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Harmony Search: Selection of Sustainable Indicators for the Hotel Industry

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ABSTRACT

The hotel industry has a negative effect on the environment, since its activities generate large consumption of resources and greenhouse gas emissions, which is why the World Tourism Organization makes a strong call to all its sectors to move towards a sustainable development model. In the hotel industry, indicators have been used to improve sustainable performance, however, these sustainable indicators are scattered in the literature, which makes it difficult to select them. Therefore, Harmony Search (HS) is proposed to determine which are the best indicators to evaluate the environmental impact generated by the hotel industry. As a result of the HS search, a list of 20 indicators was obtained, which best met the selection criteria: frequency of use, level of application and year of publication.

1. INTRODUCTION

The hotel industry is one of the most influential sectors within tourism and both share a very close relationship. On the one hand, tourism makes use of lodging establishments when travelers seek to stay overnight at a destination, and a hotel can even be recognized as a tourist attraction, as is the case of Xcaret in Mexico; on the other hand, the hotel industry benefits from the tourists who arrive at various destinations in search of its services. Furthermore, adding links in the tourism-hotel industry relationship, Zhang et al. [1] point out that the specialization and tourist competition of the destination influences the efficiency and quality of the hotel industry. And Torres and Anchundia [2] affirm that lodging and accommodation services constitute a strategic and fundamental element for the development of tourism, since they represent part of the tourism infrastructure.

Tourism has grown significantly in recent years, to such an extent that it has become a key element for the development and socioeconomic growth of nations. Consequently, the hotel industry has benefited from this boom and has positioned itself as an important economic sector, since it represents, together with tourism, a considerable source of income, in addition to creating jobs for the benefit of the economic sector and society [3].

While it is true that tourism and hospitality complement each other, that they bring benefits to nations and that they are crucial agents for the development of countries, to such an extent that this sector currently has a turnover equal to or even higher than that of businesses such as oil exports, automobiles and the food products industry, it is also true that tourism and hospitality are crucial for the development of countries [4], the negative impact they have on the environment is also a major concern.

Tourism, due to the nature of its activities and processes, contributes to global warming with 5% of the total emissions produced by humans and it is estimated that by 2030 this figure will increase to 5.3% [5], it also leads to increased consumption of resources such as soil, water and energy, increased generation of solid waste and wastewater, destruction of landscapes due to infrastructure and buildings, alteration of ecosystems, introduction of exotic species of animals and plants, as well as inducing population flows to more depopulated areas [3].

On the other hand, the hotel industry is considered a major consumer of energy and other resources such as water, gas and materials. It also produces large amounts of waste and greenhouse gases (GHG), and 21% of the total ecological footprint caused by tourism belongs to the hotel industry; all these factors contribute to global warming and generate negative impacts on the environment [6-10].

Besides, the hotel industry impacts on local communities through the occupation of space, the use of infrastructure, relations with local businesses and governments, even hotels have the ability to influence the behavior of the population and promote social exclusion, non-compliance with regulations and the introduction of foreign ideologies that could distort the local culture, as well as tangible and intangible heritage [6, 7].

Faced with this problem, the World Tourism Organization (UNWTO) adopts the model of sustainable development, hence, the concept of sustainable tourism arises in order to meet the current and future needs of visitors, both the industry, environment and host communities [11]. As a result, sustainability has gained popularity in studies of the hospitality industry, and in recent years research has focused on green practices, sustainable construction of lodging establishments and employee and customer perspectives and interest in environmental stewardship [12-14]. At the same time, sustainable criteria have been identified [15]. Of the latter, indicators can be identified.

Indicators in this case are parameters that help to analyze, measure and evaluate green practices within the hotel industry. In the literature there is a wide variety of indicators that have been applied in various case studies, such as those mentioned by the authors identified 66 criteria distributed in five dimensions: environmental, social, cultural, economic and political [15]. Also Duric and Potočnik Topler [16] present 6 factors as the main indicators for the performance of environmental management practices in hotels according to the importance of their impacts; whereas, Asadi et al. [8] developed 8 constructs for which they assigned 32 measurement items, as well, [17] they defined 8 criteria containing 33 sub-criteria, i.e. indicators. Or [18] that take specific indicators such as nZEBs for energy performance.

