Journal of Environmental Management 285 (2021) 112016

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: http://www.elsevier.com/locate/jenvman

Research article

Multi-objective optimization technique: A novel approach in tourism sustainability planning

Roberta Arbolino [a], Raffaele Boffardi [a,*], Luisa De Simone [b], Giuseppe Ioppolo [c]

[a] *Department of Social and Human Science, University of Naples "L'Orientale", L.go San Giovanni Maggiore 30, 80134, Naples, Italy*
[b] *LattanzioKIBS, Via Domenico Cimarosa, 4, 20144, Milano, Italy*
[c] *Department of Economics, University of Messina, Piazza Pugliatti, 1, 98122, Messina, Italy*

ARTICLE INFO

Keywords:
Strategic management
Regional sustainable development
Decision support systems
Urban and regional planning
Sustainable tourism

ABSTRACT

Strategic management of complex decisional problems in the tourism sector requires the implementation of proper planning procedures for sustainable tourism activities, due to either the number of actors involved, the presence of conflicting goals and the need of resource rationalization. Thus, the aim of the research is to implement a new approach for the selection of projects to be funded by public administration, in order to maximize the efficiency of public resource allocation. Furthermore, the proposed technique enhances the inclusion of the three dimensions of sustainability in tourism policy planning and implementation phases. The Multi-objective Optimization model accounts for environmental, social and economic impacts, to select tourism activities to be realized in order to maximize stakeholder utility. In order to test the model, we selected a case study: a call for tender drafted by an Italian Public administration, whose aim was to support the attractiveness of the urban areas. Findings illustrate that, in comparison with multicriteria techniques, the proposed model allows to achieve a better allocation of public funds, in both quantitative (i.e., amount of resources allocated) and qualitative (selection of projects with positive social and environmental implication) terms.

1. Introduction

Over the last year, both scholars and policymakers have recognized the negative implications of tourism activities on both surrounding environment (e.g. pollution, ecosystem degradation and over-exploitation) and socio-economic background (e.g. damaging or loss of local traditional cultures and networks) (Zhong et al., 2011). However, on the reverse side, if proper planning and management practices are implemented, tourism-related activities have a clear potential for either boosting local economies and protecting their social and natural capital (Sun et al., 2020). The economic relevance of tourism is clear in the European context, where almost 10% of GDP and around 20 million jobs can be attributed to this sector. Accordingly, European Commission has recognized that tourism has largely contributed to boost growth, generate new job opportunities and attract investments (European Commission, 2006). Furthermore, tourism largely depends on the attractiveness of tourist localities (Romao, 2020). Therefore, it is in the interest of both tourism services providers and policymakers preserving natural environment, social and cultural peculiarities and local well-being (Hollinshead, 1991). At tourist destinations, increasing the quality of life of residents by maximizing the economic benefits, protecting nature and providing visitors with high quality experiences is a main goal for sustainable tourism activities. The *Agenda for sustainable and competitive European tourism* recognizes the existence of a dual interaction between tourism and the protection of the distinctive social and environmental local features: (i) the relevance of these issues is widely recognized and their protection is directly supported; (ii) it becomes economically advantageous for local agents to protect environmental and socio-cultural heritage (European Commission, 2007). With these premises, over the last decades, the idea of tourism as a powerful channel to promote sustainability has rapidly spread across scholars and policymakers (Yadav et al., 2018). Thus, the definition of sustainable tourism deals with reconciling positive and long-term economic effects with social equity and natural capital preservation (Swarbrooke, 1999).

* Corresponding author.
E-mail addresses: rboffardi@unior.it (R. Boffardi), ldesimone.1984@gmail.com (L. De Simone), giuseppe.ioppolo@unime.it (G. Ioppolo).

https://doi.org/10.1016/j.jenvman.2021.112016
Received 21 July 2020; Received in revised form 26 November 2020; Accepted 17 January 2021
Available online 6 February 2021
0301-4797/

