

Composite indicator for the assessment of sustainability: The case of Cuban nature-based tourism destinations

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ABSTRACT

This paper presents a methodology for building a composite indicator to evaluate the sustainability of nature-based tourism destinations. It combines Principal Component Analysis (PCA), the distance to a reference point, and Data Envelopment Analysis (DEA) with the aim of addressing some of the objections related to the aggregation procedure. The synthetic index obtained is based on a representative series of sub-indicators of the concept of sustainable tourist development as outlined by the World Tourism Organization (WTO). We apply it to evaluate Cuban nature-based tourism destinations. The results identify the strengths and weaknesses of destinations according to sustainability, and serve as a guideline for tourism planning in the future.

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1. Introduction

In recent years, the concept of sustainability has received an immense amount of attention in the socio-economic and managerial literature. This concept forms a nexus between the development of society and the economic agents that operate within it, and is bounded by the environmental, socio-cultural and economic framework (Sancho et al., 2002). Its link with development began with the publication of the report “Our Common Future” (Brundtland Report, 1987), which offered the most well-known definition of sustainable development. This definition addresses the relationship between economics and ecology, paying special attention to the social and cultural effects of economic growth (Van Broeck, 2005).

The relationship between sustainability and tourism has been known since the United Nations Earth Summit in June 1992, where efforts to apply the principles of sustainability to tourism development began as an attempt to apply these principles to the environment. From this time on, researchers and different organizations have been working to achieve a commonly accepted definition of sustainable tourism development. The World Tourism Organization (WTO) defines it as the kind of tourism that “...makes optimal use of environmental resources; respects the

socio-cultural authenticity of host communities; ensures viable, long-term economic operations, providing socio-economic benefits to all stakeholders; requires the informed participation of all relevant stakeholders, as well as strong political leadership; and also maintains a high level of tourist satisfaction” (WTO, 2004).

In addition to providing economic returns and a high-quality experience for visitors, sustainable tourism development should therefore also aim at protecting the natural environment and improving the quality of life of host residents (Choi and Sirakaya, 2006; Larson and Herr, 2008). In fact, given appropriate management and planning, this kind of tourism could be quite beneficial for developing countries (Yildirim et al., 2008).

In line with this new paradigm, government policies for tourism planning are directed toward a tourism model based on diversity, quality, and sustainability that can improve the competitiveness of destinations.

Taking this into account, many countries need to diversify their tourist offer, such as the Caribbean islands, where the main offer is based on sun and beach tourism due to their similarities. Thus, Cuba, for example, should design and implement policies aimed at diversification based on sustainability criteria.

The Tourism Ministry of the Cuban Republic (MINTUR) has prioritized nature-based tourism, based on three main issues (Medina and Santamarina, 2004):

- Increasing concern for the environment at the world level. This is related to the demand for tourist products associated with nature and the local cultures, while respecting the environment.

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- The potential in Cuba for developing this kind of tourism, either based on the natural environment, or on the environmental wealth and cultural diversity that exists in almost all regions of the country.
- The need to enrich the main tourist product of Cuba (sun and beach) with the natural resources and cultural attractions of each region.

This process requires the use of tools to evaluate the destinations and define the most suitable policies for their development. In this sense, indicators of sustainable tourist development can be used to great effect.

In this study, the indicator system is understood as a set of measurements used to provide data that would shed light on the links between sustainable tourism and industry and on impacts on the natural and cultural environments. Each component of the system evaluates an aspect of sustainability; these aspects can be taken into account individually or in combination with the rest of the system (Blancas et al., 2010a).

The indicator systems used in the planning process must be able to summarize information in order to facilitate decision-making by the agents involved. Composite indicators are widely used for this task and are defined as the mathematical combination of individual indicators that represent different dimensions of a concept whose description is the objective of the analysis (see Saisana and Tarantola, 2002); their use represents an innovative approach to evaluating sustainable development (Singh et al., 2009). They are invaluable regarding their ability to simplify complex measurements (Singh et al., 2007), such as sustainability, and are ideal for measuring multidimensional concepts that cannot be captured by a simple sub-indicator (Saisana and Tarantola, 2002; Nardo et al., 2005a).

Many methods have been used to build composite indicators (OECD, 2008). These methods depend more on the creator's abilities than the accepted rules for building them. Thus, the analyst must choose which procedure to apply for its construction according to the concept to be measured, such as choosing which sub-indicators to use, how these are divided into classes, whether a normalization method has to be used (and which one), the choice of the weighting method, and how information is aggregated (Nardo et al., 2005b).

Given this background, the present work has two objectives: the first is to define an indicator system to measure the sustainability of Cuban nature-based tourism destinations; the second is to build a global composite indicator able to measure the degree of sustainability of these destinations that gathers all the information contained in the initial indicators, allowing us to make a comparative analysis of these destinations.

Moreover, this indicator should allow a certain degree of freedom such that each destination analyzed can be evaluated regarding its strengths and weaknesses. Thus, we present a new two-stage methodology which combines three techniques: Principal Component Analysis (PCA) (statistical multivariate technique), the distance to a reference point (multiobjective programming), and Data Envelopment Analysis (DEA) (linear programming technique). This has the aim of obtaining a composite indicator which the end-user can understand, making a comparative analysis, and identifying the sub-indicators and dimensions that have the most influence on the global value.

Our study is divided into 5 sections. In the next section we describe how the indicators were obtained to measure sustainability in the destinations. In Section 3 we present the new aggregation procedure. The results and discussions are presented in Section 4 and the conclusions in the final section.

2. Indicators to measure sustainability in Cuban nature-based tourism destinations

Cuba is considered to be one of the ten outstanding islands in relation to biodiversity, which is mainly due to its tropical climate and the complexity of its geological history and topography. It has six wetlands included in the Ramsar List because of their international importance, one of which is the largest and best conserved in the insular Caribbean: Ciénaga de Zapata. Cuba also has ten National Parks. In total, 22% of the surface area lies within protected natural areas. Despite these resources, the tourist offer has been fundamentally oriented to sun and beach tourism.

