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Hospitality Environmental Indicators Enhancing Tourism Destination Sustainable Management

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Abstract: Environmental aspects are considered a specific process that requires a multidisciplinary analysis, as the application of indicators in organizations stems from effective performance management; the tourism sector is no exception. In 2015, the United Nations formulated 17 sustainable development goals to contribute to a common vision for people and the planet. The main objective of this study is to propose a framework of science-based environmental sustainability indicators for the hospitality industry, which can be used by hotel managers to improve the efficiency of sustainable management of tourism destinations. This study used a mixed methodology of systematic review and content analysis, which is an innovative methodological approach; an in-depth analysis of various scientific articles, consultancy firms' websites, and technical books was carried out. The results categorized the environmental indicators into four domains: water, energy, waste, and emissions. After a framework was established with 24 environmental indicators, the most relevant were water consumption per guest, water consumption per occupied room, and energy consumption per square meter/foot. However, there were disparities in the use of indicators between the scientific literature, consultancy firms, and the technical books. In this way, there is a need to create stronger relationships between these sources for effective adoption by hoteliers, allowing for adequate environmental indicators with positive impacts on the tourism destination management.

Keywords: hospitality industry; environmental indicators; sustainability indicators; tourism destination; sustainable management

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1. Introduction

Sustainability, an increasingly discussed concept in the literature, is grounded in three fundamental pillars: economic, sociocultural, and environmental (Lee et al. 2021). Sustainability, in general, embraces a variety of concepts, which include the three perspectives of the sustainability triple bottom line.

In this regard, in 2015, the United Nations established 17 Sustainable Development Goals aimed at the sustainable development of people and the planet at large. In the same way, according to the European Commission's Standards and Guidelines (FI Group 2023), companies' sustainability reports will soon become mandatory. In this way, companies will have to present concrete information on various topics such as environmental, social, and governance. Some companies have already adopted these practices in anticipation of the criteria and a roadmap for non-financial information (Pestana Hotel Group 2022).

Addressing environmental sustainability, the aim is to preserve natural resources and protect global ecosystems, even though decisions with environmental impacts may be delayed in producing perceived effects. In the particular case of the tourism sector, environmental sustainability is considered crucial (Baydeniz and Kart 2024; Sphera 2024), given that current institutional pressures impose a voluntary environmental strategy on

companies to mitigate impacts (Mata et al. 2018), justifying the connection with the scope and objective of this study.

Furthermore, the attractiveness of tourism destinations is significantly related to the quality and quantity of natural resources, and some destinations suffer serious environmental impacts from tourism. There is, therefore, a growing need to assess environmental sustainability in this sector using indicators that consider the specific characteristics of the natural environment (Leka et al. 2023). In this way, sustainable tourism is a complex phenomenon that requires the development of a future vision and the establishment of objectives. Planning involves anticipating and regulating a system that promotes development and enhances social, economic, and environmental processes. These processes serve as the foundation for understanding tourism in a destination (Morpeth and Yan 2015).

Despite making a significant contribution to the economies of countries, tourism is a sector associated with increasing concerns about sustainability-related negative impacts (Lee et al. 2021; Aria et al. 2023). However, tourists have become more discerning, showing increased awareness of sustainable practices implemented at destinations. According to Pagliara et al. (2020) and Campa et al. (2019), countries with high tourist attractiveness rates consider the impacts of high-speed rail to be important. This awareness extends to their accommodation choices, making sustainability a critical factor for the hospitality industry (Lee et al. 2021). Sustainability is viewed as something volatile in the hospitality industry (Oriade et al. 2021). However, Oriade et al. (2021) suggest the establishment of a robust corporate culture to assist in sustainability management and advocate for the empowerment of employees in this regard.

In this way, hoteliers should seek measures to enhance sustainable performance. One way to conduct this analysis is using hospitality sustainability indicators. Sustainability indicators assist managers in assessing sustainability impacts and taking actions to mitigate these consequences (Lee et al. 2021). These indicators are essential tools for measuring and monitoring, for instance, the consumption of natural resources, emission of pollutants, and proper waste management. However, the effectiveness of these indicators is only achievable when aligned with various initiatives planned by managers (Duric and Topler 2021).

In the same context, even the most widely used accounting system in the hospitality industry, the USALI (Uniform System of Accounts for the Lodging Industry) has developed specific environmental sustainability indicators, recently modifying an operational statement on energy (HANYC 2022). Moreover, according to Lee et al. (2021), companies utilizing sustainability indicators enable better planning, management, and monitoring of their processes. Thus, these authors assert that the development of sustainable indicator frameworks is crucial for tourism. However, they argue that assessments of sustainability indicators are limited.

