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Sustainability Indicators in the Hotel Industry: A Systematic Review and Multiple Criteria Decision Analysis

Indicadores de Sostenibilidad en la Industria Hotelera: Una Revisión Sistemática y un Análisis de Decisión de Criterios Múltiples

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Abstract

The hotel industry is an important sector for the economic development of many countries. While the positive effect is reflected in increased revenue, it often negatively affects the environment due to resource consumption and waste and emissions production. Additionally, it can cause social problems such as social exclusion, cultural distortion, and damage to material and immaterial heritage. Currently, the hotel industry seeks to minimize these effects by applying sustainable indicators; however, the diversity of indicators and the lack of a universally accepted indicator list make it difficult to determine which are appropriate for the hotel industry under current conditions. Therefore, the aim of this study is to identify sustainability indicators that have been applied by the hotel industry during the period 2016-2021 to facilitate their identification, grouping, and delimitation for future research. To this end, a systematic literature review based on the PRISMA 2020 statement was conducted, resulting in the identification of scientific articles reporting sustainability indicators, which were subsequently grouped into the following categories: Environmental, Social, Economic, Political, Cultural and Technological. Subsequently, a multi-criteria decision-making method was applied to identify the most commonly used indicators in the hotel industry, resulting in an updated list that ranks the indicators from best to worst rated.

Keywords:
Tourism, hospitality industry, sustainability indicators, systematic review, multi-criteria decision-making..

Resumen

La industria hotelera es un sector importante para el desarrollo económico de muchos países, si bien, el efecto positivo se refleja en más ingresos, a menudo se afecta negativamente al medio ambiente por el consumo de recursos y la producción de residuos y emisiones. Además, puede causar problemas sociales como exclusión social, distorsión cultural y daños al patrimonio material e inmaterial. En la actualidad, la industria hotelera intenta minimizar estos efectos mediante la aplicación de indicadores sostenibles, sin embargo, la diversidad de indicadores y la falta de una lista de indicadores universalmente aceptada dificultan la determinación de cuáles son apropiados para la industria hotelera en las condiciones actuales. Por ello, el objetivo de este trabajo es identificar aquellos indicadores de sostenibilidad que han sido aplicados por la Industria Hotelera en el periodo 2016-2021 con el fin de facilitar su identificación, agrupación y delimitación a futuras investigaciones. Para ello, se ha llevado a cabo una revisión sistemática de la literatura basada en la declaración PRISMA 2020, que ha dado como resultado la identificación artículos científicos que reportan indicadores de sostenibilidad, mismos que posteriormente se han agrupado en las categorías: Ambiental, Social, Económica, Política, Cultural y Tecnológica. Posteriormente, para identificar los indicadores más utilizados en la industria hotelera se aplicó un método de Toma de Decisiones Multicriterio, con el cual se obtuvo un listado actualizado que indica cuáles son los indicadores más apropiados y los ordena del mejor al peor calificado.

Resumen:
Turismo, industria hotelera, indicadores de sostenibilidad, revisión sistemática, toma de decisiones multicriterio.

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Introduction

The negative effects of global warming and climate change include damage to ecosystems due to the loss of biodiversity as well as negative social effects such as food insecurity and a shortage of drinking water (Fawzy *et al*., 2020), and even damage to health, agriculture, recreation, and tourism. Finding solutions to these problems is one of the greatest challenges humanity has ever faced (Bouman *et al*., 2020; Scott, 2021).

Tourism is important for the economic development of many nations, being also a fundamental element for social development; however, it is currently responsible for 5% of total anthropogenic emissions and it is estimated that by 2030 that figure will increase to 5.3% (OMT, 2020). Furthermore, 21% of the total ecological footprint of tourism is generated by the hotel industry (Leyva and Parra, 2021). The hotel industry, which is one of the most influential tourism sectors, is a high consumer of resources such as energy, water and materials, and it produces a significant amount of waste and greenhouse gases (GHG); further contributing to global warming and other types of environmental damage (Al-Aomar and Hussain, 2018; Asadi *et al*., 2020; Kit-Yeng, Abang and May-Chiun, 2021; Leyva and Parra, 2021; Sangeetha, 2020). The hotel industry further impacts local communities sometimes negatively through the occupation of space, use of infrastructure, relationships with local businesses and governments (Al-Aomar and Hussain, 2018). Hotels sometimes promote social exclusion, non-compliance with regulations and introduction of foreign ideologies that distort local culture and damage both tangible and intangible heritage. Therefore, meeting the challenge of sustainability requires the combined efforts of all members of society, and tourism has been identified as a sector with substantial potential to transition to sustainable development (Chen *et al*., 2021; Hassan, Hassan and Moustafa, 2020; Reyes-Santiago, Sánchez-Medina and Díaz-Pichardo, 2019; Walheer and Zhang, 2018). As an essential element of tourism, the hotel industry to achieve this transition has been implementing green strategies and practices and sustainability indicators.

Sustainable practice has recently gained popularity in studies of the hotel industry, with research focused on sustainable management strategies (Rodríguez, 2022) or green practices (Alberton *et al*., 2020; Gössling and Lund-Durlacher, 2021; Hassan *et al*., 2020; Kim, Barber and Kim, 2018; Oriade *et al*., 2021; Reyes-Santiago *et al*., 2019; Sangeetha 2020) being the most frequent. Highlighting literature review reports focused on sustainable practices and strategies (Abdulaali *et al*., 2020; Arun *et al*., 2021; Dolnicar and Otter, 2003; Hsieh and Sang-Mi, 2010; Janković and Krivačić, 2014; Khonje, Simatele and Musavengane, 2019; Kim, Lee and Fairhurst, 2017; Migale, Stimie and Brent, 2019; Mohammed *et al*., 2018; Nisa, Varum and Botelho, 2017; Pirani and Arafat, 2014). Accordingly, there has been significant growth in research in this area since 2003, both in terms of the topics studied and the number of texts analyzed. Concerning topics studied, for example, Arun *et al*. (2021) describes a study focused on customers' reactions to green hotels. However, there has been little study done of how the measure and evaluate the effectiveness of sustainability indicators and practices within the hotel industry either empirically or by means of literature review.