These features pose sustainable tourism practices as a promising tool to achieve the sustainable development goals (SDGs) stated by the UN 2030 Agenda[1] "to end poverty, protect the planet and ensure prosperity for all" (Siakwah et al., 2020). Indeed, in spite of the absence of a clear reference to tourism in the Agenda, six Goals implicitly recognize the relevance of this economic sector for sustainable development (UNDP, 2015; UNWTO, 2011). Implicit references can be identified in SDGs 8, 12 and 14, which regard: (i) inclusive and sustainable economic growth, (ii) sustainable consumption and production (SCP) and (iii) sustainable use of oceans and marine resources, respectively. At the same time, the achievement of sustainable tourism targets must account for and, simultaneously, balance the interests of different stakeholders – i.e., local population, entrepreneurs, etc. – in all the phases of policymaking (Garcia-Melon et al., 2012). Similarly, Goal 16 deals with justice and institutions as tools for promoting inclusive equitable development, regarding tourism governance (Emas, 2015). In the context of a wide policy and literature support to sustainable tourism, several initiatives have been implemented all over the world. Among these projects, *Kasbah du Toubkal* is a small lodge in the midst of a Berber community in Morocco, whose mission is to promote tourism while both avoiding negative effects of mass tourism developments and promoting employee education by re-investing profits. Similarly, *Juist Island* project (Germany), *Greenest hotels* in Thailand (Tongsai Bay), *Gili Lankanfushi* and the *Coral Line* Project (Maldives) have been recognized as best practices in the sector. However, in spite of this background, a framework for supporting investment decisions in sustainable tourism initiatives is missing.

Furthermore, over the last months, the Covid-19 pandemic has dramatically reduced tourist numbers, posing the problem of identifying new solutions for correctly planning tourist initiatives and channelling flows without enhancing the spread of the virus (Reza Farzanegan et al., 2020). In addition, if the recovery of tourist areas after the pandemic will be guided by authorities and tourist organization according to appropriate measures (i.e., accounting for social, environmental and economic issues) the social costs of tourism will reduce (Qiu et al., 2020). In fact, despite the steadily increasing tourism inflows experienced over the last decades by several areas, many of them still lack a clear international destination image allowing them to exploit the benefit of international tourism (Della Corte et al., 2015). Therefore, several promotion activities might be carried out by, in order to increase the attractiveness of urban areas, by supporting the exploitation of the natural, historical, artistic and cultural heritage.

As also recognized by the literature, tourism sustainability is only achievable if local population interests are protected, natural resources preservation is posed among its goals by authorities, citizens and service providers and, finally, local social capital is constantly enhanced by the implemented tourism policies (Garcia-Melon et al., 2012). Furthermore, in order to achieve environmental security, both local population and tourists have to be made aware of environmental risks inherent in tourism activities (Petrosillo et al., 2009). However, decision-making is a crucial moment of the planning cycle, since multiple actors – e.g. interest groups, institutions, private actors – strategically interact with each other. By contrast, from the point of view of private actors, sustainable lifecycle assessment becomes fundamental for determining the efficiency in each process by simultaneously controlling environmental impact (Vila et al., 2015). Indeed, several issues might hamper the achievement of these goals. First, when formulating tourism policies, several actors have to be taken into account – i.e., policymakers, tourists, host communities (Adongo et al., 2018). These stakeholders present different and, often conflicting interests (Önder et al., 2013; Petrosillo et al., 2010). Thus, consultation and collaboration among the stakeholders is fundamental to balance all the involved interests (Ballantyne et al., 2009; Petrosillo et al., 2009). In addition, Public Administration is increasingly required to solve decision problems characterized by the necessity of expenditure rationalization. This issue forces decision-makers to define priorities of actions according to sets of variables other than merely economic ones – such as social, environmental, and cultural variables (Fraiz et al., 2020).

Thus, the promotion of sustainable development within the framework of tourism policies can only be addressed by implementing environmental governance mechanisms accounting for all these issues and related risks (Petrosillo et al., 2009; Lozano-Oyola et al., 2019). Such a managerial approach to sustainability and ecology is integral to the documents presented by the UNWTO on the achievement of SDGs and, overall, to the policy recommendations aiming at promoting SDGs (Hall, 2019). The strategic approach required to planning should be a goal-oriented, participatory and comprehensive one (Tan et al., 2018). Effective and efficient management of complex issues requires sophisticated instruments and tools to be integrated in the internal decision-making processes. Literature has proposed a wide set of instruments, each relying on different methodologies, which might be ascribed to two broad groups: Multi-dimension Criteria Analysis (MCDA) and multi-objective optimization techniques (Soltani et al., 2015). The former group comprehends a wide set of multidisciplinary approaches, allowing to either formulate rankings among alternatives or eliminating inefficient ones, according to economic, social, environmental, aesthetic and ethical concerns (Rostirolla, 1998). The latter exploits different calculation procedure and algorithms to identify the optimal and best-compromise solutions among a set of available alternatives (Arbolino et al., 2018).