Therefore, considering the challenges presented earlier, the main objective of this study is to propose a science-based framework of environmental sustainability indicators for the hospitality industry, which can be used by hoteliers as a tool for assessing the quality of destinations' environmental management. Scientific contributions are evident through the compilation of various environmental sustainability indicators applied to the hospitality industry in a single study, reflecting practical application by hoteliers. This enables a comprehensive assessment of environmental performance. Moreover, economic viability can also be evaluated by managers, as the application of these indicators enhances cost control effectiveness.

Several previously studies have analyzed various sustainable practices, showing that they are increasing (Golicic and Smith 2013; González-Rodríguez et al. 2019). However, it is necessary to monitor them. In addition, environmental indicators have already been developed for several tourism destinations, but this has not yet been conducted for hotels (Tournaki et al. 2018). In this way, the present study stands out for realizing environmental indicators that manifest in a useful framework for hotel managers to better control their costs and make more informed decisions based on important and monitored informa-

tion and to have useful indicators for hotel management and the consequent responsible management of the tourism destination.

In other research, the excessive number of visitors in tourism destinations highlights the importance that should be given to environmental practices and indicators, which sometimes clash with the performance of other indicators (e.g., economic), and this can lead to problems (Berselli et al. 2022; Matarazzo 2022).

In the study by Silveira et al. (2021), various environmental practices and indicators were developed, among others, for the tourism sector. However, not all of them can be applied to the hospitality subsector, as the performance management of a hotel is reflected in various ways: social responsibility, continuous development, and satisfaction of guests and stakeholders. Over the years, several strategies have been developed to promote the environmental sustainability of businesses by applying indicators that enable effective environmental performance management. This involves the application of various techniques and tools to empower managers, enhance individual employee performance and ensure the proper utilization of resources in a hotel business (Duric and Topler 2021).

According to Jhunjhnuwala (2023), customers are interested in understanding the environmental strategy adopted by hotels in various aspects such as decarbonization, water management, waste management, electric vehicle charging facilities, and even the implementation of a circular economy. Garrido et al. (2023), in their study, introduced an index model on the circular economy for practical implementation to compare the performance of sustainability practices between hotels. This index makes it possible to benchmark the performance of hotels with a lower level of implementation of these practices, identifying viable paths for improvement. However, as Krivokapi and Jovanovi (2009) note, the only environmental management system commonly used is the ISO 14001 standard, which does not recognize environmental performance as a key factor for certification. Additionally, hotel managers must ascertain whether the environmental sustainability strategies they adopt align with guest preferences, understanding how this affects the guest−hotel relationship and behavior positively or negatively (Bashir et al. 2019).

To address these weaknesses, Rao et al. (2009) present several categories of environmental sustainability indicators in their study, such as environmental performance indicators and environmental management indicators. The category of environmental performance indicators suggests the following ones: consumption/output ratio; raw material efficiency; packaging-to-output ratio; reusable packaging ratio; hazardous material ratio; recyclable raw materials ratio; energy cost ratio; energy consumption ratio; renewable energy ratio; water consumption ratio; total waste-to-output ratio; recycling waste ratio; waste for disposal ratio; hazardous waste ratio; specific waste ratio; amount of air emissions; recycled wastewater ratio; wastewater ratio. The category of environmental management indicators suggests the following ones: environment investment per year; operating cost of environmental protection per year (specifying the kind of investment made); training on environment issues; environmental training/employees; environmentally trained employees (number); budget for environmental training (yes/no); importance of environment training to employee; environment assessment of suppliers conducted; ratio of purchased goods from environmentally assessed suppliers. More recently, Cheong and Lee (2021) further divided environmental indicators into different dimensions, including environmental policy; water resources; energy; solid waste; indoor environment; green purchasing; corporate management; staff education; public and community relationships; consumer education.

The study by Horng et al. (2016) also identified some indicators that can assist managers in maintaining environmentally sustainable innovation, as the knowledge of managers is limited (Lee et al. 2021). Petrevska and Cingoski (2017) corroborate and state that hoteliers are aware of the concept of environmental sustainability, such as renewable energy sources, but measures are not adopted to replace conventional energy with alternative sources.

The study by Alipour et al. (2019) contradicts previous authors and asserts that hotel operations comply with sustainability principles implicit in various organizations

(UNWTO—World Tourism Organization, European Union), particularly at the environmental level, and hotel company employees consider these sustainability practices as genuine.

Environmental indicators enable the optimization of environmental management and enhance internal processes in decision-making (Stylos et al. 2018). Moreover, they allow for measuring future economic prosperity (Jurigová et al. 2016). Consequently, the relevance of the present study is evident through the importance that environmental sustainability indicators hold in the hospitality industry.