Given the dearth of analysis of the most recent 15 years of exponential growth in this field, the objective of this paper is to conduct a systematic literature review that integrates the work done in the field of sustainable hospitality, in order to identify sustainable indicators that are currently applied in the hotel industry (in the period 2016-2021) and provide an updated list of them, to facilitate their

understanding and delimitation. As there are a large number and diversity of indicators, it is difficult to determine which are the appropriate ones to ensure sustainable development in hotel industry. Therefore, proposed Fuzzy TOPSIS in order to analyze a method that facilitate the determination of the most used and most appropriate indicators for the transition to sustainable development in hotel industry according to three criteria: frequency of use, level of application and year of publication. The rest of the document is structured as follows: methodology, where the methods used in the identification and selection of indicators are presented, followed by the results section, where the indicators found are presented, as well as the updated list obtained, and finally the conclusions, where the possible applications of the information obtained are presented.

Methodology

The development of this research was carried out in three phases, the first one corresponds to the literature review and the second one to an indicator clustering and third to the multi-criteria decision making method.

Literature review

To carry out the systematic literature review for the identification of indicators, the methodology used was based on the PRISMA 2020 statement, taking into account the checklist and diagram provided by that statement (Yepes-Nuñez *et al.,* 2021). To focus study criteria, only those documents that included sustainable indicators within the hotel industry or hotel-oriented tourism, and only scientific articles from 2016 to August 2021 were taken into account.

Google Scholar was the initial source of information, from there relevant topics were selected and the websites of recognized publishers such as Emerald, Elsevier, Routledge Taylor & Francis Group, MDPI, Springer and SAGE were visited, as well as Oxford University Press, Fayoum University and University of Bologna, last but not least, journals such as UTMS Journal of Economics, Research in Hospitality Management, Civil Engineering Journal (Iran), Advances in Economics, Business and Management Research, Malaya Journal of Matematik, International Journal of Advanced Research in Engineering and Technology (IJARET) and International Journal of Applied Information Technology.

The study used three search terms to query the various search engines: *indicators of sustainable hotels*, *indicator hotel sustainable* and *criteria sustainable hotel*, with a search interval of 2016-2021. Articles were first reviewed to verify that they met the eligibility criteria. Such eligible documents were then downloaded and stored in a folder. Once all the documents were selected, the summary or conclusions of each article was analyzed, and those that did not use sustainability indicators were discarded. The next review round excluded those articles that did not apply the indicators to the hotel industry. Finally, the articles were completely analyzed and only those that made use of sustainability indicators within the hotel industry in the established period were selected. Once the documents were selected, a data dump was made (table 1), where the year, publisher, journal, number of indicators, place where the indicators were applied, at what level (international, national or regional) and authors were specified.

Indicator clustering

After identified a large number of indicators, first, the nature of each variable was analyzed to determine to which dimension of sustainable development it belongs, then it was decided to group them by categories, including six since they are the ones mentioned in the literature reviewed. Next, each category was reviewed indicator by indicator and those that shared the same characteristics were grouped into a single indicator, in other words, those indicators that measure the same thing but have different wording were grouped into a single indicator (figure 4).

Multi-criteria decision-making method

To determine which are the most relevant and appropriate sustainable indicators for the hotel industry, the TOPSIS multi-criteria decision method was used to obtain a list of indicators ordered from the best to the worst, the method evaluates according to previously established criteria to reach the best option sought. In consequence, it is important to mention that in order to work any multi alternative decision application a preaddressing must be approach. Based on Munier *et al*. (2019) any multi-criteria analysis demands the conceptualization of several requirements before implementing (Munier, Hontoria and Jiménez-Sáez, 2019):

- Commencing with the definition of all the possible alternatives (A_i), these alternatives will depend on the availability of suitable approaches for solving the decision, therefore their number should be finite and preferably small.
- Continuing by establishing the main criteria set (C_i) for selecting the best alternative, the criteria set should be decided by an expert panel or a previous assessment and analysis for inferring the relevant factors for deciding among the possible alternatives. In simpler terms, it consists on finding which decision criteria is more relevant for the final choice. For this work three criteria were established: C_1= Frequency of use, C_2= Level of application and C_3= Year of publication.
- Consequently, when the two previous sections were achieved a relevant data (D_i) research should be address as well, in order to obtain enough information for the decision-making process. In this case each indicator it was assigned a value according to the information found in literature. In this case, each indicator was assigned a value according to the information found in the literature. For example, for the criterion Frequency of use and Year of application, being quantitative data, the values were left according to the corresponding numbers (if an indicator was used 20 times, its value is 20, while for the criterion of Year of publication within the 20 times it was used, the most recent date is taken into account, that is, if it was used in 2018 but also in 2021, the value given to that indicator is the most recent in this case 2021) finally, for the criterion of Level of application, a number was assigned for each level (international 5, national 4, regional 3, combined 2 and other 1).

Once the mentioned conceptualization was address, the decision can be approach in form of a decision matrix, mentioned structure creates a visual aid when solving multi-criteria decision-making analysis by indexing the decision parameters into a graphic structure for better comprehension as show in equation (1).

$$\begin{bmatrix} \square & C_1 & C_2 & \cdots & Cn \\ A_1 & D_{1,1} & D_{2,1} & \cdots & D_{n,1} \\ A_2 & D_{1,2} & D_{2,2} & \cdots & D_{n,2} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ A_n & D_{1,n} & D_{2,n} & \cdots & D_{n,n} \end{bmatrix} \quad (1)$$

Continuing with the process, the method of TOPSIS was selected for the decision-making process, TOPSIS bases its selection approach on the concept of Euclidian distances, meaning that this method determines distances from one point to another. In consequence, distance evaluation demands an ideal or better value contrasted with a worse o non ideal one for the selection process. Therefore, decision criteria depend on the annexation of weights (W_i) to define priorities and importance which can separated mentioned criteria into better or worse scenarios. For this problem, expert judgment was not used, since the aim was to remove the human bias that could result from the ratings of each attribute, and instead, it was decided to give the same weight to each criterion (Frequency of use, Level of application and Year of publication). As consequence, the decision matrix ends with the form shown next in equation (2):

$$\begin{bmatrix} \square & W_1 & W_2 & \cdots & W_n \\ - & - & - & - & - \\ \square & C_1 & C_2 & \cdots & Cn \\ A_1 & D_{1,1} & D_{2,1} & \cdots & D_{n,1} \\ A_2 & D_{1,2} & D_{2,2} & \cdots & D_{n,2} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ A_n & D_{1,n} & D_{2,n} & \cdots & D_{n,n} \end{bmatrix} \quad (2)$$

In order to turn a TOPSIS analysis into a Fuzzy TOPSIS one the inclusion of Fuzzy logic is a must. Fuzzy logic comes from a change of number properties and its widely use on multi-criteria decision making problems (Hodgett, 2013), and the procedure for turning number into fuzzy sets can be address as follow:

- Determining the geometrical structure for fuzzification, in this research triangular geometry is suggested (equation (3)).
- Fuzzification of number, based on the triangular geometry the fuzzification consist on changing regular number into fuzzy sets. In consequence, it can be express as:
  $n = common\ number$
  $F = fuzzi\ number = (n - 1, n, n + 1)$
- Defuzzification, after utilizing the fuzzy numbers, the final result should be express as common numbers, in triangular geometry case, averages can be utilized to retransform fuzzy sets into single numbers again, as presented in equation (4).