However, although the number of visitors has changed little in recent years, in 2009, Cuba received 12.4% of the visitors to the Caribbean, 10% of whom went to nature-based destinations, representing a remarkable increase compared to the 0.26% recorded in 2004.

Even so, the Cuban tourist offer needs to diversify further and it should be characterized by products that respect the sustainability of the tourist sector. Thus, the construction of an indicator system to measure the sustainability of the destinations is considered a necessity.

Several studies have attempted to determine the basic indicators to measure the sustainability of tourism destinations (e.g. Farsari and Prastacos, 2001; WTO, 2004; Gallego and Moniche, 2005; Díaz and Norman, 2006; Sancho et al., 2007). Due to the absence of a group of unanimously accepted indicators, as well as the different social, natural and economic conditions of the destinations, the stakeholders select those indicators that better reflect the needs and capacities of each region.

One example is provided by the Caribbean Zone of Sustainable Tourism (CZST), which was established as a "...cultural, socio-economic, and biologically rich and diverse unit in which tourism development will depend on sustainability (...), aimed at facilitating the integrated development of the Greater Caribbean." (Association of Caribbean States, ACS, 2001). As a result, the "Proceedings Manual for Sustainable Tourism Trainers" was created by Díaz and Norman (2006) with the objective of monitoring the work aimed at creating more sustainable tourism destinations in the Caribbean area.

In this work, the authors offer an indicator system for the development of a global process that includes the Greater Caribbean and a local indicator system adapted to the needs and capacities of the regions. The indicators were divided into two groups:

- Normative indicators: common to all destinations and agreed in the Convention for the establishment of the CZST.
- Local indicators: determined by the destinations (coastal, mountain, cities, etc.) based on their local priorities.

Given the lack of a unanimously accepted list of indicators (Masera et al., 2000), those chosen for a sustainability study should represent the needs of all the agents involved in developing tourism in each destination.

There is continuing debate on the dimensions of sustainable tourism development. These dimensions have been identified in different ways by several authors (e.g., WTO, 2004; Van Broeck, 2005; Krajnc and Glavic, 2005; Choi and Sirakaya, 2006; Díaz and Norman, 2006; Brun and Hirsch, 2008); however, the currently accepted dimensions include all the sectors that operate in any locality and their relationships in different contexts. In this study, we use the three dimensions proposed by Díaz and Norman (2006) for sustainable tourism development in the CZST:

Social dimension: related to people, their lives, the relationships they establish, quality of life, employment, and other factors related to tourist development.

Economic dimension: related to tourism management and commercialization, and material and financial resources.

Patrimonial dimension: related to everything concerning the natural and cultural environment.

2.1. Indicators

The Workshop on Indicators of Sustainable Tourism, related to the establishment of the CZST, took place on June 2008 in Viñales, Pinar del Río, Cuba. The participants were stakeholders (public and private enterprises, institutions, and groups or population sectors with a strong influence in the region), executives from the Cuban Tourism Ministry, and other organizations with information on the destinations.

In order to select the indicators for this study, we consulted the participants in the workshop taking into account the indicators proposed by the WTO (2004), Choi and Sirakaya (2006), Díaz and Norman (2006) and Sancho et al. (2007). Each participant was given a list of indicators which they rated on a scale ranging from 0 to 10, where 0 indicated that it was not necessary for the study and 10 indicated that it was essential to the study. Any other value between 0 and 10 could be chosen.

Those indicators which were given a score higher than or equal to the median of the scores were selected. In total, 39 indicators were selected (11 social, 14 economic and 14 patrimonial), which were representative of the concept of sustainable tourism development proposed by the WTO (2004) (Appendix A, Table A.1).

The social indicators included information related to improvements in living conditions due to tourist activity, the social carrying capacity of the destinations, changes in traditional occupations and social behavior leading to dissatisfaction among residents or visitors, the potential of tourism to generate employment, perceived safety or risk in the destinations, and the quality of public services.

The economic indicators included information on the level of tourist satisfaction, seasonality of tourism, the tourist offer, infrastructure design and accessibility, the economic benefits derived from tourism, and to what extent the territorial plan for the municipality had been completed.

The patrimonial indicators included energy consumption, water consumption and safety, the generation and disposal of residue, the cleanness of the destination, intensity of use, and the impact of tourism at the environmental and cultural level.

2.2. Database

Due to the Cuban interest in promoting nature-based tourism, all the sites with the potential for developing this modality were analyzed by an interdisciplinary team composed of specialists from the Development Department of the Cuban Ministry of Tourism, the Cuban Ministry of Science, Technology and the Environment, the Institute of Planning, and the Ministry of Agriculture, with the aim of developing an inventory of the environmental wealth of these destinations.

As a result, a Working paper (MINTUR, 2003) was published that identified 64 sites covering 20,100 km² (18% of the Cuban surface area), 62 of which are Protected Areas from different categories. These include seven Biosphere Reserves, three areas that have been declared National Patrimony, one Ramsar Site and one National Monument.

We consulted the list prepared by the nature-based tourism working group to select the destinations for inclusion in our study.

We chose those destinations fulfilling the criteria proposed by Díaz and Norman (2006) considered necessary for choosing a site as a sustainable tourism destination. These are:

- A site proposed by tourism professionals.
- A site visited by tourists.
- A site with a local population.
- A site that is locally organized and administered.

During the selection process, sites with accommodation for international tourism were taken into account, such that data related to night stays and the percentage of occupation could be collected. Thus, not all the sites listed were included. Those without tourist accommodation or service installations were not included because it was not possible to calculate some of the most important indicators, such as the number of tourists, the occupancy ratio for official accommodation, or average tourist stay.