2. Materials and Methods

The present study chose a systematic review-mixed methodology with a bibliometric approach (Araújo 2006; Koseoglu et al. 2016; Cardoso et al. 2024; Almeida et al. 2023; Nguyen et al. 2020) by using content analysis to achieve the stated objective. The objective revolved around proposing a framework of environmental sustainability indicators for the hospitality industry based on the existing literature, like the approaches taken by Paterno et al. (2023) and Lee et al. (2021) in their studies.

To develop a rigorous and replicable methodological process for other researchers, the study commenced with the creation of a search chain that encompassed topics such as hospitality, environment, and indicators: (hotel* OR hospitality* OR lodging*) AND (ratio* OR indicator* OR metric* OR rate*) AND environment* AND NOT (build* OR construction). The Scopus database was employed for this purpose. This database was also used by other authors to achieve their results (Cardoso et al. 2022; Soliman et al. 2021; Campos et al. 2023). This database was chosen as the data source due to its status as one of the largest multidisciplinary repositories of high-quality abstracts and citations from the peer-reviewed literature (Scopus 2023).

In the initial phase, the search string yielded 1316 documents. Search criteria were established, namely specific areas such as environmental science; social science; business, management and accounting; economics, econometrics and finance; multidisciplinary, which resulted in 751 documents. Only scientific articles (616 documents) in English (594 documents) were selected. Additionally, considering that the Sustainable Development Goals were set by the United Nations in 2015, the authors decided to include only the period from 2015 until the date of the research—24 October 2023, imparting contemporary nature to the present study, resulting in the selection of 418 documents.

Following this phase, all scientific articles were extracted (downloaded) for reading their abstracts and performing comprehensive analysis to check for environmental sustainability indicators. After this analysis, 322 articles were excluded for not being related to the topic (such as plants, health, organization environment, or macro tourism) or not presenting environmental sustainability indicators, resulting in a total of 96 scientific articles. All the documents were read in detail, and the final sample resulted in 28 studies.

Given that the sample was considered small by the authors, additional sources of evidence, such as the websites of 19 international consulting firms and nine technical books, were accessed. This research resulted in relevant information from four consulting firms (HSR 2023; Verdant Consulting 2023; Spider Strategies 2021; CBRE 2023) and one technical book (HANYC 2014). This search for a larger number of relevant sources of evidence promoted a diversity of perspectives and an understanding of different contexts and cultural phenomena (Turato 2000). The same method was applied in the study by Paterno et al. (2023) by using triangulation.

Figure 1 summarizes the process described above. Considering the main objective of the study, which was the creation of a framework of environmental sustainability indicators useful for hoteliers, micro-indicators were analyzed, excluding macro-indicators, as the intention was to apply them to a hotel and not to an area or sector such as tourism. The Scientific Procedures and Rationales for Systematic Literature Reviews (SPAR-4-SLR) protocol was adopted, as in the study of Cardoso et al. (2024).