Table 1. Selection of sustainable indicators applied

Author	Research	Method
[15]	Criteria for assessing a sustainable hotel business Rodrigo	Extensive literature review, semi-structured questionnaire (applied to 177 professionals linked to the hotel market and academia). In-depth interview (in a workshop with 18 participants) and confirmatory factor analysis (R software).
[16]	The role of performance and environmental sustainability indicators in hotel competitiveness	Questionnaire based on a literature review, with Likert Scale, Cronbach's Alpha coefficient and a one-factor analysis of variance (ANOVA), applied to hotels in Serbia.
[8]	Investigating influence of green innovation on sustainability performance: A case on Malaysian hotel industry	Purposive sampling for the survey of 183 hotels in Malaysia, use of online questionnaire and literature review for items. For measurement, different scales such as Likert scale and partial least squares structural equation modeling (PLS-SEM) were used for data analysis.
[17]	Sustainable management practices in UAE hotels	Literature review to identify service management practices. Survey and expert opinion to categorize and prioritize the most important practices and used an analytical hierarchical process (AHP) to prioritize the main criteria and sub-criteria.
[18]	Comparison of nZEB indicators for hotel renovations under different European climatic conditions	Extension of the study on the application of nZEB (Near Zero Energy Efficiency Building) energy performance indicators.

These studies are contained in Table 1, where it is highlighted that the common method for the selection of indicators is based on literature review for the design of questionnaires, surveys or in-depth interviews and an expert evaluation (application in the industry) accompanied by statistical analysis to determine the correlation of indicators, or a group of specific indicators is taken for a given evaluation, as in the case of the study [18] indicators are taken for energy consumption. However, the latter method neglects the selection of indicators that integrate all dimensions of sustainable development. In addition, the studies do not include a selection method that helps to optimally identify indicators that measure the sustainable performance of hotels across large numbers of variables.

Based on the above, it can be inferred that the process for this selection is composed of three main stages or steps:

1. Literature Review. This must be extensive in order to obtain information on relevant factors in the field of study.
2. Identification of Indicators. Where the parameters reported in theory and in practice are sought, that is, the parameters that have been used by the academy and the hotel industry.
3. Indicator Selection. It consists of defining the indicators that best help to analyze the phenomenon or subject of study with the support of mathematical and statistical tools.

From the process described above, it is explained that once the parameters have been identified, the next step is to select the indicators that are useful for the study to be carried out. At this point, the studies show that the indicators are taken and added to a questionnaire, and then subjected to an expert evaluation and with the help of various statistical methods, those that are most significant are selected. For methods such as confirmatory factor analysis, Cronbach's Alpha coefficient, one-factor analysis of variance and partial least squares, the number of indicators to be analyzed is limited, and the time it takes to apply them is greater compared to the use of a metaheuristic algorithm, since in a matter of minutes they obtain the result on optimal indicators, the algorithm indicates which are the best within an analysis of more than 100,000 variables.

Thus, the use of metaheuristic algorithms is proposed as a method for the selection of indicators, as well as the inclusion of the dimensions of sustainable development in the hotel industry as a distinctive element. Figure 1 shows the indicator selection process explained previously, as well as the point where the metaheuristic algorithm is incorporated.

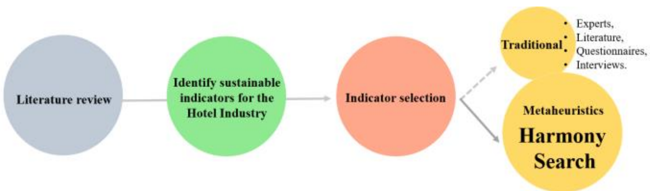

Figure 1. Aggregation of Metaheuristics in the indicator selection process

The proposed algorithm is Harmony Search (HS) which is highlighted in yellow at the bottom with the larger circle, while at the top are the methods that are widely used.

1.1 Metaheuristics

Metaheuristics are part of the field of heuristics, which are regaining value in scientific methodology, being applied mainly by cognitive psychology and artificial intelligence [19]. Within the latter is the use of Metaheuristics essentially for solving optimization problems through algorithms, which offers a broad framework of generic algorithms that can be applied to almost any optimization problem [20], Therefore, its use is proposed for the indicator selection problem in order to optimize the process.

Metaheuristics are originally a solution method that directs an interaction between local improvement procedures and higher level strategies, in order to obtain a process capable of scaling from the local optimum, through a robust search within a solution space. Over time, these methods have also come to include all procedures that employ strategies to overcome the limitation of local optimality and search in complex solution spaces, especially procedures that use one or more neighborhood structures as a means to define admissible moves from one solution to another, or to construct or destroy solutions in constructive and destructive processes [21]. In other words, its robust search mechanism focuses on the harmonization between two search elements, exploration or diversification and exploitation or intensification, where the former consists of a search in the areas surrounded by the best (local) solution, while the latter usually seeks to reach new search areas (scalar) [20].