In this framework, the following research is aimed at proposing a methodology to assess and select tourism-related projects, in order to increase the efficiency in resource allocation and minimize socio-environmental impacts on the territories. A comparison between the optimization model (i.e. the proposed approach) and the traditional multicriteria methods (i.e. weighted sum and AHP) allows to assess the goodness of our methodology. To test our, we hypothesise a generic call for tender drafted by a Public administration willing to promote sustainable tourism through the financing of a set of projects. Projects to be funded are selected based on a multi-objective optimization model accounting for social, environmental, and economic sustainability principle. In order to test the goodness of the proposed approach, we compare the result with other multicriteria techniques: namely, "weighted sum" and "Analytic Hierarchical Process". Our research participates in the ongoing debate on the methodologies used to support decision-makers in promoting sustainable tourism (Garcia-Melon et al., 2012; Aljerf, 2015). The proposed approach supports policymakers in the selection of initiatives to be funded in the tourist sector, providing suggestions to optimize the allocation of public resources. Basing on both the reference legislation – i.e. the call for tender - and a set of environmental, economic and social constraints, it will enable decision-makers to implement effective, comprehensive and goal-oriented ex-ante evaluation of the interventions.

The paper is structured as follows. The second section shows the main techniques exploited as a decision support system. The third section presents the complexity of the tourism decision process and the different methodologies to solve it. Section four and five show and discusse the results. Conclusions are presented in Section six.

2. Methodological approaches applied to tourism-policy making

Over the whole process of tourism policymaking process, a variety of relationships and interests surrounding the tourism sector must be considered. This array generates multi-decision maker, multi-objective,

[1] http://www.un.org/sustainabledevelopment/There are various definitions of rural areas, i.e., those with population density below 150 inhabitants per squared km"; Šimková, 2007) or those characterized by rapid depopulation of rural areas, disproportionate aging of populations, reduced rural labor forces, stagnating economies and general degradation of the quality of life (Park and Yoon, 2011).

multi-criteria and multidimensional decision problems. Therefore, in the framework of tourism policies, the application of traditional evaluation techniques resorting to monetary values – such as cost-benefit analysis – is difficult and, often, unsuccessful (Douissa and Jabeur, 2020). Based on these concerns, several techniques have been exploited to facilitate decision making in tourism policy planning and implementation, such as the construction of synthetic indicators (Blancas et al., 2010), theoretical modelling (e.g., Evolutionary game theory; Blanco et al., 2009), Multidimensional Analysis (Carrillo and Jorge, 2017).

Among the vast array of techniques, Multi-Criteria dimension analysis (MCDA) methods allow to simultaneously address many issues related to tourism policymaking (Cinelli et al., 2014). These techniques are multidisciplinary approaches to complex decision problems, aiming at simultaneously accounting for economic, social, environmental, aesthetic and ethical concerns by evaluating the impacts of either projects, plans or policies based on their original measurement scales (Rostirolla, 1998). Furthermore, MCDA techniques leave the final choice on the alternative(s) to be selected to the decision-makers, choosing on the basis of stated objectives, interests, and values, or, alternatively, past experience (Soltani et al., 2015; Baba and HakemZadeh, 2012). Indeed, given the plurality of decision-makers and stakeholder involved, no unique optimal solution can be identified. Therefore, MCDA techniques aim at identifying a combination of alternatives to be modified, in order to achieve the best compromise solution (an equilibrium which cannot be modified without reducing the utility of at least one of the stakeholders involved).