Now to integrate fuzzy logic into the TOPSIS method the follow description of the procedure is given:

- The data input of the performance of the alternatives in the criteria should be fuzzified to indexed it into the decision matrix as shown in equation (5). In case of multiple sources of data, the fuzzification in triangle geometry can be express as follows:

$$F_{ij} = (a_{ij}, b_{ij}, c_{ij}) \tag{3}$$

$$F_{ij} = (\min(D_{ij}), K\sum_{k=1}^{K} D_{ij}, , \max(D_{ij}) \tag{4}$$

Where k is the cuantity of data values.

$$\begin{bmatrix} \square & W_1 & W_2 & \cdots & W_n \\ - & - & - & - & - \\ \square & C_1 & C_2 & \cdots & Cn \\ A_1 & F_{1,1} & F_{2,1} & \cdots & F_{n,1} \\ A_2 & F_{1,2} & F_{2,2} & \cdots & F_{n,2} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ A_n & F_{1,n} & F_{2,n} & \cdots & F_{n,n} \end{bmatrix} \tag{5}$$

- Compute the normalized fuzzy decision matrix, this section requires the separation on beneficial or non-beneficial criteria and utilizes a normalization of the data to scale the values and utilize mentioned data. In this case, only the beneficial criteria were utilized because the aim of this project is to maximize the three criteria, in other words, finding the alternative which gain the highest use, at the high level (international with a value of 5) and the most recent with respect to the literature (equation (6)).

$$r_{ij} = \left(\frac{a_{ij}}{c_{ij}}, \frac{b_{ij}}{c_{ij}}, \frac{c_{ij}}{c_{ij}}\right) \; for \; benefical \; criteria \tag{6}$$

- Pondering the weight into the analysis, the weights are multiplied into the respective normalized fuzzy values using the next formula:

$$v_{ij} = r_{ij} * w_j \tag{7}$$

- Calculation of best and worse value, follow the adjustment of the data based on the weight of the decision, maximum values will be obtained for beneficial criteria and minimum for non-beneficial, functioning as best and worst goal for the distance decision method. Nonetheless, TOPSIS method allows the application of only beneficial criteria while finding a result, as result of this, the implementation request only the comparison of every alternative with the best possible value.
- Determination of Euclidean distance, once the goal of best and worst solution has been stablished, each alternative and its respective criteria is evaluated in terms of distance to both previous mention solutions (equation (8)).

$$d(\tilde{x}, \tilde{y}) = \sqrt{\frac{1}{3}[(a_1 - a_2)^2 + (b_1 - b_2)^2 + (c_1 - c_2)^2]} \tag{8}$$

- Stablishing the distance result, least base on the result of the distance an average of the fuzzy number is obtained and presented, determined that the grates number represents the best option for the indicator.

It is pertinent to clarify that all this process was carried out in Excell, so the matrices and equations were converted to formulas in the cells of Excell.

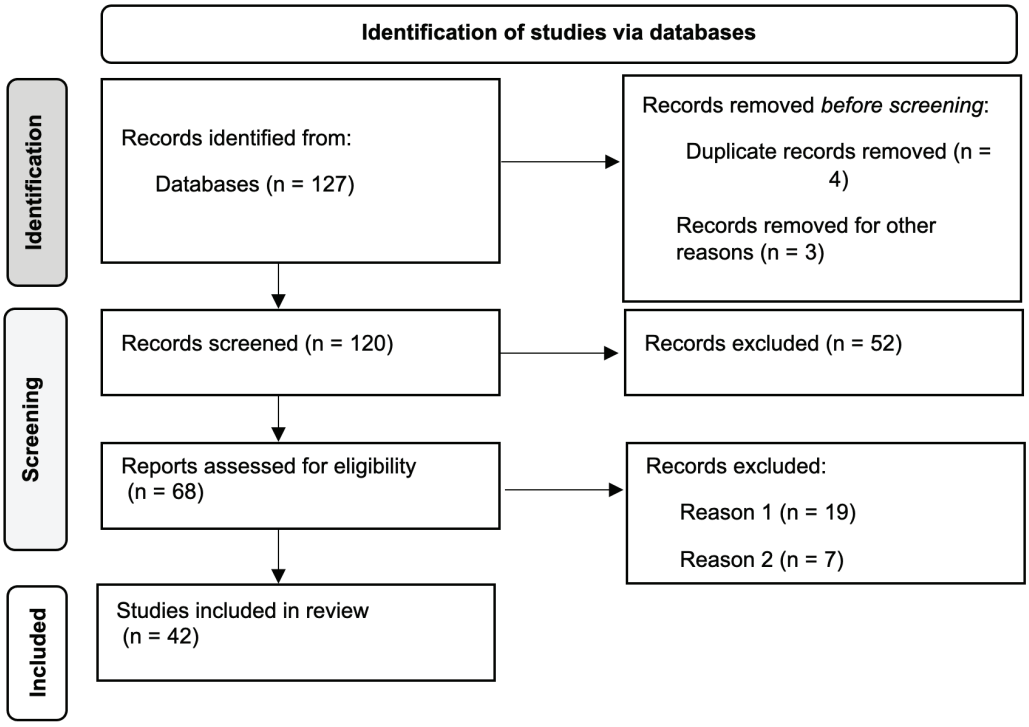
Results

This section presents the results obtained from the literature review, the clustering of indicators and the list of indicators ranking from best to worst obtained by the Fuzzy TOPSIS multi-criteria decision making method.

Literature review

Following a literature review based on the PRISMA 2020 statement, 127 studies were identified within the field of tourism and the hotel industry, of which 7 were omitted for the next stage, as 4 were duplicated and 3 did not contemplate indicators. In the review of the remaining 120 articles, 52 articles were discarded because the indicators used were applied entirely to tourism and did not include the hotel industry.

Figure 1. Flowchart: PRISMA 2020 Statement



Source: Own elaboration based on (Yepes-Nuñez *et al.*, 2021).