Optimization algorithms within the metaheuristic framework are able to exhibit a higher mass implementation capability with few critical code changes [22], this capability makes a metaheuristic algorithm a viable tool for general and specific industrial applications, differing from a traditional iterative methodology as the application of surveys [23].

The metaheuristic optimization algorithms have the following characteristics pointed out by the studies [20, 23]:

- They use generally approximate data and results.
- They search for the possible solution in a solution space.
- They range from basic local search to learning techniques.
- They can incorporate several methods to avoid premature convergence of data and results.
- They use an orientation memory that preserves the search experience.
- They do not apply only to a particular problem.
- They allow parallel implementation.

1.2 Taxonomy

In the taxonomy of metaheuristic algorithms, there are several classifications, either according to the trajectory and population, if they are based on metaphors, inspirations in nature, or bioinspiration's. Figure 2 shows the classification proposed by Abdel-Basset, Abdel-Fatah, and Kumar in 2018, which divides metaheuristics into metaphor-based and non-metaphor-based; where non-metaphor-based ones focus on mathematical models, while metaphor-based ones include the mathematical basis as well as inspiration from nature.

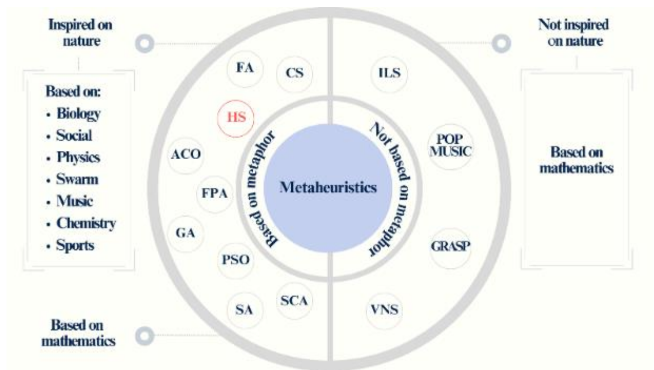

Figure 2. Taxonomy of Metaheuristics
Source: own elaboration with information from the study [20].

The first group contains algorithms such as *Iterated Local Search* (ILS), Pop Music, Grasp and Variable Neighborhood Search (VNS); whereas *Cuckoo Search* (CS), *Firefly Algorithm* (FA), *Ant Colony Optimization* (ACO), *Flower Pollination Algorithm* (FPA), *Genetic Algorithm* (GA), Particle Swarm Optimization (PSO), *Simulated Annealing* (SA), *Sine Cosine Algorithm* (SCA) and Harmony *Search* (HS) belong to the second group.

In turn, it can be seen that the use of those with natural inspiration is broader, since their procedure focuses on the search for optimal solutions based on biological behavior, that is, imitating an organic system such as mass movement patterns or the intelligence of colonies [20]. On the other hand, due to the complexity and variety of the biological spectrum, algorithms have been taken to the analysis and application of more complex techniques such as the imitation of the human nervous system or the harmony that jazz musicians look for when improvising a song.

1.3 Applications of metaheuristics in tourism

As mentioned above, metaheuristic algorithms are used to solve optimization problems, so that their application can be carried out in different fields of study; in the case of tourism, they have been used mainly to solve problems such as the Traveling Salesman Problem (TSP) and the Tourist Travel Design Problem, both problems focus on the creation of tourist circuits to optimize time, costs and tourist preferences.

Table 2. Metaheuristics applied in tourism

Author	Algorithm	Problem
[24]	HS	Traveling salesman problem (TSP) for travelers who need to plan a trip with 21 places located in Lampang, Thailand.
[25]	SA	Traveling salesman problem (TSP) to generate the optimal travel route taking into account various user preference criteria.
[26]	KSA (K-means and SA combination)	Tourist Trip Design Problem, consists of selecting points of interest that match user preferences to suggest personalized daily sightseeing tours.
[27]	K-means y GA	Tourist Travel Design Problem, consists of the optimization of itineraries for tourists in order to facilitate the organization of their visits.
[28]	GA	Forest road planning to reduce calculation time, road construction costs and environmental impact.

Table 2 shows that the most used algorithms belong to those based on metaphors such as GA, SA and HS. In addition, no metaheuristic was found used for the selection of sustainable indicators for the hotel industry, nor the application of HS in the field of hospitality. Therefore, this algorithm is proposed for the indicator selection process.