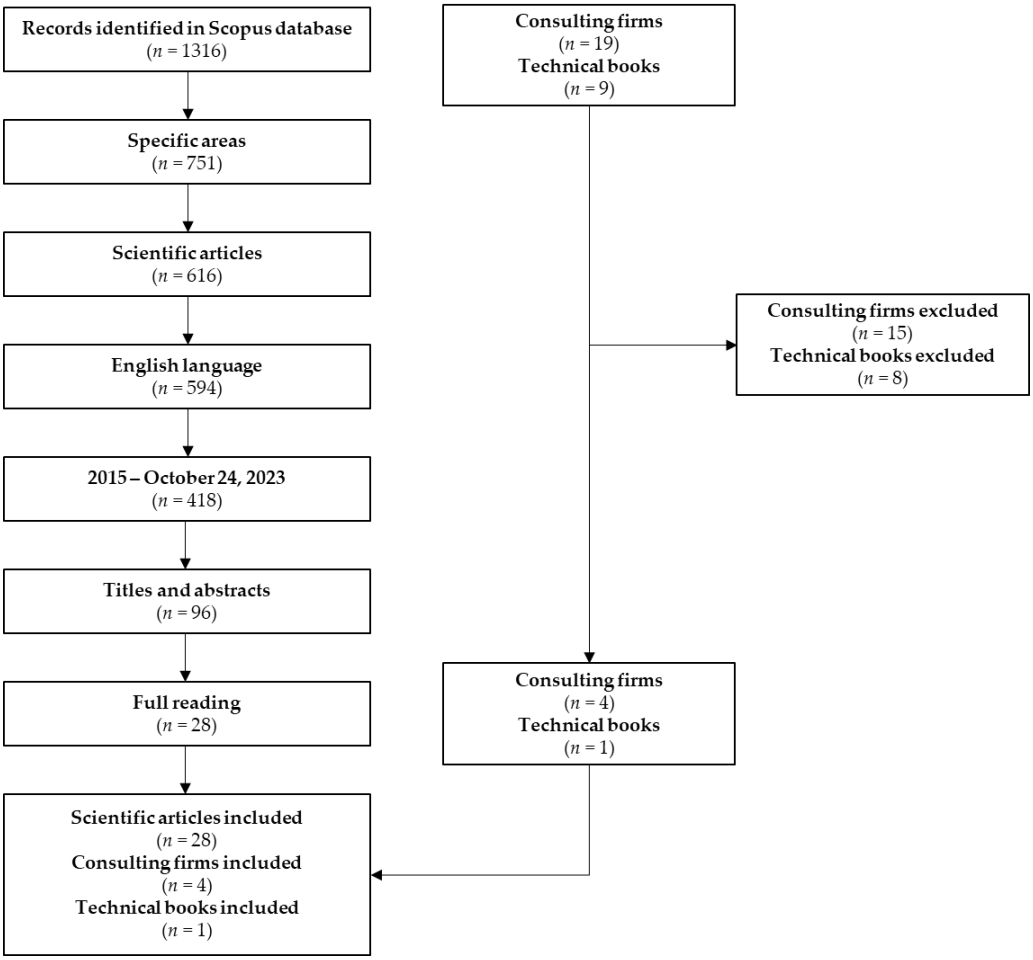

Figure 1. Selection process for studies.

3. Results

3.1. Overall Results

After an in-depth analysis of the final sample, based on information from the scientific literature, the consulting firms, and the technical book, the environmental indicators were categorized into four different domains: energy, water, waste, and emissions. The domain with the highest number of environmental indicators was water, which is perceptible as water resources are becoming increasingly scarce in different tourism destinations of the world (Becken and McLennan 2017; Asseng et al. 2001). Energy had also a significant number of environmental indicators, some of which are related to companies' commitment to renewable energies (Omune et al. 2021; Lee et al. 2021). Waste indicators are currently growing in prominence, with a focus on the waste generated by food production (Omune et al. 2021; Voukkali et al. 2021; Khan et al. 2023; Lee et al. 2021). In some regions of the world, tourism has led to an increase in waste production (Aria et al. 2023). Regarding the hospitality industry studied here, emissions were not the most important when compared to subsectors such as transport (i.e., aviation) (Tournaki et al. 2018); however, the technical book (HANYC 2014) included in the sample highlighted emissions indicators, distinguishing them by gas and steam. Various tables containing the environmental indicators obtained from the sample organized by domain are shown as follows.

Table 1 presents a total of 28 water indicators. The table includes simpler indicators such as water use, effective water use, and water recycling, as well as more complex indicators that rely on formulas for measurement, such as water consumption, water saving, chilled water, consumption per night, and percentage (all with different purposes). The indicators most explored in this domain by sources of evidence were water use with

seven references in the scientific literature; water savings with eight references in the scientific literature; and water consumption per overnight guest with one reference in the scientific literature, two references in the consulting firms, and one reference in the technical book.

Table 1. Water indicators.

Indicator		Formula	Source(s)
Water use		N.A.	Becken and McLennan (2017); Bianco et al. (2023); Duric and Topler (2021); Hsiao and Chuang (2016); Mendoza et al. (2023); Omune et al. (2021); Voukkali et al. (2021)
Effective use of water		N.A.	Bagheri et al. (2020); Chan and Hsu (2016); Singh et al. (2023); HSR (2023)
Water recycling		N.A.	Lee et al. (2021); Piya et al. (2022)
Water consumption	Cost	N.A.	Omune et al. (2021); Dziuba (2016); Becken and McLennan (2017)
	Per available room	$\frac{\text{Water use}}{\text{Rooms available}}$	HANYC (2014); Michailidou et al. (2015)
	Per occupied room	$\frac{\text{Water use}}{\text{Rooms occupied}}$	CBRE (2023); Greenview (2022); HANYC (2014); Michailidou et al. (2015)
	Per overnight guest	$\frac{\text{Water use}}{\text{Number of overnight guests}}$	Becken and McLennan (2017); Michailidou et al. (2015); Styles et al. (2015); HANYC (2014); Verdant Consulting (2023)
	Per square meter/foot	$\frac{\text{Water use}}{m^2 \text{ or feet}}$	Becken and McLennan (2017); Greenview (2022); Michailidou et al. (2015)
	Water use intensity	$\frac{\text{Anual water use}}{\text{Total hotel space consuming water}}$	Duric and Topler (2021)
Water saving	Water savings	N.A.	Bianco et al. (2023); Duric and Topler (2021); Mendoza et al. (2023); Omune et al. (2021); Rodríguez-García et al. (2023); Sarmiento and El Hanandeh (2018); Silveira et al. (2021); Styles et al. (2015)
	Per available room	$\frac{\text{Water saving}}{\text{Rooms available}}$	Styles et al. (2015)
	Per overnight guest	$\frac{\text{Water saving}}{\text{Number of overnight guests}}$	Wong et al. (2021)
Chilled water	Per available room	$\frac{\text{Water use}}{\text{Rooms available}}$	HANYC (2014)
	Per occupied room	$\frac{\text{Water use}}{\text{Rooms occupied}}$	HANYC (2014)
	Per overnight guest	$\frac{\text{Water use}}{\text{Number of overnight guests}}$	HANYC (2014)

