

Article

Measuring Sustainability with Unweighted TOPSIS: An Application to Sustainable Tourism in Spain

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Abstract: The measurement of sustainability is complex due to its multiple dimensions of different relative importance and different natures. From the perspective of sustainability, three types of tourism can be established: traditional tourism, sustainable tourism, and sustainable impact tourism. In the context of multiple-criteria decision analysis, this paper presents a flexible method for assess and rank decision alternatives based on their sustainability. The proposal does not require the relative importance of each criterion to be precisely assigned beforehand, which reduces the subjectivity of the decision making and yields results that can be of interest for decision makers. To show the difference between these three sustainability options in tourism and the benefits of the method, the proposal is applied to public and private tourism management in Spain—in particular, to hotel booking and the evaluation and management of sustainability in the autonomous regions.

Keywords: sustainability; tourism; multiple-criteria decision analysis



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1. Introduction

It is difficult to find real-world situations in which decisions depend on a single criterion. In fact, it is common for multiple objectives and/or criteria to come into conflict and for decisions to favor some at the cost of others [1,2]. This has led to the rapid development of multiple-criteria decision analysis (MCDA) over the last decades [3,4]. The Sustainable Development Goals set by the United Nations are clear examples of multiple criteria and targets. They consist of 17 objectives and 169 goals that aim to ensure a balance between economic wellbeing, environmental conservation, social progress, and quality of life [5].

At present, it is clear that the difficulties inherent in the fulfillment of the Sustainable Development Goals (SDGs) are compounded by the COVID-19 pandemic, which has not only gravely damaged public health and economies, but has also modified social patterns and leisure management, with direct impacts on the tourism industry. For these reasons, it is adequate to consider the use of MCDA to be highly beneficial in facilitating decision making for the advancement of the SDGs, while remaining flexible enough to accommodate a wide diversity of situations.

Sustainability objectives usually implies actions with medium- and long-term impacts; for this reason, decisions must be based on indicators that are stable with respect to scores obtained with predetermined criteria and the importance of each criterion. Nevertheless, stability is not the only difficulty to be encountered. In some cases, criteria can be defined directly with precision, which allows them to be measured. However, in many other cases, there is a lack of consensus around the definitions of the criteria, so the measurements need to be indirect or imprecise evaluations and indicators need to be used [6,7]. This situation can be further aggravated when intangible objects, such as perceptions and opinions, need to be evaluated [8,9]. Many current studies have analyzed the possibilities of building

consensus in cases like the latter [10,11], and there are no guarantees that it can always be achieved [12,13].

In the present study, we will use the Technique for Order of Preference by Similarity to the Ideal Solution (TOPSIS) [14]. This choice is based on the multitude of successful decisions that have been made based on this method [15], including those relating to sustainability [16], education for sustainable development [7], environmental sustainability [17], and sustainable development in EU states [18].

To avoid the inconvenience of assigning a relative importance to each criterion involved in the decision making, we believe that methods based on sustainability require generalizations of the original TOPSIS that introduce more flexibility. This is why we will be using the method proposed by Liern and Pérez-Gladish [19] and Benítez and Liern [3], Unweighted TOPSIS (uwTOPSIS), in which the importance of each criterion is assigned in intervals to prevent decisions from being constrained by previous impositions.

In this work, we will apply our proposal to sustainable tourism in Spain. From a conceptual point of view, we do not recognize the existence of a biunivocal definition of “sustainable tourism”, although the use of the term usually refers to a form of tourism that aims to minimize the impact on the environment and the local culture while contributing to the generation of income and employment for the local population. The World Tourism Organization (WTO) defines sustainable tourism as “tourism that takes full account of its current and future economic, social, and environmental impacts, addressing the needs of visitors, the industry, the environment, and host communities”. This definition assumes the balancing of economic, social, environmental, and other interests, therefore requiring use of MCDA methods for decision making.

Specifically, to aid decision making, two indicators are proposed: the TOPSIS indicator, which will be used when the relative importance of each criterion used in the decision is known, and uwTOPSIS, which should be used when the relative importance of a criterion is not precisely known.

From a technical point of view, all data used are public and can be accessed on the referenced websites; all calculations were performed with the R programming language and a software library called uwTOPSIS [3], which allows users to reproduce results and apply the method to their own problems. This software was chosen because it is an open-source initiative that, due to its free availability, has become very common in computational statistics and many other scientific fields.

2. Approach of the Proposal

To lay the groundwork for the proposal, a similar approach to the one applied to other contexts by Benítez and Liern [3] was considered. The classification of types of tourism is based on a user or client perspective with consideration of the interest in sustainability (see Figure 1). In this paper, when the contracting of a tourism asset (hotel, trip, tour, etc.) does not explicitly seek to minimize the impact on the environment, the local culture, etc., it is classified as unsustainable tourism, in which the following criteria should be optimized: (1) maximizing the adaptation of the tourism asset to the client’s needs and (2) minimizing the costs of the tourism activity.