It would have been useful to analyze the natural protected zones, but due to the lack of information they could not be included. A new group of initial indicators based on their characteristics would be needed for their inclusion.

In total, 15 nature-based tourism destinations were identified, three of which are in the CZST: Viñales, Soroa and Ciénaga de Zapata.

These 15 zones are priority areas for the development of nature-based tourism (MINTUR, 2003). They cover 7774.97 km² – approximately 40% of the total surface area identified by the working group – and received 10% of the total number of tourists who visited Cuba in 2009. Except for San Diego de los Baños and Marea del Portillo, the other zones are located in or constitute areas with some degree of protection according to the National System of Protected Areas. There are three Biosphere Reserves: Soroa-Las Terrazas, Ciénaga de Zapata, Baconao; five National Parks: Guana-hacabibes, Viñales, Caguana, Desembarco del Granma, Alejandro de Humboldt; four Protected Natural Landscapes: Hanabánilla, Guajimico-Gavilanes, Topes de Collantes, Mayarí; and one Ecological Reserve: Alturas de Banao.

They are evenly distributed over the entire island: five in the East, five in the center and five in the West.

To quantify the indicators, the destinations were assigned to the municipality they belong to, because the municipalities have information systems for evaluating social, economic and environmental conditions (Jam, 2007). In addition, the organization of the municipalities is less complex than that of the provinces.

Of the 39 indicators selected, 23 are objective (obtained from sources of statistical information), and the other 16 are subjective (reflecting the perceptions of all agents involved in tourism development). Subjective indicators were used because local populations are rarely included in sustainability studies, even though they are important agents in the tourist management process (Gursoy et al., 2002). Furthermore, objective indicators are often stressed at the expense of the role played by subjective components and perceptions in the satisfaction of internal clients (local population) and external clients (tourists) (Sancho et al., 2007).

The objective indicators were based on information obtained in 2009 by the Territorial Office of Statistics, which is part of the National Office of Statistics. Data were also acquired from the Aqueducts and Sewer Systems Offices of each municipality, the Union of Companies that recycle waste material, the National Center of Protected Areas and the Vice-presidency of Monuments of the National Council of Cultural Heritage.

Regarding the subjective indicators, both the tourists and the residents were surveyed to obtain information on their perceptions of specific aspects relevant to tourism development. Paper Assisted Personal Interviewing (PAPI) was applied in both cases to analyze the qualitative variables using a five-point Likert rating scale where, in the case of tourists, a rating of 1 indicates complete

disagreement and 5 indicates complete agreement. The investigation units consisted of the international tourists lodging in hotels in all destinations; systematic sampling with random start was used. In the case of residents, 1 indicates complete disagreement and 5 indicates complete agreement; a two-stage cluster sampling procedure was performed. In the first stage, the clusters were defined as the districts where the hotels are located and in the second stage, the houses within the selected cluster were randomly chosen; the survey was applied to all individuals between 17 and 70 years of age (for further details, see Pérez, 2011).

Thus, a quantified indicators system was obtained to compare nature-based tourism destinations covering requirements such as relevance, accuracy, timeliness and punctuality, accessibility and clarity, comparability and coherence (OECD, 2008) that guarantee the reliability of the synthetic indicators derived from it.

3. Aggregation procedure

The construction of composite indicators involves stages in which subjective judgments have to be made: the selection of indicators, how missing values are dealt with, the choice of aggregation model, the indicator weights, etc. These subjective choices can be used to manipulate the results (Nardo et al., 2005b).

As shown in different studies (e.g., Nardo et al., 2005a; OECD, 2008; Castellani and Sala, 2009; Blancas et al., 2010a), there are many ways to create a composite indicator; other studies show that no methodology is more suitable than any other for constructing synthetic indicators (Saisana and Tarantola, 2002; Nardo et al., 2005a). When no information has been provided by the decision-makers on the relative importance of the basic indicators, various procedures can be used to determine the synthetic indicators where the weights are obtained using different methods and all the weights are the same for all units. However, although these methodologies provide homogeneity, they do not take into account the special characteristics of each destination analyzed; this is the reason we developed a method to determine a synthetic indicator that can be easily interpreted and that takes these characteristics into account.

The methodology presented is divided into two stages. In the first stage, we calculate a composite indicator for each dimension of the concept under evaluation. In this case, we use a synthetic indicator called the distance-principal component (DPC) developed by Blancas et al. (2010a). This indicator combines PCA with the concept of distance to a reference point based on a multicriteria decision-making philosophy. It is defined by the following formula:

$$DPC_i = \sum_{j=1}^q \left[VE_j \left(\sum_{k=1}^p IN_{ik} |Corr_{jk}| \right) \right]$$

for $i = 1, 2, \dots, n$, where n is the number of observations, p is the number of original indicators, q is the number of components selected, VE_j is the variance explained by the j th component, and $Corr_{jk}$ is the correlation between the j th component and the k th indicator. IN_{ik} is the normalized value of the i th observation in the k th indicator, which is needed to normalize the data such that the measuring units used for each indicator have no effect on the final result. This procedure involves dividing the distance to the anti-ideal point by the difference between the maximum and the minimum value:

$$IN_{ik} = \frac{I_{ik} - \text{Min}}{\text{Max} - \text{Min}}$$

where I_{ik} is the value of the i th observation in the k th indicator. We have chosen the minimum value of each indicator as the

reference value, under the assumption that higher values indicate that the destination is more sustainable. Thus, when measuring the distance to the minimum value, we obtain the distance to an anti-ideal point; the greater the distance, the higher the destination's level of sustainability.

This approach makes the final result easier to interpret because the values of the initial indicators are defined according to their distance to a fixed reference value, such that the synthetic indicator is a linear combination of these distances and not of the principal components. The end-users' task is easier because they only have to choose the initial indicators and the criteria to select the components.