Once defined the decision problem, when applying techniques belonging to the first groups, the first step consists in eliminating "inefficient" alternatives (Arbolino et al., 2018). In doing so one could refer to the concept of "dominance" (or "Pareto-efficiency"), according to whom an alternative is dominated if there is, at least, one different and preferable option in terms of, at least, one attribute (leaving the other constant) (Tan et al., 2010; Guo and Yang, 2009). Otherwise, alternative might be eliminated because, despite not being "dominated" ones, they do not satisfy some exogenously determined comparison criteria. This selection might be performed by resorting to either conjunctive (an alternative is selected if it achieves "excellent" scores in at least one attribute) or disjunctive (an alternative is deleted if it does not achieve "sufficient" scores in all the parameter) methods. The second group of techniques might be further ranked, by distinguishing between techniques using equal weighting and techniques applying weights calculated according to their operational sheets. Within the first group, two ordering techniques can be identified: *maximin*, establishing the overall performance of each alternative as the lowest value achieved by one of its attributes, and *maximax*, calculating the overall performance of each alternative based as the highest value achieved by one of its attributes.

The most frequently applied techniques may be traced back to the second group of ordering techniques (i.e., those applying different weighting), including:

- *Weighted sum*, classifying alternatives based on the weighted sum of the values achieved by each attribute of the alternative (Fishburn, 1967);
- *Weighted Product*, ranking alternatives based on the weighted product of the values achieved by each attribute of the alternative. Differently from the previous one, this technique strongly penalises alternatives achieving low scores in one or more alternatives (Miller and Starr, 1969);
- *Minimum distance from the target*, ranking alternatives according to their distance from a set of targets established ex-ante;
- *Minimum desirable value*, obtaining a ranking through the weighted sum of the distance of each alternative from some threshold, representing the minimum values achievable, according to the decision-maker preferences (Rostirolla, 1998).
- *Technique for Order Preference by Similarity to Ideal Solution* (TOPSIS), ranking alternatives by simultaneously accounting for the distances from both "ideal" and "worst" solutions. This technique was elaborated by Hwang and Yoon (1981).
- *Electre Methods* aim at (i) preselecting (Electre I) or (ii) ranking alternatives (Electre II, III, IV) (Roy, 1991). Differently from the previously mentioned techniques (mainly from the *weighted sum*), this group of techniques do not rely on a "compensatory" approach but, rather, on a deterministic one. This technique requires the identification of several thresholds (i.e., concordance and discordance indexes), meant as the limits within which the decision-maker is available to express a judgement in case a conflict arise among two or more alternatives. All the alternatives exceeding these thresholds are listed in a final ranking (Electre II, III, IV).
- *Analytic Hierarchy Processes* (AHP; Saaty, 1988), allowing to deal with decision problems assessed by qualitative data, based on pairwise comparisons. It proceeds as follows: first, the problem has to be broken down into elementary sub-problems (hierarchical decomposition); subsequently, pairwise comparisons are performed among all the elements grouped in the same hierarchical level; finally, the decision problem is reassembled and alternatives are ordered. An extension of this model has been elaborated and called Analytic Network Processes (ANP).
- *Preference Ranking Organization Method for Enrichment Evaluation* (PROMETHEE) and its descriptive complement *Geometrical Analysis for Interactive Aid* (GAIA) (Brans et al., 1986). It is a set of outranking techniques aimed at achieving partial (PROMETHEE I) or complete rankings (PROMETHEE II, which is the basis for the following versions: PROMETHEE III to VI). It is based on five subsequent steps: (i) calculation of the deviations based on pair-wise comparisons; (ii) application of relevant preference function to each criterion; (iii) determination of the global preference index; (iv) calculation of either positive and negative outranking flows; (v) ranking construction based on net outranking flows calculation (Behzadian et al., 2010).
- The *Dominance-based Rough Set Approach* (DRSA) is a relatively new automated valuation methodology for mass appraisal. Differently from the Classical Rough Set Approach (CRSA), DRSA modifies the indiscernibility principle by applying a dominance principle. In this model, data are not organized in value classes, with the aim of estimating a value interval for each alternative in terms of "at least" and "at most" values (Cinelli et al., 2014).

These techniques are intended to achieve the best-compromise solutions among the most relevant objectives, thus waiving the paradigm of "optimality". Tourism policymakers express a huge set of heterogeneous goals to be achieved through the allocation of public resource (Stevenson, 2007). This provides room for the application of MCDA methods. Table 1 lists studies applying MCDA technique to sustainable tourism problems.