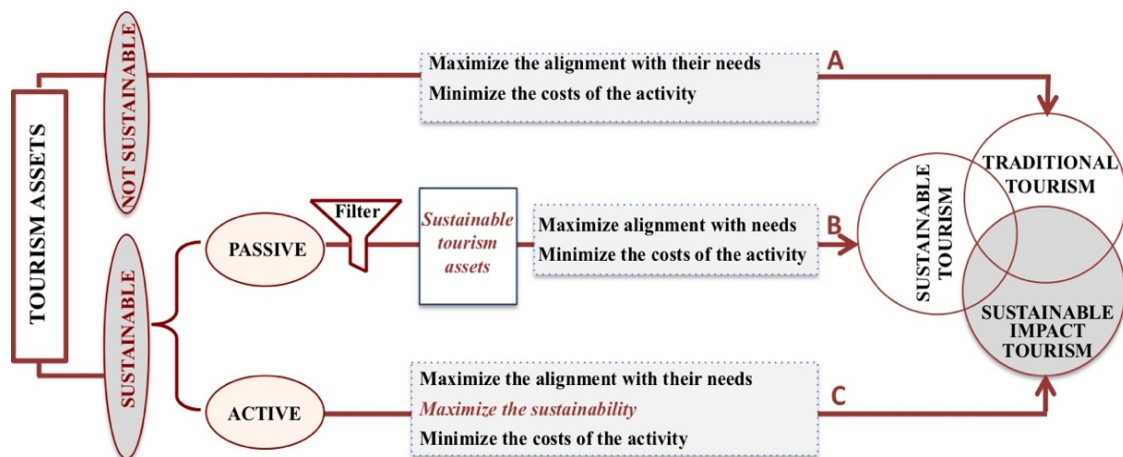


Figure 1. Tourism classification based on a multicriteria sustainability perspective.

When a tourism activity does not explicitly seek to be sustainable, there are two forms of sustainable tourism:

1. Passively managed sustainable tourism: Tourists are concerned about sustainability and therefore only use assets classified as sustainable. Namely, there is a pre-existing filter (institutional, commercial, corporate, etc.) that allows the selection of only assets that are considered sustainable (green hotels, sustainable tours, etc.) With these sustainable assets, tourists seek to:
 - (a) Maximize the alignment with their needs.
 - (b) Minimize the costs of the activity.
2. Actively managed sustainable tourism: Tourists decide whether they consider an asset to be sustainable by analyzing a set of criteria. In this case, tourists seek to:
 - (a) Maximize the sustainability of the tourism asset (Sections 2 and 3 of this paper are devoted to the construction of synthetic indicators that measure sustainability, and these will be the ones to be maximized).
 - (b) Maximize the alignment with their needs.
 - (c) Minimize the costs of the tourism activity.

Naturally, as shown in Figure 1, any of the three options presented could lead to an engagement with the same tourism asset, meaning that the decisions can overlap. An example of this overlap is shown in Figure 2. If an alternative had to be chosen between H6, H7, H8, H9, H10, and H11, the perspectives of sustainable tourism and that of sustainable impact tourism would lead to the same decision: H7. If the classification were to be performed from the point of view of the tourism industry, objectives such as “profit maximization” or price–quality ratio optimization would have to be added to the “cost minimization”. Nevertheless, we have opted not to add this perspective, as the method would remain largely unchanged.

The decisions in cases A and B of Figure 1 can be structured as multicriteria decision analysis (MCDA) problems. Let us imagine a scenario where a tourist wants to rent an apartment and must choose between various alternatives, A_1, A_2, \dots, A_n . The customer’s needs, such as the number of rooms, distance to the airport or to the beach, etc., are represented as criteria N_1, N_2, \dots, N_p , and the rental cost is represented as C (see Table 1). Regardless of the importance assigned to each criterion, the standard process would aim to minimize the cost and maximize the value of the criteria.

