H5, the authors used the linear relationship (Eq. (1)):

$$Y = ax + b \quad \text{(Eq. 1)}$$

A commonly used measure to test the dependence between two variables is the correlation which reveals strength and direction of a linear relationship between two random variables. The output of this measure is, for example, the Pearson correlation coefficient, which is indicated with r [3]. For this reason, in one case the correlation was tested and, consequently, the correlation coefficient p-value index was always between −1 and 1. In particular:

- If $p\text{-value}_{AB} > 0$, the data series X and Y are directly correlated or positively correlated; and if $p\text{-value}_{AB}$ is 1, the positive correlation is strong;
- If $p\text{-value}_{AB} = 0$, then the data series X and Y are uncorrelated;
- If $p\text{-value}_{AB} < 0$, the data series X and Y indicate an inverse correlation or a negative correlation; and if $p\text{-value}_{AB}$ is −1, the negative correlation is strong.

Through r using the Pearson correlation (Eq. (2)), in this case, known as the correlation coefficient, the authors evaluated the linear correlation between two variables (X and Y) as indicated by H1 to H5:

$$r = \frac{\Sigma\left[(xi - x)(yi - y)\right]}{\sqrt{\Sigma\,(xi - x)^2 * \Sigma(yi - y)^2}} \quad \text{(Eq. 2)}$$

4. Results and discussion

In this section of the study, the authors provide the results and findings of the statistical analysis carried out to verify the hypotheses from H1 to H5.

Statistically, firstly, H1 goal is to test the nexus between economic growth for tourism and environmental impact. For this reason, the authors considered TGDP and CF in the pilot case of Australia. The scatter graph (Table 5) and the results showed a linear regular correlation considering *r of Pearson = 0.5499*; thus, this hypothesis is considerable. The significance of this outcome revealed that as the TGDP values increase, the environmental impacts measured with the CF also increase. Therefore, countries can monitor the level of TGDP in order to develop and apply some sustainable practices in order to reduce or maintain environmental impacts.

Subsequently, the aim of H2 is to verify the linkage between the production of MSW and environmental impact. For this reason, the authors compared the quantities of MSW per capita (kg/year), of which a part is produced by tourists and related activities, with the

Table 2
Synthesis of the hypotheses presented.

Hypothesis	Hypothesis Description	Theoretical reference	Source data	Cluster analysis	SDGs	Indicators involved
H1	There is a nexus between economic growth for tourism and environmental impact.	[2]	OECD and GFN	Pilot case of Australia	8.9.1 and 13	GDP vs CF
H2	There is a linkage between the production of waste and the environmental impact.	[37,38]	OECD and GFN	Pilot case of Australia	13	MSW vs CF
H3	There is an interaction between the production of waste and environmental performance.	[39]	Statista, Yale	Sample countries	12	MSW vs EPI score
H4	Tourism development affects the quality of the environment	[3]	Statista, Yale	Sample countries	8.9.1	TGDP vs EPI score
H5	There is an interaction between economic development and economic growth of tourism	[40]	OECD	Pilot case of Australia	8.9.1	GDP vs TGDP

Source: Authors' elaboration.

amount of GHG (t/per capita) for the Australian pilot case (Table 5).

In particular, the authors underlined that MSW produced presents a relationship with the CF. Moreover, if there is a linear relationship between MSW and CF, there will also be a linear relationship between CF and the amount of waste associated with tourism because this quantity flows into the total amount of the MSW.

Moreover, statistically, considering that the *p-value* is equivalent to *0.029* (less than 0.05), $r^2 = 0.7352$; consequently, H2 is significant. Furthermore, the authors calculated the Pearson coefficient with the aim of validating the correlation between TMSW and CF. In this case, $r = 0.85$ (Pearson); hence, there is a strong positive correlation because $r > 0.7$ (Table 5). Also, in this case, with the increase in TMSW there is an increase in emissions. Moreover, in this case, the authors decided not to dwell on the outcomes of the linear regression analysis since it concerns a small sample of six observations, despite having a *p-value* lower than 0.05 (0.029).