When the relative importance of the criteria is unknown, the weights are determined endogenously taking into account data variability.

The composite indicator is based on a reference point, which can be easily understood by the end-user. The method used to obtain it is transparent since the principal components are the linear combinations of the distances between the indicators and their reference units; thus, we evaluate the distance to the anti-ideal point.

Once we have obtained the dimensional indicators, the second stage involves calculating the global synthetic index. This involves evaluating each unit's strengths. With this aim, we use Data Envelopment Analysis (DEA), a linear programming tool initially developed by Charnes et al. (1978) for evaluating the performance of a set of peer entities that use one or more inputs to produce one or more outputs. The method has been alternatively labeled the "Benefit-of-the-Doubt" approach (Moesen and Cherchye, 1998; Nardo et al., 2005a; Cherchye et al., 2007). This can be used to design composite indicators (see, for example, Cherchye et al. (2006), Castellani and Sala, 2009), among other applications.

In this context, the synthetic index is defined for each unit as the ratio of the weighted sum of its outputs and inputs, where the main aim is to determine the weights that represent the highest efficient score for each unit, represented by the following ratio: virtual output/virtual input. Virtual input and output values provide information on the importance a unit attaches to particular inputs and outputs to attain its maximum efficiency rating (Boussofiene et al., 1991). These can be understood as normalized weights.

As pointed out by Murias et al. (2008), three features of DEA make it especially appealing regarding constructing a composite indicator. First, benchmarking provides a measure of performance based on real data. Best performance is not a theoretical or abstract concept; it is defined by merely observing the best performer. Second, DEA models possess the immense advantage of displaying unit invariance, which makes the normalization stage redundant. Finally, by allowing every unit to choose its individual weights, DEA respects the individual characteristics of the units and their own particular value systems.

For the second stage, we use the dimensional indicators obtained for each destination as initial information. They are positive and can be employed as outputs to obtain the global synthetic index. We can use a single dummy input with value unity for each destination; the global index value is the virtual output. This model is formally equivalent to the original input-oriented, constant-returns-to-scale DEA model presented by Charnes et al. (1978). In this way, the global synthetic index DEAPC (Data Envelopment Analysis after distance-Principal Component) for the i_0 observation is obtained by solving the following Linear Programming problem:

$$DEAPC_{i_0} = \text{Max}_w \sum_{j=1}^d w_j^{i_0} DPC_{i_0j}$$

subject to:

$$\begin{aligned} \sum_{j=1}^d w_j^{i_0} \text{DPC}_{ij} &\leq 1 \quad \forall i = 1, \dots, n \text{ (normalization constraint)} \\ w_j^{i_0} \text{DPC}_{ij} &\geq \omega \quad \forall i = 1, \dots, n; \forall j = 1, \dots, d \text{ (virtual output constraint)} \\ w_j^{i_0} &\geq 0 \quad \forall j = 1, \dots, d \text{ (non-negativity constraint)} \end{aligned}$$

where $w_j^{i_0}$ are the weights for the observation i_0 , DPC_{ij} represents the j th dimension indicator for the i th observation, d is the number of dimensions considered (in our case, three: social, economic, and patrimonial), and ω is a real number that represents the minimum value allowed for the j th virtual output for the i th observation.

The objective function chooses the weights that maximize the value of the composite index for observation i_0 . In the best situation, the global synthetic index takes a value of 1, which implies that the destination has a performance equal to its reference unit, and the synthetic index takes a value of 0 representing the worst situation. Thus, the global synthetic index value takes the form $0 \leq \text{DEAPC}_i \leq 1$ for each destination, where higher values represent better overall relative sustainability.

As mentioned, synthetic indicators usually take into account the same weights for all the basic indicators such that all units are equally valued to avoid subjectivity. However, this may be less suitable in some cases as this approach does not permit emphasizing any particularly positive or negative aspects of the units, which can be very helpful in decision-making. Thus, to allow the decision-makers to visualize this information we have to allow them to use different weights, but not to the extent that the results become biased.

To further restrict the endogenously selected weights, another constraint is added to the model: the virtual output constraint, that is, the establishment of a lower bound ω for each virtual output. This guarantees that all the dimensions included are taken into account.

Weights are dependent on the unit of measurement of the initial indicators; this is the reason why the analysis is based on the virtual outputs. These are particularly interesting because they do not depend on measurement units and directly reveal how the respective outputs contribute to a composite indicator value, thus showing their relative importance. Thus, this set of constraints means that a certain amount ω of each dimension must be reflected in the global indicator. This amount can be provided by the decision-maker or it could be found by parametric analysis.

The proposed aggregation procedure thus offers a synthetic indicator in two stages. In the initial dimensional stage, equal weights are used; in the second stage, using DEA, different weights for each unit can be used, although only when evaluating each dimension such that the special characteristics of the units considered can be included. We note that combining DPC and DEA methods only makes sense if there is no information on the weights of the basic indicators. In other cases, if the weights are known, they can be used in the first stage instead of those computed by PCA.

This procedure has the advantage of obtaining a composite indicator value sensitive to the stakeholder's needs; more weight is given to those indicators for which some destinations are in a better position compared to others included in the study. In this way, the strengths and weaknesses of destinations can be evaluated.

Weights are calculated such that the maximum possible value is determined for the composite indicator in each destination. This indicates the flexibility of the procedure, since the same level of importance does not need to be given to each indicator in the different destinations. In addition, the use of DEA in the second stage indicates how each dimension contributes to the overall value of the DEAPC index.

Furthermore, a normalization procedure is not required in the second stage, a composite indicator is not affected by the measurement units of the initial indicators, and finally, the user does not need to select the indicators to build the composite index again because the aggregation procedure is based on the dimensional indicators obtained from the DPC index.