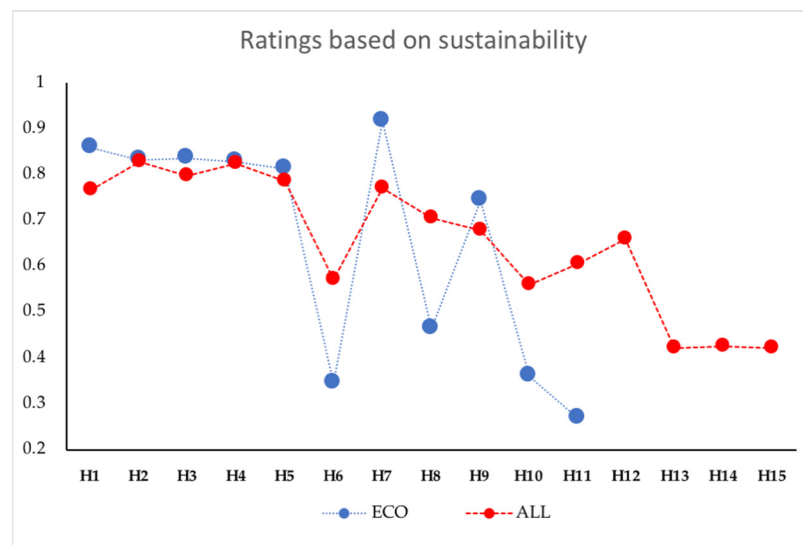


Figure 2. Hotel ratings based on a passive approach (ECO) and an active approach (ALL) to sustainability.

Table 1. Multicriteria decision analysis criteria for decision making in sustainable tourism (passive management).

	Alignment with Their Needs			Cost
Alternatives	N_1	...	N_p	C
A_1	a_{11}	...	a_{1p}	a_{1p+1}
A_2	a_{21}	...	a_{2p}	a_{2p+1}

A_n	a_{n1}	...	a_{np}	a_{2p+1}
Weights	u_1	...	u_p	v

The difference between cases A and B in Figure 1 is the set of alternatives: In A, all apartments in the area would be included, whereas in B, only those defined as sustainable would be included.

According to Oztel et al. [20] and Benítez and Liern [3], the TOPSIS method [14] is not only particularly suitable for solving this kind of problem, but it is also easy to implement in computational terms. In summary, once the criteria are known and the importance of each is assigned, the method for ranking the alternatives works as follows (Scheme 1):

INPUTS:

1. Alternatives, $A_i, 1 \leq i \leq n$, valued in m criteria $[x_{ij}]$.
2. Relative importance (weight) of each criterion, $w_j, 1 \leq j \leq m$.

STEP 1: Normalized decision matrix $[r_{ij}]$.

STEP 2: Weighted normalized decision matrix.

STEP 3: Determination of the ideal A^+ and anti-ideal A^- solutions (choosing, from among all the alternatives, the best and worst values, respectively, for each criterion).

STEP 4: Compute the distance, d , of each alternative from A^+ and A^- .

STEP 5: Relative proximity: Calculate the TOPSIS indicator

$$R_i = d(A_i, A^-) / [d(A_i, A^-) + d(A_i, A^+)], 1 \leq i \leq n.$$

OUTPUTS: Ranking of the alternatives according to the values of R_i .

Scheme 1. TOPSIS ALGORITHM.

In this work, the Euclidean distance is used in steps 4 and 5, as this is one of the most common approaches; however, many other distances can be chosen, and this choice has implications in the evaluation process (see, for instance, [21]). From the perspective of sustainable impact tourism (case C in Figure 1), the criteria in Table 1 are insufficient due to the lack of criteria for measuring and maximizing sustainability. This is the goal of the following section: to propose a method that allows the estimation of the sustainability to be maximized. As will be seen in the application to sustainable tourism in Spain, our proposal could be of use for applying filters (passive management), but also as a basis for clients to maximize sustainability (active management).

3. A Tool for Sustainable Decision Making

Although there is growing consensus around the definition of sustainability, and the approaches to the concept depend heavily on the type of activity involved (business, culture, leisure, etc.), there is unanimity around the fact that sustainability depends on a large range of criteria and cannot be seen as an aggregate of rigid values, as it is made up of imprecise components, including numbers, predictions, and even opinions [22,23]. For this reason, to be able to measure sustainability, it is necessary to introduce a degree of flexibility to the TOPSIS method described above (Scheme 1).

In Liern and Pérez-Gladish [4] and Benítez and Liern [3], a multi-criteria method (uwTOPSIS) was proposed, in which the criteria did not need to be weighted and fixed, and the results were presented as intervals for each alternative (relative proximity). This flexibility makes uwTOPSIS suitable for measuring sustainability, which is why in this paper it is applied for the first time to provide a synthetic indicator of sustainability. The following sections describe how to build this indicator (without making methodological contributions to the proposals in [3,4]) and show how to integrate it into the proposed method for sustainability management. This will allow us to approach the management of active and sustainable tourism from a multi-criteria perspective (option C, Figure 1).