In the next review round, 19 documents were excluded because the indicators were not germaine to sustainability or the study did not specify the indicators used. Finally, another 7 were discarded because they belonged to unreliable journals, since they were included in lists of predatory journals such as Beall's List, resulting in a total of 42 studies identified as reliable and focused on the uses of sustainability factors in the hotel industry, and therefore included in the literature review. Figure 1 shows the flow chart with the stages of analysis of the PRISMA 2020 statement, visually showing the method and results of this research. At the top is the first stage, Identification with the 127 scientific articles and the number of excluded articles, at the next level is the Screening stage with their respective article exclusion filters, finally the final articles are shown in the Included stage.

Whereas, table 1 shows the 42 studies, indicating also: the journal, publisher, year of publication, number of indicators used, the level of application of the indicators and the author of each study. It should be noted that the study with the highest number of indicators reported is from the year 2020 published by the *Journal of Cleaner Production of Elsevier* with a total of 66 variables analyzed through a judgment of experts in Brazil, this identification was made by Amado *et al*. In the same year, but at the other extreme, there is a study that used only 3 indicators, this article belongs to Sustainability a journal of MDPI and was developed at the other side of the world in Spain for Boronat-Navarro and Pérez-Aranda.

Table 1. Studies with indicators found in literature

Year	Editorial	Journals	Indicators	Region	Level	Author
2016	MDPI	Sustainability	11	Taiwan	National	(Horng *et al*., 2016)
	Elsevier	Procedia CIRP	64	Thailand	National	(Kulkajonplun, Angkasith and Rithmanee, 2016)
	Springer	Asian Journal of Business Ethics	6	Bangalore (India)	Regional	(Shanti, 2016)
	Routledge Taylor & Francis Group	Journal of Quality Assurance in Hospitality and Tourism	30	Costa Rica	National	(Brazytė, Weber and Schaffner, 2016)
	UTMS	UTMS Journal of Economics	11	Macedonia	National	(Petrevska, Cingoski and Serafimova, 2016)
	RHM	Research in Hospitality Management	4	Europe, South America, Africa, Middle East and Asia	International	(Gehrels and Suleri, 2016)
	Routledge Taylor & Francis Group	Journal of Sustainable Tourism	29	Latin America	International	(Milder *et al*., 2016)
2017	Elsevier	International Journal of Hospitality Management	9	Taiwan	National	(Horng *et al*., 2017)
	Fayoum University	International Journal of Heritage, Tourism and Hospitality	31	Egypt	National	(Karam, 2017)
	Springer	Environment, Development and Sustainability	7	Visitors (India)	International	(Kumar and Chandra, 2017)
	MDPI	Sustainability	12	Cyprus	National	(Mousavi, Hoşkara and Woosnam, 2017)

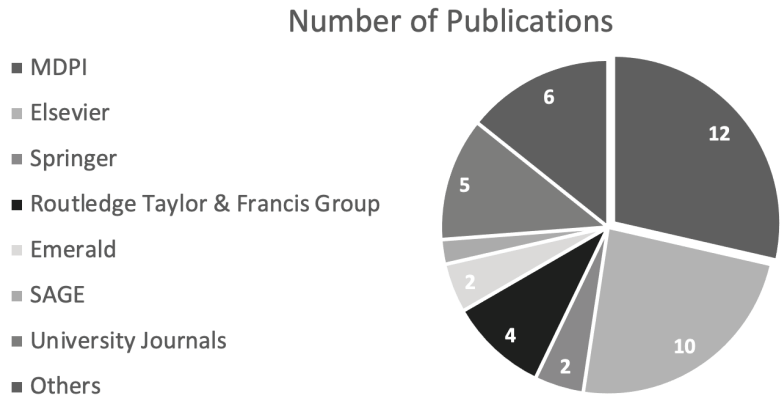
Year	Editorial	Journals	Indicators	Region	Level	Author
2018	MDPI	Sustainability	12	Switzerland	National	(Saura, Reyes-Menendez and Alvarez-Alonso, 2018)
	Emerald insight	International Journal of Culture, Tourism, and Hospitality Research	33	United Arab Emirates	National	(Alameeri *et al.*, 2018)
	MDPI	Sustainability	6	Italy	National	(Cozzio, Bullini and Zardini, 2018)
	MDPI	Recycling	29	Tunisia	National	(Chaabane, Nassour and Nelles, 2018)
	MDPI	Sustainability	16	China	National	(Ge, Chen and Chen, 2018)
	Elsevier	International Journal of Hospitality Management	11	Taiwan	National	(Hsiao, Chuang and Huang, 2018)
2019	Emerald	The Bottom Line	12	Tanzania	National	(Njoroge, Anderson and Mbura, 2019)
	MDPI	Sustainability	20	Cyprus	National	(Alipour, Safaeimanesh and Soosan, 2019)
	Elsevier	Tourism Management	29	Taiwan	National	(Mak and Chang, 2019)
	RHM	Research in Hospitality Management	5	Egypt	National	(Zaki and Qoura, 2019)
	Elsevier	Journal of Cleaner Production	57	Oaxaca (Mexico)	National	(Reyes-Santiago *et al.*, 2019)
2020	Elsevier	Journal of Cleaner Production	8	Malaysia	National	(Asadi *et al.*, 2020)
	Elsevier	Journal of Cleaner Production	66	Brazil	International	(Amado *et al.*, 2020)
	Routledge Taylor & Francis Group	Journal of Sustainable Tourism	21	Switzerland, Germany and USA.	International	(Ponnapureddy *et al.*, 2020)
	CEJ	Civil Engineering Journal (Iran)	5	Croatia	National	(Floričić, 2020)
	Atlantis Press	Advances in Economics, Business and Management Research	50	_____	International	(Kobyak *et al.*, 2020)
	MDPI	Sustainability	20	Egypt	National	(Hassan *et al.*, 2020)
	MDPI	Sustainability	3	Barcelona	Regional	(Boronat-Navarro and Pérez-Aranda, 2020)
	SAGE	Tourism and Hospitality Research	19	Fars (Iran)	Regional	(Bagheri *et al.*, 2020)
	Oxford University Press	International Journal of Low-Carbon Technologies	14	Faro (Portugal), London (England) and Athens (Greece)	International	(Cunha and Oliveira, 2020)
	Elsevier	International Journal of Hospitality Management	27	USA	National	(Fung Wong and Kim, 2020)
	MJM	Malaya Journal of Matematik	13	Chennai (India)	Regional	(Sangeetha, 2020)
	Routledge Taylor & Francis Group	Journal of Sustainable Tourism	30	Kazakhstan	National	(Olya *et al.*, 2020)