4. Results and discussion

Before calculating the dimensional indicators, we need to determine the internal consistency of the database. For this purpose we use Cronbach's Alpha Coefficient (henceforth c -alpha) (Cronbach, 1951), because it assesses how well a set of individual indicators measures a single uni-dimensional object (OECD, 2008).

C -alpha is not a statistical test, but a coefficient of reliability based on the correlation between individual indicators. High correlation indicates that individual indicators are measuring the same underlying construct. Therefore a high c -alpha, or high "reliability", indicates that individual indicators have correctly measured the latent phenomenon.

In general, an acceptable value of c -alpha varies by discipline. Nunnally (1978) suggests 0.7 as an acceptable reliability threshold. C -alpha was 0.7759 for the indicators selected in our study and thus they are representative of sustainability.

Once the internal consistency of the database was verified, we calculated the composite indicators using the methodology described in Section 3. The results are presented in Tables 1 and 2.

4.1. Dimensional indicators

The results of the first aggregation stage are shown in Table 1. In relation to the social dimension, they show how the three best destinations are those where social benefits have improved due to tourism, mainly those related to highways and the transportation infrastructure. They are also the destinations least negatively affected by tourism because of the low ratio of tourists to the local population during the month of maximum affluence.

Regarding this dimension, the best destinations also report higher economic benefits for the local community, due to the large number of local residents employed in tourism; in the selected regions, 51% of total employees work in tourism. The residents consider that the level of life has increased as a consequence of tourism development.

In the economic dimension, the best destinations have a good quality–price relationship regarding food, have a high level of seasonality, a 50.2% occupation rate of the official accommodation, and an average overnight stay of 4.7 above the mean for this tourist modality in Cuba.

These are the destinations in which the tourist offer is of the highest quality and where the tourism industry offers the best performance. They attract the greatest number of tourists – on average, 57,327 tourists representing 54.58% of the total number – and generate the highest tourism income – about 7.5 million dollars, representing approximately 51.4% of the overall income generated in all the analyzed destinations.

In the patrimonial dimension, the best destinations have a higher percentage of individuals with access to clean water (80.6%). They have the lowest intensity of use, which is beneficial for the conservation of natural areas and the patrimony, with an average of 23.8 tourists per km^2 , and a mean number of 3.5 tourists per day visiting monuments. From the residents' point of view, these are the destinations where the tourists cause less destruction to the environment and natural resources.

Table 1 also shows how some destinations, such as Bacanao or Habanilla, are very balanced regarding the different dimensions,

Table 1
Dimensional composite indicators.

Cuban nature destinations	Dimensional indicators DPC					
	Social	Ranking	Economic	Ranking	Patrimonial	Ranking
N.P. Guanahacabibes	0.5048	10	0.4522	4	0.6667	4
N.P. Viñales	0.4904	11	0.3955	10	0.5106	14
San Diego de los Baños	0.4464	13	0.3576	14	0.6349	8
Soroa-Las Terrazas	0.5189	8	0.4062	7	0.5840	13
Ciénaga de Zapata	0.5571	4	0.4369	5	0.6417	7
Hanabanilla	0.5221	7	0.4006	8	0.6319	9
Guajimico	0.4169	14	0.3151	15	0.6011	11
Topes de Collantes	0.4111	15	0.5350	2	0.4416	15
Alturas de Banao	0.5310	6	0.3832	12	0.5935	12
N.P. Caguanes	0.5699	2	0.3913	11	0.6309	10
Mayarí	0.5640	3	0.3980	9	0.6788	2
N.P. Desembarco del Granma	0.5111	9	0.3815	13	0.6748	3
Marea del Portillo	0.4483	12	0.4356	6	0.6496	5
Baconao	0.6264	1	0.5430	1	0.7120	1
N.P. Alejandro de Humboldt	0.5474	5	0.5115	3	0.6446	6

Table 2
Global synthetic index.

Cuban nature destinations	Global synthetic index DEAPC				
	Ranking	DEAPC	Social virtual output	Economic virtual output	Patrimonial virtual output
N.P. Guanahacabibes	4	0.8798	0.1842	0.2152	0.4803
N.P. Viñales	14	0.7529	0.3912	0.1883	0.1734
San Diego de los Baños	13	0.7906	0.1629	0.1702	0.4575
Soroa-Las Terrazas	12	0.8056	0.4139	0.1934	0.1983
Ciénaga de Zapata	5	0.8735	0.2033	0.2080	0.4623
Hanabanilla	9	0.8365	0.1905	0.1907	0.4553
Guajimico	15	0.7352	0.1521	0.15	0.4331
Topes de Collantes	10	0.8218	0.15	0.5218	0.15
Alturas de Banao	11	0.8075	0.4236	0.1824	0.2016
N.P. Caguanes	6	0.8551	0.4546	0.1862	0.2143
Mayarí	3	0.8843	0.2058	0.1894	0.4891
N.P. Desembarco del Granma	7	0.8542	0.1865	0.1816	0.4862
Marea del Portillo	8	0.8390	0.1636	0.2074	0.4680
Baconao	1	1	0.2286	0.2585	0.5130
N.P. Alejandro de Humboldt	2	0.9176	0.1998	0.4989	0.2189

whereas others, such as Topes de Collantes and Cuaguanes, are quite unbalanced, presenting weaknesses and strengths that are more clearly revealed in the second stage of the process.

4.2. Global composite indicator

After calculating the dimensional indicators, we calculate a global composite indicator for each destination; this constitutes the second aggregation stage in which we obtain the global composite indicator DEAPC by using the information on the dimensional indicators obtained in the previous stage.

In addition, to control the contribution of each dimension to the global synthetic index, we fix the value of ω to 0.15 such that each dimension is forced to contribute at least this value to the global synthetic index. We note that the different values of this parameter can be analyzed to show the maximum value that leads to unfeasibility due to the existence of one or more units that are unable to contribute by this amount to the virtual outputs. In our case, $\omega = 0.20$ is unfeasible.