3.1. A Flexible Algorithm for Measuring Sustainability: uwTOPSIS

Following Liern and Pérez-Gladish [4], we propose uwTOPSIS as an alternative to the subjective weight assignment by considering weights as decision variables of an optimization problem. As an algorithm, uwTOPSIS can be described as follows (Scheme 2):

In this work, for the sake of simplicity, the intervals were ranked by taking $k_1 = k_2 = 0.5$ in Step 6, i.e., the midpoints of the intervals were used as the uwTOPSIS indicator.

The proposed flexible algorithm ranks alternatives that help the decision-making process, but also provides additional information that can be of great interest for management purposes. The method establishes weights or relative importance, which provide the best and worst evaluations of each alternative. If a criterion C_j obtains a high value in the worst evaluation of alternative A_i , this means that A_i presents a weakness in criterion C_j , meaning that decision makers must rank the weaknesses of each alternative. As will be shown in the applications, when sustainability is analyzed (especially by public management), the method informs us as to which criteria should be focused on in order to be more sensitive to changes in sustainability.

INPUTS: Alternatives, $A_i, 1 \leq i \leq n$, valued in m criteria $[x_{ij}]$.

STEP 1: Normalized decision matrix $[r_{ij}]$.

STEP 2: Determination of the ideal A^+ and anti-ideal A^- solutions (choosing, from amongst all the alternatives, the best and worst values, respectively, for each criterion).

STEP 3: Let Ω be the set of non-negative value vectors $w=(w_1, \dots, w_m)$, such that $w_1+\dots+w_m=1$. Calculate

$$d_{i+}(w) = \sqrt{\sum_{j=1}^m w_j^2 (r_{ij} - A_j^+)^2}, d_{i-}(w) = \sqrt{\sum_{j=1}^m w_j^2 (r_{ij} - A_j^-)^2}, w \in \Omega.$$

STEP 4: Relative proximity: Compute

$$R_i(w) = d_{i-}(w) / [d_{i-}(w) + d_{i+}(w)], 1 \leq i \leq n.$$

STEP 5: Calculate the extreme values of the functions R_i :

$$R_{i-} = \text{Min}\{R_i(w) : w \in \Omega, l_j \leq w_j \leq u_j, 1 \leq j \leq m\}$$

$$R_{i+} = \text{Max}\{R_i(w) : w \in \Omega, l_j \leq w_j \leq u_j, 1 \leq j \leq m\}$$

and construct the intervals:

$$R_i^I = [R_{i-}, R_{i+}], 1 \leq i \leq n.$$

STEP 6: Calculate the *uwTOPSIS indicator*

$$UWR_i = k_1 R_{i-} + k_2 R_{i+}, 1 \leq i \leq n.$$

k_1 and k_2 are two preset positive constants such that $k_1 + k_2 = 1$.

OUTPUTS: Ranking of the alternatives according to the values of UWR_i .

Scheme 2. UWTOPSIS ALGORITHM.

3.2. Method for Managing Sustainability in Tourism

Estimates of sustainability with respect to tourism activities need to be useful for decision making. Therefore, one set of criteria is added to those proposed in Table 1, making three sets: alignment with client needs, cost, and sustainability (see Table 2).

Table 2. Multicriteria decision-making analysis criteria for decision-making in sustainable tourism (active management).

	Alignment with Their Needs			Cost	Sustainability
Alternatives	N_1	...	N_p	C	uwR
A_1	a_{11}	...	a_{1p}	a_{1p+1}	a_{1p+2}
A_2	a_{21}	...	a_{2p}	a_{2p+1}	a_{2p+2}

A_n	a_{n1}	...	a_{np}	a_{2p+1}	a_{2p+2}
Weights	u_1	...	u_p	v	w

It is important to underline the fact that, in most cases, clients know specifically what weight they would like to assign to each set of criteria (alignment to their needs, cost, and sustainability), despite often not knowing the particular weights of the criteria that make up each set. For example, in the application of Section 4.2, 40% was assigned to the clients' needs, 40% to cost, and 20% to sustainability, meaning that a multicriteria decision analysis

needs to be chosen appropriately. In other words, if the aim is to measure sustainability, due to its very nature, the method will need to be flexible, as will the relative importance of each criterion. For this aim, uwTOPSIS is proposed (Scheme 2). Nevertheless, once sustainability is measured, clients need to be able to decide what weight is assigned to each set of criteria, and therefore, the classic TOPSIS method will also be necessary (Scheme 1).

For the sake of clarity, the algorithmic formulation is as follows (Scheme 3):

INPUTS:

1. Alternatives, A_i , $1 \leq i \leq n$, valued in m criteria $[x_{ij}]$.
2. Relative importance (weight) of each criterion, w_j , $1 \leq j \leq m$.
3. Weights for client needs, cost, and sustainability.

STEP 1: Evaluation of each criterion for each alternative.