1.4 Harmony Search (HS)

Harmony Search is an algorithm developed in 2000, based on the analogy between improvisations performed by musicians in Jazz, searching for the best harmony determined by the aesthetic estimation and the search in the process for the optimal solution, which is determined by the evaluation of the objective function [29]. A musician produces sounds within a range to form melodies (chords), that is, he plays simultaneous superimpositions of two or more notes that have a harmonic relationship always complying with certain established aesthetic patterns. If the melodies and harmonies played form good combinations, the musician stores them in his memory, which allows him to increase his chances of creating another good combination in his next improvisation [30].

Figure 3 shows the analogy on improvisation, it describes the behavior and process of improvisation of jazz musicians, first, there are three instruments (saxophone, cello and guitar), each one plays a set of notes, in this case the saxophone plays C, D, E, F and G, the cello with G, E, D, A and C, while the guitar plays D, C, G, E and B. After that, the musician pays attention to each tone and begins to recognize those that sound good, where the perceived aesthetic notes for the saxophone is the note E, the cello with D and the guitar with G, which when combined form a new melody (E, D, G); Once the musician forms a chord, the moment of decision arrives, where, if the melody formed by these notes meets the aesthetic criteria and is heard well, the musician memorizes it and keeps it in his repertoire of melodies, otherwise, if it is heard badly, he discards it because it does not meet the aesthetic criteria. In such a way that this process of improvisation is followed until the desired number of chords is obtained.

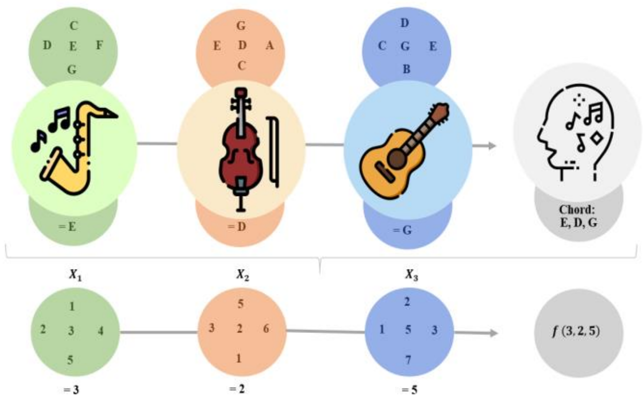

Figure 3. Harmony Search Analogy
Source: own elaboration based on the study [31].

Similarly, the lower part shows the relationship with the process of optimizing a function, where each decision variable takes random values within a certain range, forming a solution vector $\boldsymbol{f(3,2,5)}$ or $\boldsymbol{f(E,D,G)}$ that will be stored in a harmonic memory of each variable, which increases the chances of obtaining better solutions in the subsequent iteration [31].

In this context, the objective of this work is to apply a Harmony Search algorithm in the field of hospitality, to select sustainable indicators reported in the literature; in order to find the best harmony composed of the most optimal tones (indicators) when selecting indicators to evaluate the environmental impact. The following sections discuss the methodology used, followed by the results and conclusions.

2. METHODOLOGY

The indicator selection process presented above in Figure 1 of Section I is considered, so that for the last step, which corresponds to the selection of the optimal indicators for the evaluation of the environmental impact of the hotel industry, we propose the application of the HS algorithm to a sample of 149 indicators extracted from the literature, which are distributed in six dimensions of sustainable development: Environmental, Social, Economic, Technological, Cultural and Political.

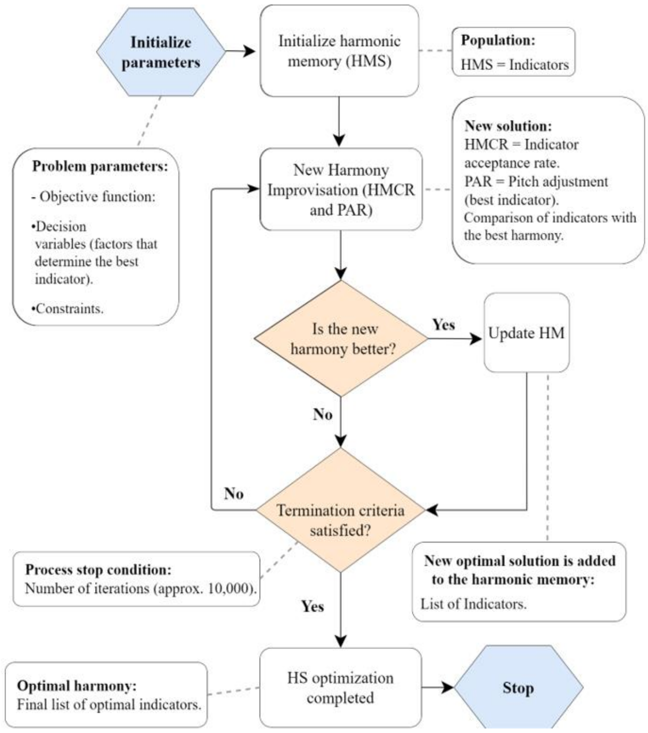

Figure 4. Flowchart: Harmony Search
Source: Own elaboration base on the study [29].