The values are shown in Table 2. The analysis is based on the virtual outputs, which express information on the level of importance attributed to the sustainability dimensions in each destination with the objective of obtaining the maximum level of efficiency. This allows us to determine the influence each dimension has in the global indicator value, and to identify the strengths and weaknesses of the units under consideration.

The results show that there is no tie for first place. Thus, the most sustainable site is Baconao, which has a virtual output greater

than the level demanded for the three dimensions; the patrimonial dimension is the strongest for this destination.

Only two destinations had the lowest value allowed in some dimensions: Guajimico, in the economic dimension, and Topes de Collantes, in the social and patrimonial dimensions. These two sites occupied the lowest positions according to the DPC indicator in these dimensions.

The proposed procedure for calculating the global indicator determines the strengths and weaknesses for each destination using the virtual output values; their sum is the value of the global index. Thus, destinations can be grouped using the virtual output and they can be grouped according to the virtual output with the highest score; this represents the dimension that has the best performance in each destination (Fig. 1). Clusters can be obtained which allows us to find common features between the destinations included in each group.

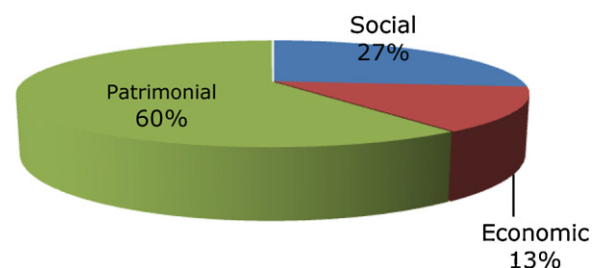
**Fig. 1.** The distribution of the destinations according to virtual outputs.

Table 3
Comparison between DEAPC and the GPSI Global Synthetic Index.

Cuban nature destinations	Global synthetic index DEAPC		Global synthetic index GPSI	
	Ranking	DEAPC	Ranking	GPSI
N.P. Guanahacabibes	4	0.8798	5	0.04
N.P. Viñales	14	0.7529	14	−0.5
San Diego de los Baños	13	0.7906	11	−0.21
Soroa-Las Terrazas	12	0.8056	10	−0.19
Ciénaga de Zapata	5	0.8735	1	1.18
Hanabánilla	9	0.8365	7	−0.13
Guajimico	15	0.7352	15	−0.54
Topes de Collantes	10	0.8218	13	−0.44
Alturas de Banao	11	0.8075	8	−0.14
N.P. Caguanes	6	0.8551	9	−0.15
Mayarí	3	0.8843	4	0.1
N.P. Desembarco del Granma	7	0.8542	6	−0.12
Marea del Portillo	8	0.8390	12	−0.27
Baconao	1	1	2	1.08
N.P. Alejandro de Humboldt	2	0.9176	3	0.27

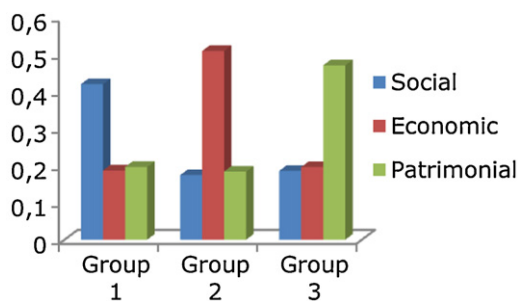


Fig. 2. Mean of the virtual output for clusters.

The social dimension is the most important in four destinations (27%), the economic in two destinations (13%), and the patrimonial in nine destinations (60%).

Similarly, destinations can be grouped according to the mean of the virtual output for each group (Fig. 2).

In the first group of destinations, the social dimension was the most important followed by the patrimonial and then the economic. In the second group, the economic dimension was the most important, followed by the patrimonial, and then the social. In the third group, the patrimonial dimension was the most important, followed by the economic, and then the social.

Compared to other methodologies, the PCA method cannot be used under the assumption of unknown weights for the basic indicators without losing information; this is due to the relationship between the number of units analyzed and the number of basic indicators. Thus, we chose the synthetic index GPSI (Blancas et al., 2010b), using the weights computed by our method in the first stage.

The results of using the GPSI method are similar in some units (see Table 3). However, under this method, cities such as Ciénaga de Zapata are in the first position due to the effect of a single basic indicator, i.e., its geographical extension, which is much greater than the other cities. Traditional methods do not limit the effect of a single basic indicator. On the other hand, our DEAPC method is able to limit this kind of effect on a single dimension, in which case this unit takes fifth place in the ranking. This results in a more balanced and reliable ranking, not only regarding extreme values in the basic indicators, but also regarding the values of the weights.

5. Conclusions

The present study presents a methodology for determining an indicator system that represents the concept of sustainable tourist

development as outlined by the WTO in order to measure the sustainability of Cuban nature-based tourism destinations. In contrast to other studies, we also quantified them according to the available statistical information, calculated the internal consistency of the system to measure the underlying phenomenon, and constructed a composite indicator for each destination to represent its degree of sustainability.

The proposed methodology aggregates all the information contained in the initial indicators and represents a new tool that can contribute to the decision-making process in nature-based tourism destinations.

The aggregation procedure has some advantages compared to other current procedures. First, it is divided into two stages, such that the dimensions included in the sustainability concept can be analyzed (first stage), and then a global composite indicator for each destination is calculated (second stage).

In the first aggregation stage, the composite indicator DPC is calculated and the weights of the indicators included in the process are endogenously determined such that each initial indicator is weighted by the amount of information assigned to the synthetic measure. The information is completely transparent to the end-user, who can identify in each dimension the characteristics that have a stronger or weaker influence on the degree of sustainability obtained.