STEP 2: Measurement of sustainability with the uwTOPSIS indicator.

STEP 3: Obtainment of the index of similarity to the ideal solution, R_i , with the TOPSIS indicator.

OUTPUTS: Ranking of the alternatives according to the values of R_i .

Scheme 3. RANKING OF SUSTAINABILITY ALTERNATIVES.

As in any other decision, the client or decision maker will have the last word. However, knowing the ranking of alternatives based on the established criteria can hugely improve the process.

4. Application to Private and Public Sustainable Tourism Management

This section presents two applications of our method for sustainable tourism management. The first considers the choice of a hotel room in Mallorca (Spain) from two perspectives: sustainable tourism (option B, Figure 1) and sustainable impact tourism (option C, Figure 1). The second application addresses public management by analyzing tourism sustainability in Spain's autonomous regions.

4.1. Application to Private Management

A client wants to book a double room in a four- or five-star hotel in Mallorca during the low season. If this client is interested in making the stay sustainable (i.e., the hotel respects its natural environment), two approaches are possible:

- (a) Searching the internet for “ecological hotels in Mallorca” and choosing from the results the one that is most aligned with his or her needs (this is what called a passive approach, or sustainable tourism).
- (b) Accessing the hotels' websites, personally deciding whether the different options are sustainable or not, and then choosing the one that is most aligned with his or her needs (this is what called an active approach, or sustainable impact tourism).

Next, two simple real-world examples are presented, showing how our method applies to each case. In both cases, tests have been carried out considering various possibilities for the weights assigned to the criteria. However, in what follows, as our objective is to present the functioning of the proposed method and to illustrate its practical applicability, we have preferred to present only the results obtained using the weights that have been suggested by the experts in tourism management from the Cercle de Economia de Mallorca (Spain).

4.1.1. Sustainable Tourism

A client chooses among the top 11 four- and five-star hotels that appear in a Google search for “ecological hotels Mallorca” (hotels H1, H2, . . . , H11 from Table 3. Once filtered,

the key aspects for the client are the alignment to their needs and the cost. In this case, the following seven indicators are used:

- N_1 = Number of stars,
- N_2 = Client ratings,
- N_3 = Distance from the center,
- N_4 = Distance from the airport,
- N_5 = Whether or not it has a spa,
- N_6 = Sports facilities, and
- C = Cost per room per night.

Table 3. Ratings of a set of hotels in Mallorca.

Hotels	Alignment with Their Needs						Cost
	N_1	N_2	N_3	N_4	N_5	N_6	
H1	4	8.6	0.8	15	1	0	88
H2	4	8.8	1.1	15	1	1	111
H3	4	8.4	1.5	15	0	1	93
H4	4	8.3	1.8	20	1	1	111
H5	4	8.5	1.9	16	0	1	101
H6	5	9.2	5.2	15	0	1	232
H7	4	8.3	10.4	15	1	1	82
H8	4	9.5	20.9	40	0	1	164
H9	4	8.9	23	35	1	1	109
H10	5	8.4	5.2	20	1	1	219
H11	4	8.6	43	58	1	1	199
H12	4	8.1	11	30	0	1	95
H13	5	9.5	0.4	20	1	1	263
H14	5	9.8	0.4	8	1	1	234
H15	4.5	9.8	0.5	18	1	1	265

Note: In criteria N_5 and N_6 , “yes” is considered as 1 and “no” is considered as 0.

Fifty percent of the decision is based on the room price and fifty percent is based on the alignment with the client’s needs. In other words, the weight assigned to each N_i ($i = 1, \dots, 6$) is 0.083, and the weight assigned to the cost (C) is 0.5.

The application of the classic TOPSIS method (Scheme 1) to the data from Table 3 yields the results shown in Table 4.

Table 4. Hotel ranking in descending order.

Hotel	Rating	Hotel	Rating
H7	0.91347898	H9	0.74177112
H1	0.85808821	H8	0.46231056
H3	0.83458709	H10	0.3605684
H2	0.83171035	H6	0.34306807
H4	0.82789739	H11	0.26848551
H5	0.81185541		

Based on the results shown in Table 4, the client should choose hotel H7 for his or her vacation.

4.1.2. Sustainable Impact Tourism

This client chooses from an unfiltered list of 15 four- or five-star hotels in Mallorca (Table 3). In order to determine that the hotels are sustainable, in addition to the previous indicators (N_i , C), he or she considers the following:

- S_1 = Availability of bicycle rentals,
- S_2 = Availability of eco-tours,
- S_3 = Adherence to quality labels,

S_4 = Use of the term “sustainability” on the hotel’s website, and
 S_5 = Personal evaluation of sustainability based on the website.