For the application of the HS algorithm, a four-step process was executed that recommends [32], the flow diagram used can be seen in Figure 4, where each element is explained, as well as the start and end points, which are represented with blue diamonds, the feedback points with pink diamonds and the steps with white rectangles.

Step 1. Initialize the HS memory (HM): define the number of randomly generated solutions to the optimization problems considered. That is, the population (HMS) which in this case corresponds to the indicators reported in literature.

Step 2. Improvisation of a new solution: a new candidate harmony is produced using the following parameters:

- HMCR = Harmony memory considering rate.
- PAR = Pitch adjustment (best indicator).

To then make a comparison of indicators with the best harmony.

Step 3. Update HM: the new solution from step 2 is evaluated. If the harmony is better than the worst harmony stored in HM, it replaces it. Otherwise, it is discarded. New optimal solution is added to the harmonic memory (list of indicators).

Step 4. Repeat steps 2 and 3 until the pre-set termination criterion is met, to obtain the optimal harmony, i.e., the final list of optimal indicators.

The following objective function is proposed to determine the best indicator:

$$Zmax = \frac{x_1}{\max x_{1j}} + \frac{x_2}{\max x_{2j}} + \frac{x_3}{\max x_{3j}} \quad (1)$$

which seeks to maximize the decision variables x_n:

$x_1 =$ Frequency of use . From the list, evaluate the indicators that are most frequently repeated, i.e., those that have been used in the greatest number of studies.

$x_2 = Level\ of\ application$. This can be international, national or regional.

$x_3 = Year$. Priority is given to indicators used in recent years.

While the restrictions for each of the variables consist of:

$x_1 < 0$: since the indicator must have been used at least once.

$x_2 > 0$, $x_2 < 6$: since the indicator must have been used at least once.

$x_3 \geq 2016$, $x_3 \leq 2022$: those between 2016 and 2022 are considered to be the best.

Finally, with respect to the programming of the algorithm, Python language is used for the code, the pseudocode is discussed in the following section.

2.1 Pseudocode HS

The pseudocode is the guide for programming the code, it describes step by step what the program will do, this should be written as close as possible to a programming language, in this case the pseudocode was based on the study [33] with Python for programming the HS algorithm.

1: Initialize and determine the parameters of the HSA problem. Input data. HMS, HSCR, PAR.
2: Initialize the harmonic memory HM.
  Construct harmonic memory vectors.
  $HM = \{x^1, x^2, \dots, x^{HMS}\}$
  Recognize the worst harmonic in the HM.
  $x^P\ E\{x^1, x^2, \dots, x^{HMS}\}$
3: Improvise a new harmony.
  $x^1 = \phi$ // new harmony
  for $i = 1, \dots, N$ **do** // N variables of decision.
    if $(input\ of\ registed\ data \leq HMCR)$ **then**
      start
      $x_i'\ E\ \{x_i^1\ x_i^2, \dots, x_i^{HMS}\}$ // Indicator acceptance rate.
      if $(indicators\ input\ \leq PAR)$ **then**
      $x_i' = v_{i,k}$ // Pitch adjustment
      end if
    end if
  end for
4: Update harmonic memory (HM)
  if $(f(x') < f(x^P))$ **then**
  Included in x' en HM
  Exclude in x^P en HM
5: Check the stop/fitness criterion
  while (that the termination criterion is not specified)
    Repeat (steps 3 y 4)
    end

3. RESULTS

According to the indicator selection process seen above, after the literature review, the indicators currently in use by the hotel industry were identified. At this point, a study was carried out where 847 factors were identified, grouped in 149 indicators contained in 6 dimensions, Table 3 shows the list of them with the values assigned to x_1, x_2, x_3.

For the selection of indicators, the values of x_1, x_2, x_3 (see Table 3) were taken to be conditioned and added to the HS code; once the algorithm is ready with all the parameters declared and well defined, it is processed and this yields the result with the best harmony, which for this problem turns out to be:

$$x_1 = 2, \qquad x_2 = 4, \qquad x_3 = 2021$$

Regarding the search area of the algorithm, Figure 5 shows a heat plot, where all the possible improvisation tones are found, i.e., the 149 indicators that will be evaluated and the best ones that will be stored in the jazz musician's memory, in this case the red dot shows where the musician identifies the best harmony.