After conducting the analysis of the two hypotheses focused on Australia, the authors carried out a test for the sample countries. For H3, the authors assessed the interaction amongst MSW and EPI score. For presenting a general comparison, the authors used data related to the sample countries selected. The graphs in Table 6 present a linear relationship between the production of MSW (kg/year) and environmental performance index (EPI) as shown by the values on the x-axis (MSW), which tend to be significantly associated with those on the y-axis (EPI). Therefore, with the aim of quantifying the strength of the linkage between these two variables, the Pearson correlation index was calculated. Then, considering this Pearson value *($r = 0.745 > 0.7$),* there is a strong positive correlation. In this case, the outcomes underlined that the amount of MSW produced at the country level affects the EPI score quantified for the reference country.

H4 aims to experiment the probable influence of TGDP on the quality of environment. With the purpose of providing a general snapshot, the authors used the TGDP and the EPI Score for the sample countries selected. The graph in Table 6 revealed the low result of $R^2 = 0.2767$ with a Pearson coefficient equal to $r = of\ 0.52$. In this case, there is a low interaction between economic development associated with the tourism sector (TGDP per capita) and environmental performance (EPI score).

Finally, H5 aims to verify the interaction between GDP and TGDP for the case pilot of Australia. There is a high relationship between GDP and TGDP (graph in Table 6), and statistically, R^2 is equal to 0.4404 and *r of Pearson* = 0.6336. In particular, in this case, it can be underlined that there is a linear relationship.

As can be seen in Table 6, in the H1 graph, the six scattered points can be connected in a straight line. The functional formula of TGDP (X-independent variable) and CF (Y-dependent variable) is (Eq. (3)):

$$Y = -0.1286x + 16.1 \quad \text{(Eq. 3)}$$

*The negative sign indicates the slope of the straight line.

The direction is negative if the variable TGDP increases, the CF decreases, and vice versa.

Considering $R^2 = 0.9184$, the fitted functional formula result of more than 91% explains the corresponding 6-year data, which are highly reliable. Under the condition that the CF of Australia is stable, the country can realize the sustainable development of low-carbon with the current growth rate of tourism.

Therefore, as also underlined in literature [2], the tourism segment is the main generator of solid waste and, in particular, this activity is responsible for a high level of CF emissions. For example, these scholars [2] underlined a very strong correlation between the disposal of MSW and pollution and degradation on the water surface during the peak of the tourist season. Therefore, H1 is considerable and was verified statistically and according to the literature above mentioned.

Moreover, in the H2 graph, the six scattered points can be connected in a straight line, too. In this case, the functional formula of MSW (X-dependent variable) and CF (Y-dependent variable) is (Eq. (4)):

$$Y = 0.0056x + 12.724 \quad \text{(Eq. 4)}$$

Thus, considering $R^2 = 0.7352$, the fitted functional formula result of more than 73% explains the corresponding 6-year data, which are highly reliable. Under the condition that the CF amount is stable, Australia can realize the MSW policies towards more sustainability. Furthermore, due to the *p-value* = *0.029* (lower than 0.05), the assumption can be made that the observed data are statistically significant. Thus, the recorded linear correlation means that the relationship is linear; therefore, the Y trait (CF) grows directly or inversely proportional to the X (TGDP) trait.

This result reveals that MSW and CF are linked by a strong dependence as highlighted in literature [37] in an analysis of the relationship between CF and the amount of solid waste in cruise tourism. Moreover, with the aim to reduce CF emissions associated with MSW in tourism, policymakers must provide specific measures for the reduction, reuse, and disposal of the wastes produced by guests in hotels and the tourist sector as underlined by other scholars in 2021 [38]. For this reason, on-site waste management and

Table 3
Dataset of the sample countries (2020).

Countries	GDP ($)	TGDP ($)	GDP/CAPITA ($)	TGDP/CAPITA ($)	MSW (per capita kg/year)	EPI score index
Mexico	1.27E+18	9.55E+11	1,01E+10	7,58E+03	3.43E+05	74.60
Australia	1.53E+18	3.51E+10	5,95E+10	1,37E+03	5.40E+05	77.40
Guatemala	8.59E+12	6.54E+09	5,09E+05	3,88E+02	3.01E+05	21.80
Portugal	2.54E+11	1.67E+11	2,47E+04	1,62E+04	4.82E+05	62.50
Indonesia	1.186E+18	2.42E+10	4,38E+12	8,93E+01	2.77E+05	29.50

Source: Authors' elaboration based on Statista [58] and Yale [44].

Table 4
Dataset of Australia (2015–2020).