Table 5 shows the values of these indicators and the relative importance of each one. S_5 weighs between 30 and 50%, and the others between 10 and 30% (see Table 5).

Table 5. Estimate of the sustainability of a set of hotels in Mallorca.

Hotels	S_1	S_2	S_3	S_4	S_5	Sustainability	uwTOPSIS
H1	1	0	0	0	4	[0.10248, 0.48165]	0.29207
H2	0	0	0	1	7	[0.22051, 0.66656]	0.44353
H3	0	0	0	1	6	[0.18344, 0.58099]	0.38221
H4	0	0	0	1	7	[0.22051, 0.58099]	0.44350
H5	0	0	0	1	6	[0.18344, 0.58099]	0.38221
H6	0	0	0	1	9	[0.28565, 0.83388]	0.55976
H7	1	0	0	0	4	[0.10248, 0.48165]	0.29207
H8	0	1	0	0	10	[0.37215, 0.92491]	0.64853
H9	1	0	0	0	3	[0.05957, 0.44535]	0.25246
H10	0	0	0	1	7	[0.22051, 0.66656]	0.44353
H11	1	0	1	1	10	[0.43717, 0.93540]	0.68629
H12	0	0	0	0	2	[0.01693, 0.25272]	0.13482
H13	0	0	0	0	5	[0.14122, 0.33576]	0.23849
H14	0	0	0	0	2	0	0
H15	1	0	0	0	2	[0.02599, 0.35905]	0.19252
Weights	[0.1, 0.3]	[0.1, 0.3]	[0.1, 0.3]	[0.1, 0.3]	[0.3, 0.5]		

Note: In criteria S_1 , S_2 , S_3 , and S_4 , “yes” is considered as 1 and “no” is considered as 0.

As established in Section 3, hotels’ sustainability is measured by applying uwTOPSIS, and the sustainability intervals are expressed in column 7 of Table 5. In addition, the sustainability value of each hotel obtained by applying Scheme 2 appears in column 8 of Table 5.

Once the sustainability of each hotel is established, as seen in Section 4.1.1, the importance assigned to each indicator can vary. Let us assume that 40% of the decision is based on the cost (C), 40% on the alignment with their needs (N_1, \dots, N_6), and 20% on sustainability (uwTOPSIS). Considering Tables 3 and 5, the client can apply the classic TOPSIS method (Step 3 of Scheme 3) with the results, as shown in Table 6.

Table 6. Hotel ranking in descending order.

Hotel	Rating	Hotel	Rating
H2	0.82752861	H12	0.65669869
H4	0.82332153	H11	0.60382492
H3	0.79608973	H6	0.56830468
H5	0.78564263	H10	0.55992406
H7	0.77000405	H14	0.42285437
H1	0.76356583	H13	0.42043506
H8	0.70600807	H15	0.41896202
H9	0.67908731		

By applying this method, the tourist would choose hotel H2. Note that this hotel ranked fourth in Table 4. In order to facilitate a comparison, Figure 2 shows the ratings from Tables 4 and 6. As can be seen, the active and passive approaches to sustainability yield different results.

Despite having used a small sample to illustrate the use of the method, it is interesting to underline the fact that there is a number of hotels that are not labeled as sustainable in the search engines and still rank above counterparts that are.

4.2. Public Management

In this section, the utility of our method in rating the sustainability of the following seventeen autonomous regions of Spain is shown: Galicia (G), Principado de Asturias (AS), Cantabria (CAN), País Vasco (PV), Comunidad Foral de Navarra (CN), La Rioja (R), Aragón (AR), Comunidad de Madrid (MAD), Castilla y León (CL), Castilla La Mancha (CM), Extremadura (EX), Catalunya (CAT), Comunidad Valenciana (CV), Illes Balears (IB), Andalucía (AN), Región de Murcia (MU), Ciudad Autónoma de Ceuta (CE), Ciudad Autónoma de Melilla (ME), and Canarias (CA).

Three sets of criteria were used for the analysis: economic, social, and environmental (see Table 7). These criteria were agreed upon by three experts who often collaborate with the Cercle d'Economia de Mallorca (Spain) on sustainability issues. The choice of three experts aimed at representing the opinions of tourism entrepreneurs, the central government and the regional government. These experts were asked for the minimum number of representative criteria and the relative importance (weight) of each criterion.

Table 7. Criteria used for the rating of the autonomous regions of Spain.