Moreover, the dimensional composite indicators are easily understood by the end-user, because they are based on the distance to a reference point, and the calculation method is transparent. The principal components are the linear combinations of the distances between the indicators and their reference units; thus, when the composite indicators have higher values the situation is more sustainable. This makes the results of the Principal Component Analysis more understandable thus facilitating the creation of the composite indicators.

In this way, the use of DEA in the second stage allows all the available information to be included, because it considers the dimensional indicators as initial information; therefore, a new indicator selection procedure is not required to build the global composite indicator. In addition, the weights are endogenously determined and a normalization process is not needed; thus, fewer decisions are required during the aggregation process.

The proposed methodology allows all the dimensions to be included in the composite indicator and separates the synthetic value into parts that represent the contribution of each dimension to the global value. Thus, it makes it easier to obtain a detailed analysis, the dimensions that constitute a destination's strengths and weaknesses can be identified, and managers can focus on solving the main problems.

Table A.1

Indicator system for measuring the sustainability of Cuban nature-based tourism destinations.

No.	Indicator	Dimension	Sign
IS ₁	Perception by the local population that an improvement in highways and transportation infrastructure is because of tourism.	Social	Positive
IS ₂	Perception by the local population that an improvement in public services is because of tourism.	Social	Positive
IS ₃	Proportion of tourists to the local population (during the month of maximum affluence).	Social	Negative
IS ₄	Perception by the local population that tourists have an undesirable effect on lifestyle at the destination.	Social	Negative
IS ₅	Perception by the local population that tourism contributes to preventing young people from leaving the municipality.	Social	Positive
IS ₆	Number of local employees in tourism.	Social	Positive
IS ₇	Percentage of women employed in the tourist sector.	Social	Positive
IS ₈	Percentage of the local population working in the tourist sector.	Social	Positive
IS ₉	Perception by the local population that the quality of life has increased because of tourism.	Social	Positive
IS ₁₀	Tourist evaluation of safety at the destination.	Social	Positive
IS ₁₁	Tourists' perceptions of the quality of public services (illumination, transport, bank services, etc.).	Social	Positive
IE ₁₂	Perceptions regarding quality-price ratio of lodging at the destination (private and non-private).	Economic	Positive
IE ₁₃	Perception of quality-price ratio of restaurants at the destination.	Economic	Positive
IE ₁₄	Evaluation of the quality of tourism workers (in hotels, restaurants, and tourist information points).	Economic	Positive
IE ₁₅	Occupancy ratio of official accommodation.	Economic	Positive
IE ₁₆	Proportion of tourists in the months of maximum and minimum affluence.	Economic	Negative
IE ₁₇	Average tourist stay.	Economic	Positive
IE ₁₈	Percentage of seasonal employees in tourism.	Economic	Negative
IE ₁₉	Tourist offer.	Economic	Positive
IE ₂₀	Tourist evaluation of accessibility and attractiveness.	Economic	Positive
IE ₂₁	Number of tourists.	Economic	Positive
IE ₂₂	Tourist spending.	Economic	Positive
IE ₂₃	Destination profitability.	Economic	Positive
IE ₂₄	Average tourist-day expenditure.	Economic	Positive
IE ₂₅	Percentage of general economic plan completed according to desired aim.	Economic	Positive
IP ₂₆	Energy consumption by tourist per day.	Patrimonial	Negative
IP ₂₇	Energy consumption of renewable sources per year attributable to tourism.	Patrimonial	Positive
IP ₂₈	Volume of daily water consumed by tourists.	Patrimonial	Negative
IP ₂₉	Percentage of local population with access to clean water.	Patrimonial	Positive
IP ₃₀	Volume of solid waste attributable to tourism.	Patrimonial	Negative
IP ₃₁	Reduction of solid waste attributable to tourism.	Patrimonial	Positive
IP ₃₂	Tourist evaluation of cleanliness at the destination.	Patrimonial	Positive
IP ₃₃	Size of the area dedicated to tourism.	Patrimonial	Positive
IP ₃₄	Number of tourists per square kilometer.	Patrimonial	Negative
IP ₃₅	Intensity of use of cultural sites.	Patrimonial	Negative
IP ₃₆	Tourist evaluation of activities related to natural resources at the destination.	Patrimonial	Positive
IP ₃₇	Perceptions by the local population concerning environmental damage caused by tourism.	Patrimonial	Negative
IP ₃₈	Perceptions by the local population concerning the stimulation of local crafts and culture due to tourism.	Patrimonial	Positive
IP ₃₉	Tourist evaluation of the conservation of natural resources and heritage at the destination.	Patrimonial	Positive

The two-stage synthetic indicator proposed combines statistical methods, which are more objective, with efficiency methods. This offers the possibility of considering the strengths of the destinations analyzed as well as providing the decision-makers with useful information by which they can improve these destinations.

Finally, we would like to point out that this methodology may be applied to other destinations by making simple changes to the original database, and can also be used to analyze other issues in different areas.

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Appendix A.

See Table A.1.