Year	Editorial	Journals	Indicators	Region	Level	Author
2021	Elsevier	Sustainable Futures journal	7	Cuba	National	(Leyva and Parra, 2021)
	MDPI	Sustainability	11	Asia, Europe and Africa	International	(Dibene-Arriola *et al.*, 2021)
	University of Bologna	Almatourism	7	Brazil	National	(Kremer, Flach and Sallaberry, 2021)
	IAEME Publication	International Journal of Advanced Research in Engineering and Technology (IJARET)	4	West Bengal (India)	Regional	(Bose and Bardhan, 2021)
	Foundation of Computer Science FCS	International Journal of Applied Information Technology	42	Yemen	National	(Said, Nasser and Alkhulaidi, 2021)
	Elsevier	Journal of Cleaner Production	6	Norway and Sweden	International	(Smitt *et al.*, 2021)
	MDPI	Sustainability	44	Macao	Regional	(Cheong and Lee, 2021)
	MDPI	Sustainability	6	Serbia	National	(Duric and Potočnik, 2021)
		Total	**847**			

Source: Own elaboration.

An important consideration is the publisher, its record and expertise in the area, and its reputation for reliability. The MDPI publishing house has the largest number of publications with a total of 12, and has been publishing in the area every year since 2016 through its journal Sustainability. The second most prolific publisher, Elsevier has, in the same period, 10 publications. While Routledge Taylor & Francis Group is in third place with the publication of 4 studies, 2 in 2016 and 2 during 2020, in figure 2 shows the distribution of all publications with respect to their publisher.

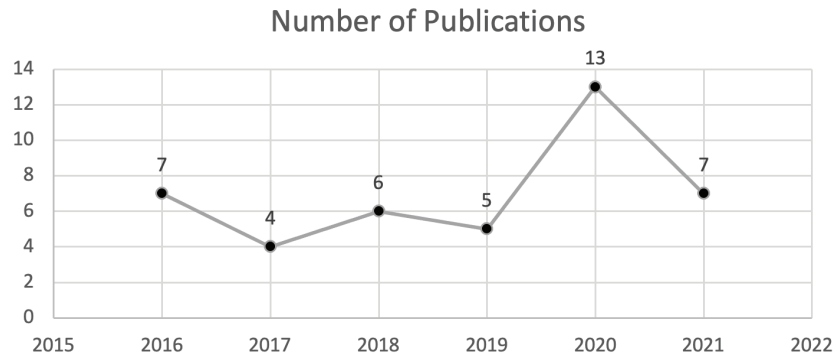
Figure 2. Publications by editorial



Source: Own elaboration.

Another relevant consideration is the year of publication, since a period ranging from 2016 to 2021 was set, it is important to identify the year in which the greatest interest and use of sustainable indicators is obtained, figure 3 shows the distribution of publications with respect to the year of publication. The year 2020 was when the largest number of included studies were published with 13 in total; while in 2019 only 5 articles were published with sustainable indicators. And 2017 was the year with the fewest publications, with only 4.

Figure 3. Publications by year



Source: Own elaboration.

Table 2. Descriptive analysis of publications by journal

Journal	Year of issue						Total publications
Tourism / Hospitality	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
Journal of Quality Assurance in Hospitality and Tourism	1						1
Research in Hospitality Management	1			1			2
Journal of Sustainable Tourism	1				2		3
International Journal of Hospitality Management		1	1		1		3
International Journal of Heritage, Tourism and Hospitality		1					1
International Journal of Culture, Tourism, and Hospitality Research			1				1
Tourism Management				1			1
Tourism and Hospitality Research					1		1
Almatourism						1	1
Sustainability							
Sustainability	1	1	3	1	2	3	11
Environment, Development and Sustainability		1					1
Recycling			1				1
Journal of Cleaner Production				1	2	1	4

Journal	Year of issue						Total publications
Tourism / Hospitality	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
International Journal of Low-Carbon Technologies					1		1
Sustainable Futures journal					1		1
Others							
Procedia CIRP	1						1
Asian Journal of Business Ethics	1						1
UTMS Journal of Economics	1						1
The Bottom Line				1			1
Civil Engineering Journal (Iran)					1		1
Advances in Economics, Business and Management Research					1		1
Malaya Journal of Matematik					1		1
International Journal of Advanced Research in Engineering and Technology (IJARET)						1	1
International Journal of Applied Information Technology						1	1
Total	7	4	6	5	13	7	**42**

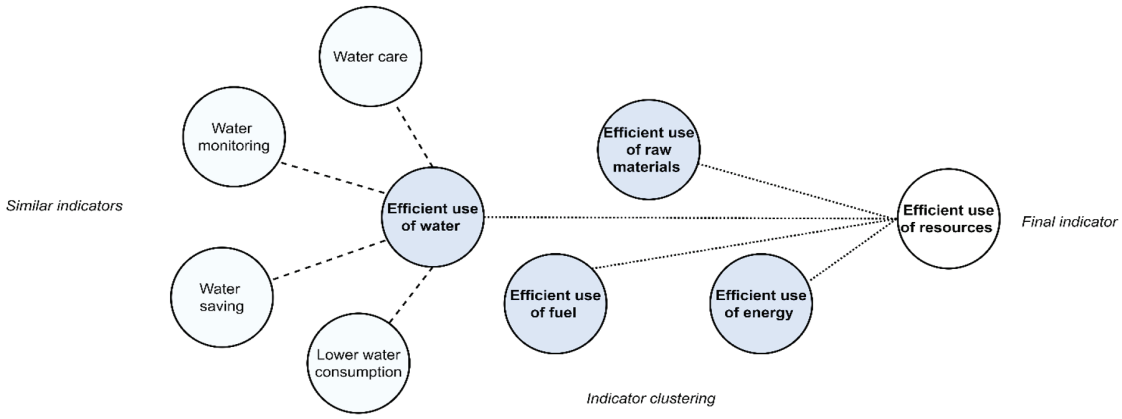
Source: own elaboration.

Finally, a descriptive analysis of publications by journal was performed to visualize the distribution of publications by journal. Table 2 shows a variety of journals publish articles on sustainability indicators as used in the hotel industry. As mentioned previously, Sustainability (MDPI) has published the largest number, followed by the *Journal of Cleaner Production* (Elsevier). These two journals specialize in sustainability, but not necessarily tourism or the hotel industry. The journals that specialize in tourism and hospitality are the *Journal of Sustainable Tourism* (Routledge Taylor & Francis Group) and the *International Journal of Hospitality Management* (Elsevier), which have the largest number of publications. Once the articles have been identified in the literature, the next phase of the methodology corresponds to extracting and grouping the indicators in a list.