Australia	GDP ($)	TGDP ($)	GDP/CAPITA ($)	TGDP/CAPITA ($)	MSW (kg/capita)	CF (mt/capita)
2015	1,35E+18	4,16E+16	5,67E+10	1,75E+09	5,83E+02	1,59E+01
2016	1,21E+18	3,71E+16	5,00E+10	1,53E+09	5,38E+02	1,59E+01
2017	1,33E+18	4,13E+16	5,41E+10	1,68E+09	5,12E+02	1,58E+01
2018	1,43E+18	4,44E+16	5,73E+10	1,78E+09	5,06E+02	1,55E+01
2019	1,39E+18	3,59E+16	5,49E+10	1,42E+09	4,96E+02	1,55E+01
2020	1,33E+18	3,42E+16	5,18E+10	1,33E+09	4,74E+02	1,53E+01

Source: Authors' elaboration based on OECD data [41–43] for GDP, TGDP, and MSW, on GFN [52] for CF.

related waste separation are some of the key methods for achieving net-zero emissions in tourist cities [59].

Then, the results of the H3 test presents a linear interaction between MSW and the environmental performance of the sample of countries investigated. In particular, (Eq. (5)):

$$Y = 0.0003x - 11.438 \quad \text{(Eq. 5)}$$

where $R^2 = 0.5558$ means that the functional formula result is more than 55.58%, which explains the interaction between MSW and the EPI score index.

However, it can be concluded that the per capita GDP and EPI have a weak correlation, especially in developing countries as determined in literature [39], and a linear correlation for developed countries.

Conversely, the H4 function records a low interaction described by $R^2 = 0.2767$. Only 27% of the functional formula (Eq. (6)) explains the interaction among these two variables:

$$Y = 3E - 11x + 45.197 \quad \text{(Eq. 6)}$$

TGDT affected the quality of the sample investigated in a lower manner.

The results of H4 show that there is a significant, positive lower dependence and asymmetry between the growth rates of tourism and GDP and this can also be variable as identified by other scholars in 2015 [3].

The results for H3 highlighted that the EPI score elaborated on the basis of three elements, in particular, MSW (household and commercial waste), recycling rates, post-consumer recyclable materials (metal, plastic, paper, and glass) reprocessed in each country, and ocean plastic pollution could be affected by human activities. Thus, a probable increase in this index could be associated with the increase in MSW. Therefore, MSW represents the category that most influences the value of the EPI Index [46].

A relationship between MSW and the EPI score emerges, as well as between the EPI rankings and the other indicators.

It has to be underlined that the good political results achieved by countries are due to welfare (GDP per capita). Hence, economic prosperity supports nations investing in policies and programs to achieve sustainability [60]. For this reason, H4 tested in this study is useful in order to present a replicable analysis of good policy associated with welfare (GDP per capita in general and in particular TGDP per capita for tourism), meaning that economic welfare also supports nations to invest in policies and programs for sustainability in the field of MSW. Therefore, investing in sustainable infrastructures, especially in developing countries, reduces air pollution and the production of hazardous waste, limits health crises, and generates economic returns and environmental health. In the last hypothesis (H5), the authors considered the interaction between economic development (independent variable) and economic growth of tourism (dependent variable). Thus, the GDP and TDGP indicators were tested. The results in the graph (Table 5) present a linear relationship of only 44% and is expressed in (Eq. (7)):

$$Y = 0.0434x - 8E + 08 \quad \text{(Eq. 7)}$$

Then, considering that economic growth and, in particular, tourism growth, does not have a damaging effect on environmental quality [40], this positive interaction between GDP and TGDP is cyclic and can also lead to improvements in sustainability.

As indicated in the dataset in Tables 3 and 4, the GDP indicator was used to observe some possible interactions with the other indicators and not its evolution over time as also indicated in the literature [41].

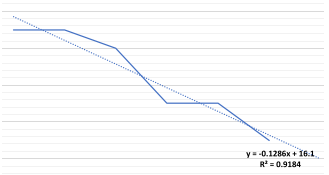
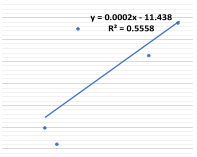
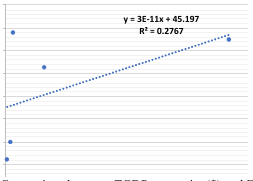
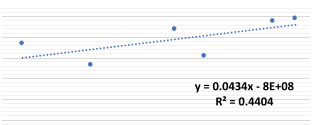
Table 5
Results from the regression analysis.