Criteria	Description	Source
	Economic	
C1	GDP per capita (euros).	[24]
C2	Average monthly salary (euros).	[25]
C3	Expenditure on R&D as a percentage of GDP.	[26]
	Social	
C4	Inequality (S80/S20). Ratio of the average income of the 20% of the population with the highest income and the 20% of the population with the lowest income.	[27]
C5	Percentage of population over 16 with higher education.	[28]
C6	Education dropout rates at 18–24 years.	[29]
C7	Percentage of the population with difficulties in making ends meet.	[30]
C8	Average price of rent per square meter (euros).	[31]
	Environment	
C9	Percentage of the population that suffers from pollution or other environmental problems.	[32]
C10	CO ₂ equivalent emissions. A metric used to compare the emissions from various greenhouse gases on the basis of their global-warming potential (thousands of tonnes).	[33]
C11	Volume of reused water (m ³ /day).	[34]

The information collected from the experts was expressed in intervals [35]. The intervals were established with the lowest and highest weight assigned by each expert (see Table 8).

Table 8. Weights assigned for the chosen criteria.

Criterion	Weight	Criterion	Weight
C1	[0.025, 0.05]	C7	[0.1, 0.15]
C2	[0.025, 0.05]	C8	[0.1, 0.15]
C3	[0.1, 0.15]	C9	[0.1, 0.15]
C4	[0.1, 0.15]	C10	[0.1, 0.15]
C5	[0.025, 0.05]	C11	[0.025, 0.05]
C6	[0.1, 0.15]		

Data from the years 2013, 2016, and 2018 for the criteria shown in Table 7 yielded the following ratings of the autonomous regions through uwTOPSIS (Scheme 2).

Figure 3 shows the values expressed in Table 9. Firstly, it is noted that País Vasco, Comunidad Foral de Navarra, La Rioja, and Aragón (in 2018) occupy the upper third of the graph. Andalucía, Ciudad Autónoma de Ceuta (in 2016 and 2018), Ciudad Autónoma

de Melilla, and Canarias (in 2016) occupy the lower third of the graph, and the remaining regions occupy the middle.

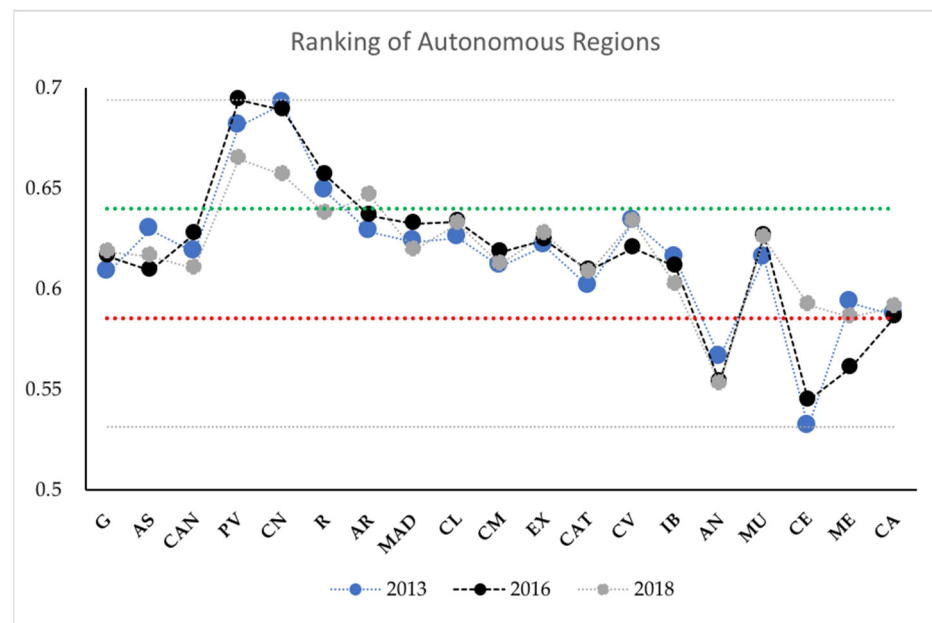


Figure 3. Ranking of the autonomous regions of Spain based on sustainability criteria.

Table 9. Autonomous region ratings.

	2013	2016	2018
G	0.60804004	0.61612784	0.618774
AS	0.62963472	0.60894686	0.616407
CAN	0.61827026	0.6272534	0.610694
PV	0.68120959	0.69459564	0.664528
CN	0.69226388	0.68939609	0.656817
R	0.64867183	0.65688444	0.637464
AR	0.62910691	0.63676344	0.646581
MAD	0.62356817	0.63268126	0.61948
CL	0.62525086	0.63351036	0.632914
CM	0.61178363	0.61872122	0.612491
EX	0.62130654	0.62415215	0.627851
CAT	0.60157059	0.60899477	0.608813
CV	0.63387812	0.62061758	0.633177
IB	0.61578498	0.61179817	0.601898
AN	0.56595284	0.55394867	0.552414
MU	0.6151311	0.6260996	0.625303
CE	0.53157768	0.54468348	0.59223
ME	0.59366351	0.56109981	0.586032
CA	0.58688223	0.58635907	0.591586

These ratings could have been used by public administrations to plan tourism promotion up until the advent of the COVID-19 pandemic; hopefully, this will be a possibility again in the near future. Nevertheless, this utility is not exclusive to our proposal and could be achieved based on a number of other indicators [36–38].