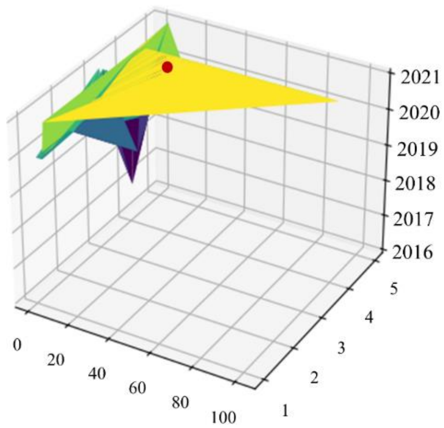

Figure 5. HS search space

Table 3. Sustainable indicators and values for x_1, x_2, x_3

#	x_1	x_2	x_3	#	x_1	x_2	x_3
1En	2	4	2021	76Ec	3	3	2021
2En	8	4	2021	77Ec	9	4	2021
3En	32	4	2021	78Ec	1	4	2020
4En	23	4	2021	79Ec	6	4	2020
5En	4	4	2016	80Ec	4	4	2018
6En	29	4	2021	81Ec	6	4	2020
7En	12	4	2021	82Ec	1	4	2018
8En	6	4	2021	83Ec	8	4	2018
9En	10	4	2021	84Ec	1	4	2016
10En	102	4	2021	85Ec	2	4	2016
11En	2	4	2020	86Ec	3	4	2021
12En	13	4	2020	87Ec	2	4	2019
13En	16	4	2021	88Ec	2	4	2019
14En	3	2	2020	89Ec	1	4	2019
15En	1	5	2020	90Ec	4	5	2020
16En	1	5	2020	91Ec	1	4	2019
17En	3	5	2020	92T	6	1	2020
18En	6	4	2021	93T	2	1	2020
19En	2	3	2020	94T	3	1	2020
20En	3	4	2020	95T	1	5	2020
21En	1	4	2018	96T	3	1	2020
22En	1	4	2017	97T	1	5	2020
23En	1	4	2017	98T	6	4	2020
24En	1	4	2016	99T	12	5	2020
25En	6	4	2021	100T	1	4	2017
26S	8	4	2020	101T	2	2	2021
27S	7	4	2021	102T	1	4	2018
28S	13	4	2021	103T	2	2	2021
29S	7	4	2020	104T	2	2	2021
30S	12	4	2021	105T	1	3	2021
31S	21	4	2021	106T	4	4	2021
32S	5	4	2020	107T	1	4	2016

33S	3	3	2021	108C	5	4	2020
34S	1	5	2020	109C	6	4	2021
35S	20	4	2021	110C	3	4	2021
36S	6	1	2021	111C	7	4	2021
37S	10	4	2021	112C	1	5	2020
38S	2	4	2018	113C	2	5	2020
39S	1	4	2018	114C	4	4	2021
40S	7	4	2021	115C	2	4	2021
41S	6	4	2020	116C	1	4	2016
42S	1	5	2020	117C	3	4	2017
43S	3	5	2020	118C	1	4	2016
44S	8	4	2021	119C	2	4	2018
45S	1	4	2021	120P	19	4	2021
46S	2	2	2020	121P	4	4	2020
47S	2	4	2019	122P	5	5	2021
48S	3	4	2019	123P	15	4	2021
49S	1	4	2018	124P	2	5	2020
50S	2	1	2020	125P	3	4	2020
51S	2	4	2018	126P	11	4	2021
52S	1	4	2018	127P	3	4	2020
53S	2	4	2018	128P	10	4	2021
54S	5	1	2020	129P	1	4	2018
55S	1	4	2019	130P	2	4	2020
56S	2	4	2021	131P	6	4	2020
57S	3	4	2020	132P	4	4	2018
58S	1	4	2019	133P	5	4	2021
59Ec	5	4	2019	134P	3	1	2020
60Ec	15	4	2021	135P	3	1	2021
61Ec	19	4	2021	136P	11	4	2021
62Ec	2	4	2021	137P	2	1	2021
63Ec	15	4	2021	138P	4	1	2020
64Ec	8	4	2021	139P	3	5	2020
65Ec	3	4	2019	140P	2	1	2020
66Ec	4	2	2020	141P	2	5	2020
67Ec	12	4	2019	142P	2	5	2020
68Ec	1	4	2018	143P	1	4	2020
69Ec	7	4	2020	144P	1	4	2016
70Ec	5	4	2020	145P	3	4	2020
71Ec	5	4	2020	146P	2	1	2020
72Ec	2	1	2021	147P	1	4	2016
73Ec	6	4	2020	148P	2	4	2018
74Ec	3	5	2020	149P	1	4	2018
75Ec	6	1	2021				

The indicators corresponding to the best harmony ($x_1 = 2$, $x_2 = 4$, $x_3 = 2021$ are 1 En, 56 S and 115 C, these being the best since they have a regional application and are the most updated according to their date of application. However, in order to obtain a list instead of a small group of optimal indicators, it was decided to select the ten best harmonies given by HS.