References

- Association of Caribbean States, 2001. Agreement for the establishment of the Caribbean Zone of Sustainable Tourism (CZST). Margarita Island, Republic of Venezuela, 12 December 2001.
- Blancas, F.J., Gonzalez, M., Lozano, M., Pérez, F., 2010a. The assessment of sustainable tourism: application to Spanish coastal destinations. *Ecol. Indic.* 10, 484–492.
- Blancas, F.J., Caballero, R., Gonzalez, M., Lozano-Oyola, M., Pérez, F., 2010b. Goal programming synthetic indicators: an application for sustainable tourism in Andalusian coastal counties. *Ecol. Econ.* 69, 2158–2172.
- Boussofiane, A., Dyson, R.G., Thanassoulis, E., 1991. Applied data envelopment analysis. *Eur. J. Oper. Res.* 52, 1–15.
- Brun, G., Hirsch, H.G., 2008. Ranking policy options for sustainable development. *Poiesis Prax.* 5, 15–31.
- Brundtland, G.H. (Report), 1987. Our Common Future: The World Commission on Environment and Development. Oxford University Press, Oxford.
- Castellani, V., Sala, S., 2009. Sustainable performance index for tourism policy development. *Tourism Manage.*, 1–10, <http://dx.doi.org/10.1016/j.tourman.2009.10.001>.
- Charnes, A., Cooper, W.W., Rhodes, E., 1978. Measuring the efficiency of decision making units. *Eur. J. Oper. Res.* 2, 429–444.
- Cherchye, L., Moesen, W., Rogge, N., Van Puyenbroeck, T., 2006. Creating Composite Indicators with DEA Analysis: The Case of the Technology Achievement Index. Joint Research Centre, European Commission, Italy.
- Cherchye, L., Moesen, W., Rogge, N., Van Puyenbroeck, T., 2007. An introduction to benefit of the doubt composite indicators. *Soc. Indic. Res.* 1 (82), 111–145.
- Choi, H.C., Sirakaya, E., 2006. Sustainability indicators for managing community tourism. *Tourism Manage.* 27, 1274–1289.
- Cronbach, L.J., 1951. Coefficient alpha and the internal structure of tests. *Psychometrika* 16, 297–334.
- Díaz, G., Norman, A., 2006. Proceedings Manual for Sustainable Tourism Trainers. ACS, Available in <http://www.acs-aec.org/Tourism/manuals1.htm> (accessed June 2008).
- Farsari, Y., Prastacos, P., 2001. Sustainable tourism indicators for Mediterranean established destinations. *Tourism Today* 11, 103–121.
- Gallego, I., Moniche, A., 2005. Sistema de indicadores territoriales para un destino turístico. Conferencia de la OMT Iguazú, Argentina/Brasil/Paraguay, 3–6 de octubre de 2005: La Cuenta Satélite del Turismo (CST): Comprender el Turismo y Diseñar Estrategias.
- Gursoy, D., Jurowski, C., Uysal, M., 2002. Resident attitudes. *Ann. Tourism Res.* 29, 79–105.

- Jam, A., 2007. Iniciativa municipal para el desarrollo local. Reflexiones para el debate. *Econ. Desarrollo* 1, 36–55.
- Krajnc, D., Glavic, P., 2005. How to compare companies on relevant dimensions of sustainability. *Ecol. Econ.* 55 (4), 551–563.
- Larson, S., Herr, A., 2008. Sustainable tourism development in remote regions? Questions arising from research in the North Kimberley, Australia. *Reg. Environ. Change* 8, 1–13.
- Masera, O., Astier, M., López-Ridaura, S., 2000. Sustentabilidad y manejo de recursos naturales. El marco de evaluación de Mesmis. Mundi-prensa, México.
- Medina, N., Santamarina, J., 2004. Turismo de Naturaleza en Cuba, ed. Unión, La Habana.
- Moesen, W., Cherchye, L., 1998. The Macroeconomic Performance of Nations Measurement and Perception. Centre for Economic Studies Catholic University of Leuven, Discussion Paper.
- Murias, P., de Miguel, J.C., Rodríguez, D., 2008. A composite indicator for university quality assessment: the case of Spanish higher education system. *Soc. Indic. Res.* 89, 129–146.
- Nardo, M., Saisana, M., Saltely, A., Tarantola, S., Hoffman, A., Giovannini, E., 2005. Handbook on Constructing Composite Indicators: Methodology and User Guide. OECD Statistics Working Paper, OECD.
- Nardo, M., Saisana, M., Saltely, A., Tarantola, S., 2005b. Tools for Composite Indicators Building. Institute for the Protection and Security of the Citizen, European Commission.
- Nunnally, J., 1978. *Psychometric Theory*. McGraw-Hill, New York.
- Organization for Economic Co-operation and Development, 2008. Handbook on Constructing Composite Indicators: Methodology and User Guide. OECD.
- Pérez, V.E., 2011. Aggregation procedure to build synthetic sustainability indicators in Cuban nature-based tourism destinations. Ph.D. Thesis, Department of Mathematics, University of Pinar del Río, Cuba.
- Saisana, M., Tarantola, S., 2002. State-of-the-Art Report on Current Methodologies and Practices for Composite Indicator Development. Joint Research Centre, European Commission.
- Sancho, A., García, G., Pedro, A., Yagüe, R.M., 2002. Auditoría de sostenibilidad en los destinos turísticos. Valencia, España.
- Sancho, A., García, G., Rozo, E., 2007. Comparativa de indicadores de sostenibilidad para destinos desarrollados, en desarrollo y con poblaciones vulnerables. *Ann. Tourism Res.* 9 (1), 150–177 (en Español).
- Singh, R.K., Murty, H.R., Gupta, S.K., Dikshit, A.K., 2007. Development of composite sustainability performance index for steel industry. *Ecol. Indic.* 7, 565–588.
- Singh, R.K., Murty, H.R., Gupta, S.K., Dikshit, A.K., 2009. An overview of sustainability assessment methodologies. *Ecol. Indic.* 9, 189–212.
- Tourism Ministry of the Cuban Republic, Development Department, 2003. Report of the tourist attractions group. MINTUR, Working Paper.
- Van Broeck, E., 2005. Desarrollo Sustentable. Turismo, costas y educación. Universidad de Quintana Roo, México.
- World Tourism Organization, 2004. Indicators of Sustainable Development for Tourism Destinations. A Guidebook. World Tourism Organization, Madrid.
- Yildirim, B., Ak, T., Ölmez, Z., 2008. Assessment of the natural-cultural resources in Çanakkale for nature-based tourism. *Environ. Dev. Sustain.* 10, 871–881.