Table 1. *Cont.*

	Indicator	Formula	Source(s)
Per night	Consumption of fitting flow rates	$\frac{\text{Water consumption of fitting flow rates}}{\text{Number of nights}}$	Styles et al. (2015)
	Consumption of irrigation	$\frac{\text{Water consumption of irrigation}}{\text{Number of nights}}$	Styles et al. (2015)
	Consumption of the pool	$\frac{\text{Water consumption of pool}}{\text{Number of nights}}$	Styles et al. (2015)
	Consumption of the kitchen	$\frac{\text{Water consumption of kitchen}}{\text{Number of nights}}$	Styles et al. (2015)
	Consumption of the dishwashing	$\frac{\text{Water consumption of dishwashing}}{\text{Number of nights}}$	Styles et al. (2015)
	Consumption of the flush volume	$\frac{\text{Water consumption of flush volume}}{\text{Number of nights}}$	Styles et al. (2015)
	Laundry efficiency	$\frac{\text{Water use (L)}}{\text{Laundry use (Kg)}}$	Styles et al. (2015)
	Laundry generation	$\frac{\text{Laundry use (Kg)}}{\text{Number of nights}}$	Styles et al. (2015)
Percentage	Average annual cost savings from investments in water conservation	$\frac{\text{Average water costs savings}}{\text{Total of water costs}} \times 100$	Duric and Topler (2021)
	Change in total water use	$\frac{\text{Water used}_t - \text{Water used}_{t-1}}{\text{Water used}_{t-1}} \times 100$	Becken and McLennan (2017)
	Change in water use per guest-night	$\frac{\text{Water used per guest/night}_t - \text{Water used per guest/night}_{t-1}}{\text{Water used per guest/night}_{t-1}} \times 100$	Becken and McLennan (2017)
	Change in water use per square meters	$\frac{\text{Water used per m}^2{}_t - \text{Water used per square m}^2{}_{t-1}}{\text{Water used per m}^2{}_{t-1}} \times 100$	Becken and McLennan (2017)
	Water efficiency	$\frac{\text{Water output}}{\text{Water input}} \times 100$	Mendoza et al. (2023)

N.A.—Not applicable.

Table 2 presents a total of 16 energy indicators. Several indicators do not require formulas for measurement, such as energy use, supply and efficient use of energy, energy savings, energy consumption from renewable sources, and energy consumption cost. Indicators like energy consumption per overnight stay, per available room, per occupied room, per square meter/foot, and use intensity were assisted through specific formulas that can aid hotel managers; the same applied to energy percentage at various levels. Regarding the most relevant energy indicators in the sample, it was observed that energy savings and energy use appeared most frequently (11 times and eight times in the scientific literature, respectively). Energy consumption per square meter was also significant, referenced two times in the scientific literature, one time in the consulting firms, and one time in the technical book. Although the indicator energy consumption per occupied room was not referenced in the scientific literature, it was mentioned two times in the consulting firms and one time in the technical book.

Table 3 presents a total of 12 waste indicators. These indicators were mostly identified in the scientific literature, except for the percentage of waste recycled off-site and the percentage of waste reused on-site, both considered by a consulting firm. No waste indicators were found in the technical book. Food waste was the most relevant indicator in the scientific literature, appearing in four studies from the sample. It was followed by waste recycling and waste per overnight guest, both referenced in two studies in the scientific literature. The remaining waste indicators were referenced only once in the scientific literature of the studied sample.

Table 2. Energy indicators.