Thus, the indicators that are positioned as the second best in harmony are the chord $x_1 = 8$, $x_2 = 4$, $x_3 = 2021$ where indicators 2 En, 44 S and 64 Ec are selected, followed by the chord $x_1 = 32$, $x_2 = 4$, $x_3 = 2021$ which corresponds to indicator 3 En, on the other hand the $x_1 = 23$, $x_2 = 4$, $x_3 = 2021$ contains the indicator 4 En, followed by the $x_1 = 102$, $x_2 = 4$, $x_3 = 2021$ with the indicator 10 En, up to this point we have 5 chords as best harmonies with a total of 9 indicators.

Table 4. Best harmony

Best harmony	Indicator	Indicator description
2, 4, 2021	1A	Efficient use of transport
	56S	Employee commitment to the organization
	115C	Cultural interactions
8, 4, 2021	2A	Reducing the use of toxic substances and chemicals, which are harmful to the environment
	44S	Internal environmental program initiatives
	64E	Green-marketing
32, 4, 2021	3A	Waste management: adoption of a system for measuring and reducing the quantity of solid waste
23, 4, 2021	4A	Recycling and reuse of resources
102, 4, 2021	10A	Sustainable management and efficient use of resources: water, energy and raw materials
20, 4, 2021	35S	Implementation of an environmental education program by hotel companies
19, 4, 2021	61E	Customer purchase decision factors for a sustainable hotel
	120P	Commitment of top management to govern in accordance with sustainable management policies
12, 4, 2021	7A	Adoption of a system to counteract environmental threats, evaluate, control and minimize the effects of greenhouse gas emissions
	30S	Sustainable education for staff, customers and local community
7, 4, 2021	27S	Participate in internal promotion and sustainable conservation activities
	40S	Equal employment opportunity
	111C	Preservation by hotel companies of archaeological, cultural, religious and sacred sites in the area where they are located
10, 4, 2021	9A	Hotel companies minimize pollution from noise, light, runoff and other environmental hazards, as well as health and welfare risks to the community
	37S	Employee occupational health and safety
	128P	The hotel integrates environmental measures into its policies, strategies and planning

The search continues with another 5 chords and $x_1 = 20$, $x_2 = 4$, $x_3 = 2021$ is obtained as the sixth best harmony which contains the indicator number 35 S, followed by the chord $x_1 = 19$, $x_2 = 4$, $x_3 = 2021$ with the indicators 61 Ec and 120 P, the chord $x_1 = 12$, $x_2 = 4$, $x_3 = 2021$ with 7 En and 30 S, then, the chord $x_1 = 7$, $x_2 = 4$, $x_3 = 2021$ to which correspond 27 S, 40 S and 111 C, finally with the tenth best harmony the chord $x_1 = 10$, $x_2 = 4$, $x_3 = 2021$. where we have the indicators 9 En, 37 S and 128 P. It should be noted that the 9 selected harmonies share the same values of level of application and year of publication x_2, x_3 as the first best harmony.

Table 4 shows the best harmonies, as well as the indicators that compose each chord, together with the description of each of the selected indicators, these are ordered according to their position obtained with HS. A total of 20 indicators were selected, which are integrated into the dimensions of sustainable development, Environmental (En), Social (S) and Economic (Ec), as well as two other dimensions, which were identified in the Cultural (C) and Political (P) literature, as these are important in tourism and the hotel industry. However, the algorithm did not select any indicator of the Technological (T) dimension within these top 10 harmonies.

The final list of sustainable indicators is shown in Table 5, where it can be seen that most indicators correspond to the Environmental and Social dimensions, both with 7 indicators, followed by Economic, Cultural and Political with 2 indicators respectively. However, the position of each indicator does not indicate its level of importance, i.e., in this list, it is no longer considered which corresponds to the most optimal harmony, but simply proposes a list resulting from the HS algorithm.

On the other hand, *Genetic Algorithm (GA)* was used to compare the performance of HS with respect to the optimal result, i.e., with the best harmony ($x_1 = 2,\ x_2 = 4,\ x_3 = 2021$), so that the parameters and objective function of GA are the same as those used in HS.