Source	SS	df	MS
Model	2309.7038840.296202	1	2309.7038
Residual	840.296201	4	210.07405
Total	3150	5	630

var2	Coef.	Std. Err.	T	P>|t|	[95% Conf. Interval]	
var1	0.0056541	0.0017052	3.32	0.029	0.0009197	0.103885
_cons	1272.023	88.55507	14.36	0.000	1026.155	1517.891

Source: Authors' elaboration on Stata MP. (Number of observations = 6, F (1,4) = 10.99, Prob > F = 0.0295, R-squared = 0.7332, Adj R-squared = 0.6655, Root MSE = 14.494).

Table 6
Summary of the empirical results obtained.

Hypothesis	Indicator	Graph	R^2	r Pearson	Result
H1	TGDP and CF	 Nexus between TGDP ($) and CF (mt/ per capita) for Australia.	0.9184	0.5400	H considerable
H2	MSW and CF	 Comparison between MSW (kg/year) and Carbon Footprint (mt/ per capita) for Australia.	0.7352	0.85	H considerable Linear relationship Strong positive correlation p-value = 0.029 < 0.05
H3	MSW and EPI score	 Comparison between the production of MSW (kg/year) and (EPI).	0.5558	0.745	H considerable Linear relationship
H4	TGDP and EPI score	 Comparison between TGDP per capita ($) and EPI.	0.2767	0.52	Low interaction
H5	GDP and TGDP	 Comparison between GDP per capita ($) and TGDO per capita for Australia ($).	0.4404	0.6336	H considerable Linear relationship

Source: Authors' elaboration.

In light of these considerations, the authors of this paper judge that a quantitative technique would be significant to evaluate and observer the involvement of several industries, in particular tourism, to the achievement of the SDGs.

In particular, the evaluation of the interaction among five indicators, tested through five hypotheses, is better presented using quantitative data. Moreover, this kind of relationship can be multiple but based on a theoretical foundation as highlighted in the literature and theoretical framework sections.

Generally, this paper stimulates an interdependent analysis of two kinds of countries: developed countries such as Portugal and Australia and developing countries such as Guatemala, Indonesia, and Mexico.

In particular, the effects generated by environmental impacts due to tourism industries also generate social imbalances. For this reason, in the scholars' discussions on environmental sustainability, the social question is implicit too. Thus, if the first visible effect on the environment generated by tourism is the production of MSW, the first reaction is inside societies and host communities. Moreover, solid waste is a major source of greenhouse gas emissions, producing approximately 3–4% of worldwide greenhouse gas (GHG) emissions [61]. Furthermore, the major urban centers in developing countries such as Indonesia generate up to 8 million tons of waste per day [51], whereas at the global level, MSWs are responsible for the production of up to 2 billion tons of waste per day.

In particular, countries must reduce the exploitation of the workforce, enforce rights, and generate positive effects. Finally, tourism can be considered a negative externality and a consequence if it does not respect the environment and people of developing countries.

Moreover, this paper evaluates the criterions and observers the progress over time in achieving detailed quantitative targets concerning the SDGs. A proper correlation analysis and the definition of an adequate evaluation structure are needed to achieve this aim [62]. In this case, authors underlined some limits due to a very small sample of data used per country due to a lack of data and/or

uniqueness in the units of measurement; therefore, in the future, this study could be expanded toward correspondence among indicators and correlation between different variables. Another limitation of this study is due to difficulties in data retrieval and historical series because the Agenda 2030 Series of Acts was published in 2015, and thus the range of observation is quite short.

This descriptive analysis is based on a replicable framework aimed at examining and evaluating sustainability in tourism, considering the monitoring of some key indicators (previously included in the 2030 Agenda) and focusing on a granularity of observation at the country level. As mentioned previously, this case study is one of the first to test the relationships between key indicators to determine different relationships that can be recorded by the factors associated with sustainability in tourism. Moreover, as also highlighted by other scholars in a study published by Heliyon, even the study results, sometimes simple in nature, can be considered reliable and be used as a basis for basic data and insights to examine sustainability in different contexts, not only in tourism [63]. This kind of study can potentially provide stimuli, perspectives, and insights into the analysis of sustainability in different sectors of the economy, society, and institutions.