It is worth mentioning the third group of methodologies, namely the optimization methodologies. By resorting to different calculation procedure and algorithms, these techniques allow to identify the optimal and best-compromise solutions among a set of available alternatives (Arbolino et al., 2018). According to the literature, these techniques can be an effective and feasible instrument to improve tourism planning and contemporarily achieve sustainable goals (Yu, 2015).

Decision Support Systems based on multi-objective techniques allow for a feasible, effective and useful appraisal of the effects of tourism policies and a subsequent improvement of their sustainability (Shcherbina and Shembeleva, 2014). As a consequence, the objective of this research has been to show the operative advantages deriving from the exploitation of "constrained" multi-objective optimization techniques, within the planning phase of sustainable tourism initiatives. This goal is achieved through the identification of the "best-compromise" public resource allocation to the tourism sector.

Table 1
Literature review of the main application of MCDA techniques.

Source	Techique	Aim	Indicators
Ganguly et al. (2020)	Weighted Sum Method	Selecting alternatives to support Sustainable Tourism Development in the Gangetic riverine delta area (India)	Ecological Index (four sub-indexes) Socio-infrastructural Index (three sub-indexes) Demographical Index (three sub-indexes) Tourism potential Index (four sub-indexes)
Fang (2017)	Weighted Sum Method	Developing a model for assessing the suitability of different areas (alternatives) for the development of ecotourism activities.	Elevation; Surface; Slope; Aspect; Forest density; Land use; Existing sites; Distance from Waterways; Distance form Roads and Streets; Distance from Residential area; Distance from Industries; Baidu Index
Carrillo and Jorge (2017)	Weighted Product Method	Assessing the development of sustainable tourism in Spanish regions.	Economic (1. tourist expenditure; 2. Hotel occupancy rate; 3. Tourism employment rate; 4. Seasonality ratio; 5. Tourist accommodation beds; 4. Ratio of 4 and 5); Social (1. Ratio of tourist to locals; Number of crimes; Traffic accidents; Number of automobiles; Hospital beds; Assets of cultural interest); Environmental (1. N. people (tourist and locals); Water consumption; Waste generation; Energy consumption; GHG emissions; Protected areas)
Garcia-Melon et al. (2012)	ANP	Assessing sustainable tourism strategies proposed by Los Roques National Park (Venezuela) stakeholders	Water quality; Scenic Beauty preservation; Species Habitat integrity; Education Level; Existence of Public Services; Economic activities other than tourism; (influence on) Per Capita Income; Solid Waste Generation; Wastewater generation; Effect on biodiversity; Level of Private Investment; Institutional Support; Compatibility with Park Regulations.
Önder et al. (2013)	AHP and TOPSIS	Evaluating 13 tourism alternatives in four Turkish cities (Antalya,Aydın, İzmir, Muğla).	Natural resources; Transportation; accommodation; Blue flagged beaches; Cultural resources; Reputation; Popularity; Safety; Security; Health and Hygiene; Price; Quality of cuisine; Night life; Activities and recreation.
Ulkhaq et al. (2016)	AHP and TOPSIS	Assessing the degree of sustainability of tourism initiatives in the rural areas[2] of the Central Java Province (Indonesia)	Services (Accessibility; Convenience); Facilities (Accommodation; Subsidiary facilities; environment); Management (Community Planning; Community Business; Community Management; Tourism BUsiness); Outcomes (Satisfaction; Total Sales).
Michailidou et al. (2016)	ELECTRE (III)	Elaborating a framework for planning and implementing environmentally sustainable initiatives in the tourism context.	18 Mitigation measures (Renewable Energy Sources; Energy Efficiency; Attitude Change of Tourism Stakeholders); 16 Adaptation Measures (Measures against Water Scarcity, Sea Level Rise, biodiversity loss and Extreme Weather Events; Measures for Land Management; Measures in Ski Industry)
Eren and Özarı (2016)	PROMETHEE and ELECTRE	Identifying a proper famework to select ecotourism destination among set of hypothetical alternatives.	Cost; Educational Opportunities; Mode of Transportation; Quality of Accommodation and Services; Physical Activities Available; Natural Beauty Landscape; Cultural Experiences; Outdoor Recreation Activities; Historical Places; Sense of Place; Connection to Nature
Ranjan et al. (2016)	PROMETHEE-GAIA	Evaluating tourism performance of Indian states and quantifying their tourism potential.	N. of foreign tourists; N. of domestic tourists; N. of three-star or above rated hotels; N. of airports and helipads; N. of sanctuaries and zoos; N. of historical monuments; Railway track and road distance; Budget allocation; Population density; Pollution index; Cost of living.
Sahani (2019)	AHP	Selecting sites in Great Himalayan National Park Conservation Area (India) for the implementation of ecotourism using MCDA, GIS and remote sensing.	Land slope and roughness; vegetation; (ground; surface and lake) water accessibility; Altitude; visibility of snow peaks; proximity to villages; presence of naturalistic routes; climatic and habitat suitability.
Carrillo (2006)	Optimization	Determining the optimal level of tourist carrying capacity of Venice historical centre	Total outlays (milion lira/day); Waste Disposal (kg/day); Hotel beds availability; Non-hotel beds availability; daily lunches; Parking Places; Solid waste.
Shcherbina and Shembeleva (2014)	Optimization	Surveying research works on modelling recreational systems and presenting a model of optimal investment policy for the tourism.	Theoretical Modelling.
Hua (2016)	Optimization	supporting policymakers for the creation of effective urban tourism development systems	Cultural venues; Festival celebration; Folk customs; Entertainment place; Shopping dining; Sports and health enhancing; Rehabilitation and health care.