Indicator clustering

As a whole 882 indicators were identified, however 35 of them did not correspond to indicators directly related to sustainable development within the hotel industry, and they were discarded, so within the 42 articles leaving 847 indicators distributed across six categories: Environmental (288), Economic (172), Social (169), Political (133), Technological (48) and Cultural (37). These categories are aligned with the dimensions of sustainable development, where the three main ones are social, economic and environmental; however, three other dimensions were identified: cultural, technological and political, which are of interest in tourism and more specifically in the hotel industry.

Figure 4. Indicator clustering process



Source: Own elaboration.

These indicators were grouped, taking each category in order to review indicator by indicator and aggregate those that share the same characteristics into a single indicator. For example, if a series of indicators were listed as: Water care, Water monitoring, Water saving and Lower water consumption, these indicators was grouped and become in to Efficient use of water indicator. This in turn will form part of the indicator Efficient use of resources (resources include: water, energy, fuel and raw materials), this process it is showed in figure 4. The final results are a list of 72 indicators distributed as follows: Environmental (14), Economic (18), Social (10), Political (15), Technological (8) and Cultural (7).

Table 3. Indicators identified in literature

Dimension	#	Indicator	F	Year
Environmental	1	Waste management: adopting a system to measure and reduce the amount of solid waste	32	2021
	2	The hotel reduces food waste at the retail and consumer levels and reduces food losses along the production and supply chains	2	2020
	3	Recycling and reuse of resources	23	2021
	4	Hotel companies minimize pollution from noise, light, runoff and other environmental risks, as well as to the health and well-being of the community	10	2021
	5	Efficient treatment system and safe discharge of wastewater that does not have a detrimental effect on the local population or the environment	6	2021
	6	Reducing the use of toxic substances that are harmful to the environment	8	2021
	7	Biodiversity, natural and local resources conservation	36	2020
	8	They have a carrying capacity plan that balances the relationship between resource consumption and the natural attractions that support the tourism operation	1	2020
	9	They have a system to counteract environmental threats, evaluate, control and minimize the effects of greenhouse gas emissions	24	2021
	10	Sustainable management and efficient use of resources: water, energy and raw materials	102	2021
	11	Use of renewable energies	13	2020
	12	Use of sustainable equipment, materials and products, buildings and infrastructures	25	2021
	13	Sustainable hotel supplier practices	4	2020
	14	The menus are based on seasonal ingredients and the hotel offers at least one vegetarian meal on the menu	2	2017

Dimension	#	Indicator	F	Year
Social	15	The hotel participates in internal and external sustainability programs	44	2021
	16	Provides staff education and training	13	2021
	17	Encourages staff participation	7	2020
	18	Has harmonious labor relations	4	2019
	19	Provides sustainable education for staff, customers and the local community	33	2021
	20	It has a crisis and emergency response plan, the main provisions of which are made known to local residents, businesses and visitors	1	2020
	21	CSR: hotel contributes to social equity and universal access to natural resources, services and infrastructure	28	2021
	22	Provides employee health, welfare and safety at work	12	2021
	23	Promotes equal employment opportunity and retention of local key employees	17	2021
	24	Motivation and commitment of employees and customers to the hotel	10	2021
Economic	25	Ensures increased purchase of organic products	5	2019
	26	Process efficiency (use of time, resources and purchases)	13	2021
	27	Seeking long-term financial viability and organizational competitiveness so that all stakeholders can benefit	7	2020
	28	Degree of effort to seek economic performance and financial efficiency (internal resource slack, focus on revenues, profitability, financing)	13	2020
	29	Customer purchase decision factors for a sustainable hotel	25	2021
	30	Hotel occupancy and sales growth	16	2021
	31	Business innovation and sustainable marketing	16	2021
	32	R&D budget and investments for the transition to sustainability	5	2019
	33	Responsiveness of the company to implement sustainable practices	4	2020
	34	Financial benefits and environmental costs	14	2019
	35	Collaboration or business linkage with other environmental organizations	1	2019
	36	Maximize cash generation, distribution and retention in the locality	5	2020
	37	Job creation in the local community	3	2021
	38	Choose suppliers that are aware of their environmental responsibilities	5	2020
	39	Benefiting local companies to become suppliers	2	2021
	40	Hotel competitiveness (enhanced reputation, market presence, customer satisfaction, consumer confidence, improved image, positive comments on social networks)	24	2021
	41	Improve the quality of service and products and increase the value added by sustainability	6	2020
	42	Investment in the company's human resources (training, medical services, benefits)	8	2020
Technology	43	Green technology innovation	6	2020
	44	Increase the use of eco-efficient technologies: alternative energies and resource savings	26	2020
	45	Use of technology to enhance hotel and guest safety and security	4	2020
	46	Use of technology to ensure the participation of people with special needs in the hotel's activities	1	2020
	47	Application of the Internet of Things to improve the quality of service to guests	3	2020
	48	Smart hotel with sustainable designs, building materials and facilities	6	2020
	49	Software upgrade for hotel operation	1	2020
	50	The hotel works with its suppliers to develop energy-saving products	1	2018

Dimension	#	Indicator	F	Year
Cultural	51	The hotel makes use of local food and promotes local gastronomy	5	2020
	52	The hotel buys local and promotes the consumption of local products	6	2021
	53	The hotel consults with the local community to ensure the authenticity of local art (crafts, music, clothing and footwear, souvenirs) and promote their sale	3	2021
	54	Preservation by hotel companies of the archaeological, cultural, religious and sacred heritage, explaining the representativeness, symbology, customs and traditions of the local population	16	2021
	55	Culture of local service orientation	1	2016
	56	Degree of environmental education of the local community	3	2017
	57	Management of cultural resources: local experiences (attractions, churches, ancient buildings, traditions, urban and natural guided tours)	3	2018
Policy	58	The hotel seeks to comply with all requirements established by environmental legislation	11	2021
	59	Compliance with local legislation for hotel control and waste management in tourist areas	3	2018
	60	Compliance with the laws and regulations governing and regulating the display and sale of artifacts and handicrafts in hotels	2	2020
	61	The hotel complies with the legal standards of its services/products	1	2020
	62	Policies, strategies and planning to counteract any environmental emergency	18	2021
	63	Policies for administrative innovation and sustainable management, commitment of senior management	26	2021
	64	Policies against exploitation and harassment	4	2020
	65	Inform stakeholders, including guests, about its sustainable development policies, actions and results	16	2021
	66	Compliance by hotel companies with all local and national laws and regulations, including health, safety and labor laws and regulations	18	2021
	67	Transparency and trade policy based on ethical and moral principles	15	2020
	68	Hotel sustainability certifications	5	2021
	69	Policies for an egalitarian organizational structure independent of religion, gender, ethnicity, disability and sexual orientation	4	2020
	70	Learning management, evaluation and continuous assessment programs	3	2020
	71	Policy to improve the health and safety of employees and customers	2	2016
	72	Policies to ensure that stakeholders are engaged in sustainable tourism development and human rights issues	5	2020
			847	

Source: Own elaboration.