Lastly, under these perspectives, this paper can stimulate integrated approaches in tourism studies including more environmental and social aspects, as others underlined almost 20 years ago [4]. Their research sought an adequate balance between environmental, social, and economic elements in the circumstance of tourism development to optimally realize all the requirements of sustainable development. For this reason, with the aim to overcome this lack of integrated approaches, the authors of this study propose a replicable methodology that is concerned with the selection of a set of indicators focused on the country level. Hence, the role of tourism is essential not only to stimulate environmentally sustainable activities, but also for social and economic aspects. For these reasons, it is also important to support tourism in border areas or borderlands: with the aim of also providing opportunities for economic growth [64]. Conversely, the well-developed countries cover a crucial role as greater tourist attraction, generator of a higher value of TGDP, CO_2 emissions and waste and cam drive developing countries towards more sustainable models [65].

5. Conclusions, practices, policies, and future implications

This empirical study prompts a better investigation of tourism to support policies and businesses towards more effectively sustainability. This interdisciplinary approach provides a replicable quali-quantitative approach for judging different goals and criteria for making decisions in sustainable tourism development and achieving the sustainability levels provided for SDGs. In the future, scholars can apply the other indicators included in SDGs to focus on the country level and examine other tourism countries.

Apart from these considerations for future applications, this study also delivers a different framework to address (non)sustainability concerns useful in formulating future waste management strategies and better management of tourist destinations. Moreover, GDP per capita emphasizes economic growth and is also the main trigger for tourism. In fact, the TGDP measures the percentage of total GDP associated with the tourism industry.

This critical information highlights, on the one hand, the growth trend of tourism and, on the other hand, indicates the mitigation path that destinations must take to become sustainable and reduce their emissions.

Based on RQ1 and the five hypotheses tested, this paper analyzed the relationships among some key indicators with the aim of presenting the interdependencies of the tourism sector between the environment, waste, and the welfare produced.

Moreover, a quantitative technique would be crucial to effectually evaluate and observe the contribution of several industries, in particular tourism, toward the achievement of the SDGs even if there are difficulties and limitations in data retrieval and historical series.

This empirical analysis highlighted that the position of developed countries is also crucial as they have more opportunities to attract tourists and generate incomes from tourism development; at the same time, these countries also generate a high volume of CO_2 emissions, ecological hazards, and pollution, which limit tourism development in the country. Furthermore, if country-level policy measures on waste management are not put in place, the achievement of the SDGs would be complex as there is a clear relationship between GDP, tourism, and waste, which requires a comparative approach.

This study prompts governments and public decision makers to pursue potential technological installations to further increase the use of renewable energy and green services in their country with a low impact on the tourism sector. Moreover, in a bottom-up approach, this study significantly advocates for community participation and national and local institutional changes to influence the performance of community-based partnerships.

Finally, this paper also filled a gap in the scientific literature with only six products, as underlined in Section 2.1 by delivering a methodological suggestion on the investigation of sustainable tourism at the country level. In particular, the presented framework in this research article displays the current situation and launches challenges and opportunities for operating with the indicators associated to the SDGs useful for researchers and professionals of the public and private sectors in the field of sustainable tourism.

In conclusion, there are some limitations as highlighted previously: the difficulty of finding historical series with data for each indicator and for each country; the lack of data on waste production at a national level; and the poor homogenization between directives, regulations, codes, and waste management laws and practices in different countries. Particularly, data need to be normalized and standardized to facilitate comparisons at the national level. Future research will try to overcome these problems and broaden the indicators to influence sustainable tourism. For this reason, future directions of this research could include the investigation of twaste management practices evolution in tourism sector and the linkage between economic growth and environmental impacts. Moreover, a future practical recommendation is the possibility of building a unique open dataset that includes the sustainability data of each country mapped through a unique set of indicators, such as those included in Agenda 2030. Lastly, policymakers and stakeholders should operate from a joint perspective between regulatory aspects, regulatory developments, research results, and analysis frameworks offered by science with the aim of operating in the most complete way possible toward a single objective: environmentally

sustainable economic growth and tourism increasingly attentive to the needs of the planet and natural resources. It is no longer possible to imagine operating in a separate manner between science and good practices.

CRediT authorship contribution statement

Miraj Ahmed Bhuiyan: Writing – review & editing, Investigation, Data curation. **Annarita Paiano:** Writing – review & editing, Supervision, Formal analysis. **Tiziana Crovella:** Writing – original draft, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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