Indeed, MCDA techniques present several drawbacks that the proposed multi-objective optimization model allows to overcome. First, MCDA relies on weights that are explicitly assigned by the decision-maker. This issue increases the risk of subjectivity on the part of decision-makers and/or the analyst (Arbolino et al., 2018). Based on our approach, the risk of bias is completely nullified, since no prior weights assignment is required. In our model, weights are implicitly assigned, since they are automatically computed by the simplex algorithm (Dantzig and Thapa, 2003).

Secondly, most of these techniques exploit pair-wise comparisons to delete inefficient alternatives. This risks to oversimplify the problem and exclude both information and alternatives which might be relevant in the identification of efficient scenarios (Arbolino et al., 2018). Given our decisional problem, techniques for ordering or pre-selecting alternatives based on comparisons are not relevant. By contrast, the proposed multi-objective optimization allows to formulate multi-objective and multi-dimensional problems in terms of mono-objective ones. This reformulation is performed by setting one objective to be maximised or minimised and considering the others as constraints. In doing so, we are able to identify different scenarios which might be modified by the analyst according to the preferences of the decisionmaker, thus stimulating a cooperative behaviour between analyst and decisionmakers. Given these premises, the proposed DSS seems a promising opportunity to overcome the main shortcomings of MCDA techniques recognized by the literature (i.e., Arbolino et al., 2018; Soltani et al., 2015).

3. Material and methods

3.1. The decision problem

In our decision problem, the main issue is the identification of tourist projects in order to maximize the overall utility of the stakeholders involved, according to a predetermined set of "exogenous" constraints (e.g.: budget constraints). Such tourist project focuses on resource management in such a way that all economic, social needs are satisfied at the same time as respecting cultural integrity, ecologic processes and the life support system.

The evaluation of the different project alternatives, following a call for tender, requires the definition of both significant selection criteria – concerning both the firm's ability that participates to a call for tender on the basis of the main objectives - and indicators to measure them. The features of each alternative have been analysed according to seven groups of criteria, further grouped into two categories (A and B). The first category includes those criteria evaluating features linked to the proposed project and to the applicant entity (Table 2).

The second category of decision criteria describes the potential impacts generated by the project according the three dimension of the sustainability (economic, environmental and social) and, specifically, by identifying both significant decision criteria and indicators to measure them (Table 2). First, energy efficiency, water consumption, waste management and environmental management were considered as key aspects of environmental sustainability (Arbolino et al., 2020). These aspects have been analysed as follows:

- o *Energy management*, assessing both positive and negative energy impact of tourist activity. Specifically, these indicators measure the willingness to reducing energy consumption, by using energy-efficient equipment, and the potential energy consumption from renewable resources.
- o *Water availability and conservation*, in order assess the willingness to minimize water consumption and wastage.
- o *Solid waste management.* Environmental impact of tourist activity, on a local community, could be reduced by promoting awareness campaigns, in order to reduce waste consumption and to incentive separate collection.
- o *Environmental management.* The aim is to assess the positive impact of a comprehensive action in the management of a multidimensional concept such as sustainability in a tourist context. Thus, our evaluation system includes two indicators that evaluates the existence of a local administrative unit to manage environmental actions and the existence of quality certification.