Indicator		Formula	Source(s)
Energy use		N.A.	Becken and McLennan (2017); Bianco et al. (2023); Khan et al. (2023); Ohlan (2022); Singh et al. (2023); Syariati et al. (2023); Xu et al. (2021); Voukkali et al. (2021)
Supply and efficient use of energy		N.A.	El Alaoui et al. (2023); Bagheri et al. (2020); Chan and Hsu (2016); Ohlan (2022)
Energy savings		N.A.	Bianco et al. (2023); Chan and Hsu (2016); Duric and Topler (2021); Hsiao and Chuang (2016); Machete et al. (2016); Ohlan (2022); Omune et al. (2021); Rodríguez-García et al. (2023); Sarmiento and El Hanandeh (2018); Syariati et al. (2023); Lee et al. (2021)
Energy consumption (kWh)	From renewable sources	N.A.	Omune et al. (2021); Lee et al. (2021)
	Cost	N.A.	Dziuba (2016)
	Per overnight stay	$\frac{\text{Energy use}}{\text{Total overnight guests}}$	Becken and McLennan (2017); HANYC (2014)
	Per available room	$\frac{\text{Energy use}}{\text{Rooms available}}$	HANYC (2014); Michailidou et al. (2015); Wong et al. (2021)
	Per occupied room	$\frac{\text{Energy use}}{\text{Rooms occupied}}$	Greenview (2022); HANYC (2014); CBRE (2023)
	Per square meter/foot	$\frac{\text{Energy use}}{\text{m}^2 \text{ or feet}}$	Becken and McLennan (2017); Michailidou et al. (2015); Greenview (2022); HANYC (2014)
	Use intensity	$\frac{\text{Annual energy use}}{\text{Total hotel space consuming energy}}$	Duric and Topler (2021)
Percentage	Average cost savings from investments in energy conservation	$\frac{\text{Average energy costs savings}}{\text{Total of energy costs}} \times 100$	Duric and Topler (2021)
	Facilities with energy reduction targets	$\frac{\text{Facilities with energy reduction}}{\text{Total of facilities}}$	Silveira et al. (2021)
	Change in total energy use	$\frac{\text{Energy used}_t - \text{Energy used}_{t-1}}{\text{Energy used}_{t-1}} \times 100$	Becken and McLennan (2017)
	Change in energy use per guest/night	$\frac{\text{Energy used per guest/night}_t - \text{Energy used per guest/night}_{t-1}}{\text{Energy used per guest/night}_{t-1}} \times 100$	Becken and McLennan (2017)
	Change in energy use per square meters	$\frac{\text{Energy used per m}^2{}_t - \text{Energy used per m}^2{}_{t-1}}{\text{Energy used per m}^2{}_{t-1}} \times 100$	Becken and McLennan (2017)
	Energy efficiency	$\frac{\text{Energy output}}{\text{Energy input}} \times 100$	Ohlan (2022); Xu et al. (2021)

N.A.—Not applicable.

Table 4 presents a total of 18 emissions indicators. Although the emissions indicators were more numerous than waste indicators and energy indicators, eight of these indicators appeared only in the technical book. The reason why HANYC (2014) gives so much importance to these indicators may be linked to emission issues in the country of origin of

the technical book—the United States of America (Black 2009). The most relevant emission indicator in the sample was the carbon footprint, referenced four times in the scientific literature. CO_2 emissions were mentioned only two times in the scientific literature, as was the hotel carbon per occupied room; however, the latter indicator was referenced in the consulting firms. The remaining indicators presented in the table appeared only once in the scientific literature.

Table 3. Waste indicators.

Indicator		Formula	Source(s)
Waste	Food	N.A.	Omune et al. (2021); Khan et al. (2023); Li et al. (2019); Voukkali et al. (2021)
	Use	N.A.	Becken and McLennan (2017)
	Disposal costs	N.A.	Dziuba (2016)
	Recycling	N.A.	Bianco et al. (2023); Hsiao and Chuang (2016)
	Per overnight guest	$\frac{\text{Waste}}{\text{Total overnight guests}}$	Becken and McLennan (2017); Chaabane et al. (2018)
	Per square meter	$\frac{\text{Waste}}{\text{m}^2}$	Becken and McLennan (2017)
	Per capita	$\frac{\text{Waste}}{\text{Number of individuals}}$	Yu and Chiu (2021)
Percentage	Average cost savings from waste recycling	$\frac{\text{Waste cost savings}}{\text{Waste recycling}} \times 100$	Duric and Topler (2021)
	Waste recycled off-site	$\frac{\text{Waste cost savings}}{\text{Waste recycling}} \times 100$	Spider Strategies (2021)
	Waste reused on-site	$\frac{\text{Waste reused on} - \text{site}}{\text{Waste recycling}} \times 100$	Spider Strategies (2021)
	Change in total waste use	$\frac{\text{Waste}_t - \text{Waste}_{t-1}}{\text{Waste}_{t-1}} \times 100$	Becken and McLennan (2017)
	Change in waste use per guest-night	$\frac{\text{Waste per guest/night}_t - \text{Waste per guest/night}_{t-1}}{\text{Waste per guest/night}_{t-1}} \times 100$	Becken and McLennan (2017)

N.A.—Not applicable.