The table 3 shows the 72 indicators in their respective dimensions, showing the description of each indicator, as well as the frequency of use and the last year in which it was applied. It can be seen that the indicator with the highest application in studies with a frequency of use of 102 times within the hotel industry corresponds to Sustainable management and efficient use of resources: water, energy and raw materials with number ten in the environmental dimension. In second place is the indicator The hotel participates in internal and external sustainability programs with a frequency of use of 44 times, this belongs to the social dimension and is identified as number 15 in the list. In third place with a frequency of use of 36 times is another indicator of the environmental dimension, Biodiversity, natural and local resources conservation, which has the number 7 position in the list shown in the table. It should be noted that the first two has a publication year of 2021 and the third reports 2020, all with recent years.

Now with the final indicators extracted from the literature and grouped from 847 variables to 72, the next step is to evaluate which would be the best and worst qualified, to determine the most appropriate ones to select for future research in the hotel industry, according to the three criteria established for the Fuzzy TOPSIS multi-criteria analysis.

Multi-criteria decision-making method

According to the Fuzzy TOPSIS methodology, the first step is to establish the criteria to be evaluated, as well as to specify whether they are beneficial or non-beneficial. In this case, only beneficial criteria were utilized, since the objective is to maximize the criteria C_1 = Frequency of use, C_2 = Level of application and C_3 = Year of publication. The values assigned to each indicator are shown in table 4, which lists the 72 indicators with their weights and values for each indicator.

Table 4. Values and criteria for Fuzzy TOPSIS

	BENEF	BENEF	BENEF		BENEF	BENEF	BENEF
w	33.33	33.33	33.33	**w**	33.33	33.33	33.33
# Indicator	***C1***	***C2***	***C3***	**# Indicator**	***C1***	***C2***	***C3***
1	32	4	2021	**37**	3	4	2021
2	2	4	2020	**38**	5	2	2020
3	23	4	2021	**39**	2	2	2021
4	10	4	2021	**40**	24	4	2021
5	6	4	2021	**41**	6	4	2020
6	8	1	2021	**42**	8	4	2020
7	36	4	2020	**43**	6	4	2020
8	1	5	2020	**44**	26	4	2020
9	24	4	2021	**45**	4	4	2020
10	102	4	2021	**46**	1	5	2020
11	13	4	2020	**47**	3	2	2020
12	25	4	2021	**48**	6	4	2020
13	4	4	2020	**49**	1	5	2020
14	2	4	2017	**50**	1	4	2018
15	44	4	2021	**51**	5	4	2020
16	13	4	2021	**52**	6	4	2021
17	7	4	2020	**53**	3	4	2021
18	4	4	2019	**54**	16	4	2021
19	33	4	2021	**55**	1	4	2016
20	1	5	2020	**56**	3	4	2017
21	28	4	2021	**57**	3	4	2018
22	12	4	2021	**58**	11	4	2021
23	17	4	2021	**59**	3	4	2018

	BENEF	BENEF	BENEF		BENEF	BENEF	BENEF
w	33.33	33.33	33.33	**w**	33.33	33.33	33.33
# Indicator	***C1***	***C2***	***C3***	**# Indicator**	***C1***	***C2***	***C3***
24	10	4	2021	**60**	2	5	2020
25	5	4	2019	**61**	1	4	2020
26	13	4	2021	**62**	18	4	2021
27	7	4	2020	**63**	26	4	2021
28	13	4	2020	**64**	4	2	2020
29	25	4	2021	**65**	16	4	2021
30	16	4	2021	**66**	18	4	2021
31	16	4	2021	**67**	15	4	2020
32	5	4	2019	**68**	5	4	2021
33	4	4	2020	**69**	4	2	2020
34	14	4	2019	**70**	3	5	2020
35	1	4	2019	**71**	2	4	2016
36	5	2	2020	**72**	5	4	2020

Source: Own elaboration.

The selection criteria were determined as beneficial when considering the highest frequency of use, the most current year and the level of application, the list obtained is an ordering from the best to the worst indicator, that is, the 72 indicators are ordered according to their degree of closeness to the ideal solution, in this case, those indicators that showed the highest use, with the most recent year of publication and that have an international level of application. The final ranking result of indicators given by Fuzzy TOPSIS are shown in table 5.

Table 5. Indicators ranking by Fuzzy TOPSIS

Ranking	Score	# Indicator	Ranking	Score	# Indicator
1	0.97093376	10	**37**	0.10732745	52
2	0.43078013	15	**38**	0.1029336	20
3	0.3537481	7	**39**	0.1029336	30
4	0.32510859	19	**40**	0.09761381	8
5	0.27784271	21	**41**	0.09761381	55
6	0.25915881	63	**42**	0.09761368	44
7	0.25915876	44	**43**	0.09761368	46
8	0.24987861	12	**44**	0.09761368	51
9	0.24987861	29	**45**	0.09296957	71
10	0.24064582	40	**46**	0.09296944	54
11	0.24064582	9	**47**	0.09296944	75

Ranking	Score	# Indicator	Ranking	Score	# Indicator
12	0.23146597	3	**48**	0.09296934	28
13	0.19997103	1	**49**	0.09296934	35
14	0.18662476	62	**50**	0.0890867	16
15	0.18662476	66	**51**	0.0890867	36
16	0.17794022	23	**52**	0.0890867	48
17	0.16938324	30	**53**	0.08908659	21
18	0.16938324	31	**54**	0.08604308	40
19	0.16938324	54	**55**	0.08604308	56
20	0.16938324	65	**56**	0.08604276	62
21	0.16097322	67	**57**	0.08604276	60
22	0.1527334	34	**58**	0.08604271	59
23	0.14469159	26	**59**	0.08389735	5
24	0.14469159	16	**60**	0.08389711	17
25	0.14469151	28	**61**	0.08389709	74
26	0.14469151	11	**62**	0.08268084	64
27	0.13688037	22	**63**	0.08268073	38
28	0.1293391	58	**64**	0.08268065	53
29	0.12211436	7	**65**	0.08268059	58
30	0.12211436	27	**66**	0.06877559	9
31	0.11056797	73	**67**	0.04901636	41
32	0.10884305	45	**68**	0.04901636	39
33	0.10861123	63	**69**	0.04156302	72
34	0.10732745	11	**70**	0.04156302	67
35	0.10732745	23	**71**	0.03527781	50
36	0.10732745	49	**72**	0.03085053	42

Source: Own elaboration.