To better show the potential of the method, the weights shown in Table 8 are allowed to have some flexibility by assigning values between 4 and 15%. To facilitate this analysis, the example of the best and worst ratings of the Balearic Islands (Illes Balears) from 2018 is used. These ratings were obtained with the weights that appear in Table 10.

Table 10. Weights of the highest and lowest ratings of Illes Balears in 2018.

C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	
0.04	0.04	0.04	0.15	0.04	0.141137	0.15	0.058863	0.15	0.15	0.04	Max.
0.15	0.15	0.15	0.04	0.15	0.04225	0.041527	0.046224	0.04	0.04	0.15	Min.

As shown in Table 10, to obtain the maximum rating, the highest weight possible must be assigned to the criteria C₄ (inequality), C₆ (truancy), C₉ (percentage of population that suffers from pollution), and C₁₀ (CO₂ emissions). Therefore, these are clear strengths of Illes Balears. Nevertheless, to obtain the worst rating, the highest weight was assigned to the economic criteria (C₁, C₂, and C₃), the percentage of population over the age of 16 with higher education (C₅), and the volume of reused water (C₁₁). In this case, C₁, C₂, C₃, C₅, and C₁₁ were the criteria in which Illes Balears showed weaknesses. On the other hand, it should also be noted that the average price of rent per square meter (C₈) has a low impact on the autonomous region's sustainability rating according to the low weight assigned with uwTOPSIS.

Knowing the strengths and weaknesses of an autonomous region with respect to sustainability based on data instead of expert opinions can be highly useful for public authorities in that it informs them as to the best orientation of public efforts.

5. Discussion

When analyzing tourism sustainability, it is important to consider the following circumstances:

- (a) There are a multitude of indicators that are commonly used to favor particular interests of both the public and private sectors.
- (b) Online booking has grown substantially over the last decade and could likely further increase in the wake of the COVID-19 pandemic with the growing use of social networks, online search engines, etc.
- (c) The large amount of information that users have access to today means that sustainability rankings (of hotels, regions, etc.) are not always coherent with the information that users have.

For these reasons, the authors consider that it is necessary to establish tools that better fit demands for sustainability to clients' personal interests and real data. When sustainability is "measured" with indicators based on MCDA, being able to maximize the value of these indicators is an adequate strategy for making sustainable decisions.

Being able to express the relative importance of the diverse factors that contribute to sustainability in a precise manner will be beneficial in terms of the confidence placed in indicators by private users and decision makers alike. It is important to emphasize that these are real tools that reflect the will of people who engage in tourism activities, and not just mere arithmetic operations.

Clearly, the selection of criteria for Section 4 is insufficient and was not adequately justified, but our interest lies beyond this specific example, and is rather in the proposed method. Adding criteria and/or changing the value assigned does not affect our proposal in mathematical or conceptual terms.

The possibility of knowing the strengths and weaknesses of a tourism activity with arguments based on data instead of opinions (see Table 10) should be of great benefit for the strategies of political decision makers. Of course, this is not to suggest that the results obtained with this method should stand alone without being compared to experience-based opinions, but the results should be considered when developing those opinions.

On the other hand, all data used are from before the COVID-19 pandemic due to the fact that these are still the only available data of their kind. Nevertheless, the devastating drop in tourism of the last year should not directly affect the sustainability factor as much as the profitability of the sector's companies.

Finally, it should be noted that although the utility of the proposal was shown in real-world cases of public and private sustainable tourism management in Spain, the method can be equally applied in any country, region, or other specific case by simply substituting the data.

6. Conclusions

To aid in making decisions that consider the sustainability of tourism activities, two premises were considered: These are multicriteria decisions that need to be adapted to different personal situations, and there are different attitudes towards tourism sustainability. In some cases, clients do not take sustainability into account (traditional tourism), while in other cases sustainability is a key element in decisions. This paper considers a passive approach (sustainable tourism) in which potential clients trust labels and establishment rankings, as well as an active approach (sustainable impact tourism) in which potential clients search for information according to personal interests.

This paper proposes a method based on multicriteria optimization (see Scheme 3) to accommodate both public and private initiatives. This method is useful for deciding on the most appropriate alternatives and establishing the strengths and weaknesses of each option. Ultimately, we believe that facilitating sustainable decision making brings us one step closer to achieving the Sustainable Development Goals.

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