Table 4. Emissions indicators.

Indicator		Formula	Source(s)
Emissions	CO_2 emissions	N.A.	Bianco et al. (2023); Khan et al. (2023)
Steam consumption	Per available room	$\frac{\text{Thousand pounds (kilograms)}}{\text{Rooms available}}$	HANYC (2014)
	Per occupied room	$\frac{\text{Thousand pounds (kilograms)}}{\text{Rooms occupied}}$	HANYC (2014)
	Per overnight guest	$\frac{\text{Thousand pounds (kilograms)}}{\text{Number of overnight guestrs}}$	HANYC (2014)
	Per square meter/foot	$\frac{\text{Thousand pounds (kilograms)}}{\text{m}^2 \text{ or feet}}$	HANYC (2014)
	Per available room	$\frac{\text{Number of therms}}{\text{Rooms available}}$	HANYC (2014)
	Per occupied room	$\frac{\text{Number of therms}}{\text{Rooms occupied}}$	HANYC (2014)
	Per overnight guest	$\frac{\text{Number of therms}}{\text{Number of overnight guestrs}}$	HANYC (2014)
	Per square meter/foot	$\frac{\text{Number of therms}}{\text{m}^2 \text{ or feet}}$	HANYC (2014)

Table 4. *Cont.*

Indicator		Formula	Source(s)
Carbon footprint	Footprint	N.A.	Machete et al. (2016); Chan and Hsu (2016); Silveira et al. (2021); Sarmiento and El Hanandeh (2018)
	Reduction	N.A.	Chan and Hsu (2016)
	Per occupied room	$\frac{\text{Carbon footprint}}{\text{Rooms occupied}}$	Michailidou et al. (2015)
	Per guest night	$\frac{\text{Carbon footprint}}{\text{Number of overnight guestrs}}$	Michailidou et al. (2015)
	Per square meter	$\frac{\text{Carbon footprint}}{m^2}$	Michailidou et al. (2015)
HCMI (hotel carbon measurement initiative)	Per room	$\frac{\text{HCMI rooms carbon footprint}}{\text{Total of rooms}}$	Greenview (2022)
Hotel carbon	Per room	$\frac{\text{Hotel carbon}}{\text{Total of rooms}}$	Greenview (2022)
	Per occupied room	$\frac{\text{Hotel carbon}}{\text{Rooms occupied}}$	Greenview (2022); CBRE (2023)
	Per square meter/foot	$\frac{\text{Hotel carbon}}{m^2 \text{ or feet}}$	Greenview (2022)

N.A.—Not applicable.

3.2. The Framework of Environmental Indicators

To establish a scientifically based framework of environmental sustainability indicators for the hospitality industry to be used by hoteliers, Table 5 comprises a total of 24 indicators, including nine indicators related to water, nine indicators related to energy, three indicators related to waste, and three indicators related to emissions. This framework was developed based on information obtained from the scientific literature, the consulting firms, and the technical book, as well as the studies by Alves et al. (2019) and Paterno et al. (2023). An "×" in Table 5 shows that the indicator is present in the source of evidence listed at the top of the table. For the development of this framework, the authors considered indicators that simultaneously appear in three research sources (the scientific literature, the consulting firms, and the technical book) and two sources of evidence (the scientific literature and the consulting firms OR the scientific literature and the technical book OR the consulting firms and the technical book). Considering that some indicators appear multiple times in the scientific literature and consulting firms, the authors considered indicators that appear twice either in the scientific literature or in the consulting firms.

Three indicators appear simultaneously in the analyzed sources of evidence: water consumption per overnight guest, water consumption per occupied room, and energy consumption per square meter/foot. Consequently, there was greater attention to water and energy indicators by different sources of evidence compared to that to other indicators. The energy consumption per occupied room indicator was not mentioned in the scientific literature, but it was relevant in the consulting firms and the technical book, as well as the hotel carbon per occupied room, which was referenced only in the consulting firms. These indicators became interesting to analyze, because inconsistencies were observed between the scientific literature and what was developed in practices by the consulting firms in hotels. The remaining indicators in the framework were referenced only in the scientific literature.