Once the code was ready, it was processed and yielded as its best fitness, that is, best harmony or optimum result $x_1 = 102,\ x_2 = 4,\ x_3 = 2021$, which corresponds to indicator number 10, this in turn, is in the Environmental dimension and is described as: Sustainable management and efficient use of resources: water, energy and raw materials.

Table 5. List of proposed sustainable indicators

#	Dimension	Indicator
1	Environment	Efficient use of transport
2		Reducing the use of toxic substances and chemicals, which are harmful to the environment
3		Waste management: adoption of a system for measuring and reducing the quantity of solid waste
4		Sustainable management and efficient use of resources: water, energy and raw materials
5		Recycling and reuse of resources
6		Hotel companies minimize pollution from noise, light, runoff and other environmental hazards, as well as health and welfare risks to the community
7		Adoption of a system to counteract environmental threats, evaluate, control and minimize the effects of greenhouse gas emissions
8	Social	Employee commitment to the organization
9		Internal environmental program initiatives
10		Implementation of an environmental education program by hotel companies
11		Sustainable education for staff, customers and local community
12		Participate in internal promotion and sustainable conservation activities
13		Employee occupational health and safety
14		Equal employment opportunity
15	Economy	Green-marketing
16		Customer purchase decision factors for a sustainable hotel
17	Cultural	Cultural interactions
18		Preservation by hotel companies of the archaeological, cultural, religious heritage and of the sacred places in the environment where they are located
19	Politics	Commitment of senior management to govern in accordance with sustainable management policies
20		The hotel integrates environmental measures in its policies, strategies and planning

4. CONCLUSIONS

The use of Metaheuristics for problem solving in the field of tourism and the hotel industry is not widely in use, since it is mainly focused on route resolution, specifically in *Traveling Salesman Problem (TSP)* with GA algorithms. While the application of HS does not present use for this type of problems.

For its part, the process of selecting sustainable indicators for the hotel industry presents the use of tools such as questionnaires, for expert judgment and in-depth interviews, this being the most common method for this type of problems, in turn, it can be seen that the search and application of more complex methodologies is in full development, since, prior technical knowledge is required for its application, such is the case of multicriteria decision-making methods such as AHP or the method proposed in this work (HS) which is the programming for Metaheuristic algorithms.

The advantages of using this list lie in the fact that the indicators are up to date because recent literature was considered. Furthermore, since they are selected based on maximization criteria, they are not biased by the subjectivity that could arise at the time of selection based on the criteria of individuals, but rather, based on the restrictions and values given to the algorithm.

On the other hand, when comparing the optimal result given by HS and GA, despite the fact that both were programmed under the same criteria and data, there are two different results, being Efficient use of transportation with two publications, national level and from the year 2021 the best indicator for HS, while Sustainable management and efficient use of resources: water, energy and raw materials with 102 publications, national level and from the year 2021, the best option for GA.

From the above, it is concluded that GA achieved a better performance since the result it yielded has the indicator with the highest number of publications, in addition to the most recent year and its most frequent application level, i.e., the objective function is better fulfilled by maximizing the X variables, so that if the 10 best fitness are searched for, a list of indicators different from that provided by HS would be obtained, since the space and search analogy of both is different. However, the use of this list is viable due to the advantages it offers in comparison to the common methods, in addition, with this HS a precedent is set for the use of more complex methodologies in the selection of sustainable indicators, in turn, it is intended to promote the use of Metaheuristic algorithms within the hotel industry.

Thus, for future work, it is recommended to implement another type of Metaheuristics, perhaps returning to basic algorithms such as GA and PSO, which are highly consolidated and developed, allowing to go to libraries with codes and pseudocodes that serve as a basis for their conditioning and subsequent application.

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NOMENCLATURE

x_n	Relevant indicator
Z	Value of the addition of relevant indicators
HSA	Harmony search algorithm
HM	Harmony memory vectors
HMS	Harmony memory size
HMCR	Harmony search memory change rate
PAR	Pitch adjustment rate
x_i	Memory vector define in a search space
x_i'	New accepted memory vector candidate
x^p	New worst harmony within the vectors
E	Condition declaring that if the result is beyond the certain acceptance range of HM
$v_{i,k}$	Pitch adjustment based on best vector
$f(x')$	Function for evaluating acceptation in memory vector
$f(x^p)$	Function for evaluating non acceptation in memory vector
En	Environment
S	Social
C	Cultural
T	Technological
P	Political
Ec	Economical
#	Number

Greek symbols

ϕ	New harmony which fulfill fitness value