In turn, for a greater appreciation of the result given by Fuzzy TOPSIS, the 15 best rated indicators are extracted and described in table 6, in first place as expected is the indicator with the number 10: Sustainable management and efficient use of resources: water, energy and raw materials corresponding to the environmental dimension, this indicator obtained a frequency of 102 times of use, its level of application is national and its year of publication is 2021, therefore Fuzzy TOPSIS gave it a final score of 0. 97 being the highest, i.e. the best to take into account in future research and applications of indexes in the hospitality industry, this of course, according to the established criteria. In second place is positioned an indicator that belongs to the social dimension with a score of 0.43, this is number 15: The hotel participates in internal and external sustainability programs. In third place is positioned Biodiversity, natural and local resources conservation (number 7) another indicator of the environmental dimension with a score of 0.35.

Table 6. Indicators selected by Fuzzy TOPSIS

Dimension	#	Indicator
Environmental	10	Sustainable management and efficient use of resources: water, energy and raw materials
Social	15	The hotel participates in internal and external sustainability programs
Environmental	7	Biodiversity, natural and local resources conservation
Social	19	Provides sustainable education for staff, customers and the local community
Social	21	CSR: hotel contributes to social equity and universal access to natural resources, services and infrastructure
Policy	63	Policies for administrative innovation and sustainable management, commitment of senior management
Technology	44	Increase the use of eco-efficient technologies: alternative energies and resource savings
Environmental	12	Use of sustainable equipment, materials and products, buildings and infrastructures
Economic	29	Customer purchase decision factors for a sustainable hotel
Economic	40	Hotel competitiveness (enhanced reputation, market presence, customer satisfaction, consumer confidence, improved image, positive comments on social networks)
Environmental	9	They have a system to counteract environmental threats, evaluate, control and minimize the effects of greenhouse gas emissions
Environmental	3	Recycling and reuse of resources
Environmental	1	Waste management: adopting a system to measure and reduce the amount of solid waste
Policy	62	Policies, strategies and planning to counteract any environmental emergency
Policy	66	Compliance by hotel companies with all local and national laws and regulations, including health, safety and labor laws and regulations

Source: Own elaboration.

While the worst rated indicators correspond to those with values of 0.041, with indicators number 72: Policies to ensure that stakeholders are engaged in sustainable tourism development and human rights issues, and 67: Transparency and trade policy based on ethical and moral principles, in positions 69 and 70 respectively, both from the political dimension, the second lowest value is 0.035 in position 71 with an indicator from the technological dimension the number 50: The hotel works with its suppliers to develop energy-saving products, and finally, in position 72, indicator number 42: Investment in the company's human resources (training, medical services, benefits) which corresponds to the economic dimension and have a value of 0.035.

Discussion

From the systematic review, 42 scientific articles were obtained that discuss and make use of sustainable indicators, most of these publications belong to consolidated journals, including journals from universities around the world, and it is important to note that most of them are specialized journals in tourism and hotel management. At the same time, it is notorious how interest in the application of indicators has grown in recent years, both in academia and in the hotel industry.

Based on the analyze data within the terms of the indicators, it was observed that with the results of PRISMA, indicators 10, 15 and 7 are the most frequent, while those that were only applied once are 8, 20, 35, 46, 49, 50, 55 and 61. Therefore, it could be thought that the first ones are the ones to

select and avoid those that did not present the highest frequency of use; however, this criterion is not the only one to be evaluated. Therefore, with the proposed Fuzzy TOPSIS analysis method, which sought to avoid bias due to expert opinion in the selection of indicators to determine the most appropriate ones to use in the analysis of the application of indicators in the hotel industry, it was expected that indicators 10, 15 and 7 would obtain the highest values and occupy the first positions in the ranking. However, this does not mean that the analysis by Fuzzy TOPSIS was unnecessary, since this method also considers the level of application and the year of publication as criteria to be evaluated. Another important aspect is that the least recommended or worst rated indicator, indicator 42, which occupies the last place in the Fuzzy TOPSIS ranking, is not precisely one of the least frequently used. In this sense, there is a list with a ranking according to the three criteria.

Now, another important feature to highlight is that indicators which occupy the first 15 places in the ranking belong to the environmental dimension, which reinforces the argument that industry and research is more broadly focused on the environmental dimension of sustainable development, likewise indicator 10: Sustainable management and efficient use of resources: water, energy and raw materials, which occupies the first place, shows how research has focused on the efficient use of resources both in the management of water, energy and raw materials, being of vital importance the eco-efficiency in processes and services to reduce the impacts generated to the environment through the generation of waste and emissions caused by the inefficient use of these resources.

The systematic review was developed with a search period from 2016 to 2021, so it is suggested to extend this search to the year 2022 and early 2023 in order to identify the existence of new indicators, if there are any, it would be convenient to group them and add them to the list of indicators. This is to keep the list provided by this research up to date, which will be useful for future academic, research and application work in the hotel industry.

Conclusion

As a general ending to this research, it can be address that the utilization of this method provides a valuable tool to identify, evaluate and determine which sustainability indicators are applicable within the hotel industry. A total of 847 indicators were identified, which were grouped into a list of 72 updated indicators distributed in 6 of the dimensions of sustainable development (Environmental, 14; Economic, 18; Social, 10; Political, 15; Technological, 8; Cultural, 7), this list also shows the indicators ordered from the best to the worst evaluated according to their frequency of use, level of application and year of publication, therefore, those that obtain the highest value are those recommended for use in the hotel industry.

Mentioned results serve as a basis for the constructing sustainability's evaluation tools, as well as generate a reliable indicators list for studies within the hotel industry, since they were synthesized and grouped from a greater quantity of indicators dispersed within literature to obtaining an updated list. At the same time, it will be of help for future work in several fields of study, including but not limiting to sustainable tourism indicators and specifically for the hotel industry.

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