In this way, despite the growth of studies on environmental indicators in tourism destinations, tourism, and hospitality, there is still much work to be performed in this area, so that both parties—the scientific literature and the consulting firms—are complying, and the work conducted by hotel managers is facilitated. Although it is not the aim of this study, it is also important to measure compliance rates in relation to reference values, which

is part of the monitoring process and can be facilitated through the use of information technology. This dual need is not only due to the fact that environmental sustainability is an emerging topic at a global level, but also an urgent issue for the nations' well-being and for the viability of the tourism sector, particularly the hospitality industry.

Table 5. Framework of environmental indicators for the hospitality industry.

Domain	Indicators	The Scientific Literature	The Consulting Firms	The Technical Book
Water	Water consumption per overnight guest	×	×	×
	Water consumption per occupied room	×	×	×
	Water consumption per available room	×		×
	Water consumption per square meter/foot	×	×	
	Effective use of water	×	×	
	Water cost consumption	×		
	Water recycle	×		
	Water savings	×		
	Water use	×		
Energy	Energy consumption per square meter/foot	×	×	×
	Energy consumption per available room	×		×
	Energy consumption per overnight stay	×		×
	Energy consumption per occupied room		×	×
	Energy consumption from renewable source	×		
	Energy efficiency	×		
	Energy use	×		
	Energy savings	×		
	Energy supply and efficient use of energy	×		
Emissions	Hotel carbon per occupied room		×	
	Carbon footprint	×		
	CO_2 emissions	×		
Waste	Waste per overnight guest	×		
	Food waste	×		
	Waste recycling	×		

4. Conclusions

The main objective of this study was to establish a scientifically based framework of environmental sustainability indicators for the hospitality industry to be used by hoteliers. For this purpose, the methodology used was bibliometric and involved analyzing the content of various scientific articles (the scientific literature), as well as the websites of various consulting firms and technical books.

The results show that, out of the 74 environmental indicators across the four studied domains (water, energy, waste, and emissions), a framework with 24 environmental indicators has been developed and proposed. Initially, a significantly positive focus was observed on indicators related to water reduction and conservation, energy use, renewable energy, as well as concerns about food waste and the carbon footprint of hotels. However, upon presenting the framework that encompasses all four domains and comparing the various sources of evidence and the significance of indicators in each, it is evident that the indicators present across all sources of evidence were shown as follows: water consumption

per overnight guest, water consumption per occupied room, and energy consumption per square meter/foot.

The results also reveal a disparity in the indicators used among the scientific literature, the consulting firms, and the technical book. It was observed that many indicators presented in the scientific literature are not being applied in practice, and vice versa. Therefore, it is advisable to strengthen the relationships between the different sources of evidence analyzed, as some hotel practices are beginning to be adopted but cannot yet be measured through indicators.

If these environmental indicators were effectively adopted by hoteliers, they would allow for proper environmental management, which would have a positive impact on the management of the tourism destinations in which they operate. Considering the initial objective of proposing a science-based framework of environmental indicators, the greatest contribution of the research is the provision of a tool for assessing the quality of environmental management in destinations.

In terms of theoretical implications, it is evident that this study has contributed to strengthening scientific knowledge in the realm of environmental management indicators focused on the hospitality industry. Despite the frequent discourse on environmental sustainability, there remains a considerable amount to be explored in this field, particularly within the tourism and hospitality sector where environmental impacts are significant. Guests are increasingly interested in topics such as that shown in this study, highlighting a substantial potential for further development.

Regarding practical implications, the synthesis presented in this study on environmental indicators enables managers to conduct a quick analysis, which can be effectively applied in their hotel businesses. By using these indicators, managers can implement more effective environmental sustainability measures that will translate into improved assessment and communication of their performance. Furthermore, by proposing a framework of indicators, this study anticipates the mandatory implementation of sustainability reports by companies in the environmental realm.

This study also provides evidence for future research, such as exploring the association between hotel environmental management and technology to make this process more dynamic. Studies that validate the utility of these indicators in specific cases of hotels or hotel chains through interviews, questionnaires, or case studies could also be conducted in the future. These studies will allow the hospitality industry to get closer not only to the sustainable development goals established by the United Nations, but also to the mandatory introduction of sustainability indicators in hotel reports shortly. Future studies could also be replicated in the context of sustainable management of tourism destinations by connecting sustainability to the way tourists travel to the destination, whether through more sustainable transportation or not, and consequently proposing new environmental indicators. Another avenue for future research is the study of the monitoring processes of the framework of environmental indicators in relation to the reference values.

A limitation of this study was found when reading the abstracts of the downloaded articles, as the term "hospitality" is associated with both the hospitality industry and the health context. This led to the collection (and subsequent removal) of various scientific articles related to health issues during the research process, which did not contribute to the study.

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