As regards the social component, the analysis has been carried out by considering the effects on local community, in order to control the social-carrying capacity of the destination to avoid rejection by local people. First, the existence of engagement activities for society has been evaluated as well as the existence of integrated transportation mode (as an alternative to public transportation system), that ensure access to the destination and to its resources. In our model, society is represented by local communities (whose engagement is one of the objectives, Table 2). Furthermore, by promoting sustainable behaviors (i.e., recycling and composting of waste), selected projects become instruments to spread environmental education across population.

Finally, the economic dimension considers indicators such as that allow us both to control the destination's level of competitiveness and to evaluate the employment generated in the tourism activity, as territorial economic effects. Namely, the proposed indicators are based on occupancy rates of official accommodations and potential tourist demand, which indirectly show the power of attraction of destination products.

Table 3 shows, for each sustainability dimension, each decision criterion divided into objectives, whose weights have been established ex-ante. These weights are discretionary and each of them reflects the judgement value of the policy maker. Therefore, the vector of the scale coefficients associated with each objective – i.e. the weights – may be provided by the decision-maker according to their preferences, in order to reflect its marginal rate of substitution. Subsequently, each objective has been associated with the indicators or assessment level aimed at assessing its achievement.

3.2. Multi – objective optimization vs multicriteria analysis

In order to solve the decision problem above defined, different methodological approaches can be used. Among the main, in the following, we propose an explanation of the optimization model, while the description of two traditional multicriteria analysis are reported in Appendix A. Among the main available multicriteria techniques describing a ranking, we refer to both "weighted sum" and AHP.

The first methodology allows alternatives ranking, by assigning different scores to assess the overall performance of each alternative. It allows to compensate the "bad" performance achieved in terms of some indicators, through the high results of other measures.

The AHP technique organizes the evaluation in a hierarchical form that allows a detailed decomposition of the problem: the decision problem is broken down into several levels, where the first represents the objective of the problem, the second level (and any subsequent) the attributes and sub-attributes deemed to be decisive for the achievement of the objective. Each attribute or sub-attribute can be broken down to the desired level of detail.

Unfortunately, none of the MCDA methodologies allows the inclusion of budget constraints among the selection criteria. These ordering techniques list the alternatives according to the selection criteria and their "direction" – i.e. maximization or minimization – without accounting for other fundamental features of the selection process – i.e. financial criteria. These are further reasons supporting the inclusion of multi-objective optimization techniques within the framework of multicriteria analysis.

3.3. Multi – objective optimization model

The decision problem can be formulated in terms of mono-objective optimization. This transformation is carried out by identifying a clear aggregate objective to be maximised or minimised, according to a set of constraints imposed on the achievement (targets) of the other objectives.

Through the supporting calculation system, the comparison of several formulations of the decision problem becomes more feasible. These Evaluation Scenarios are based on a precise objective function, a set of technical, physical and behavioural constraints - that could be even considered as scenario-invariant – and the decision-maker statements about the achievement of the other objectives. The information provided by the different scenarios is used to generate new scenarios requiring further testing. This procedure increases the level of knowledge on the decision problem, in terms of impacts related to all the feasible choices.

The solution algorithm is based on integer numbers programming, having each decision variable associated with a binary variable of existence. This variable takes value one in the "optimal" condition – in case a project should be implemented - and zero, otherwise. Once this problem is solved, the analyst identifies a set of projects to be funded, namely those maximizing the objective function and simultaneously meeting all the constraints. Subsequently, by solving the same problem with different constraints, a different list of projects is obtained.

Predictably, a new ordering is generated after modifying the decision problem, proving that operational shortcuts defining a rigid ordering based on predefined criteria are not feasible. These shortcuts would lead to the problem of choosing the most suitable criterion to define a ranking of the analysed projects. The ranking obtained would change according to the specific criterion imposed and would be different from the one obtained setting the analysis in terms of constrained optimization.

Table 2
General selection criteria (A).

Dimension	Criteria	Objective	Weight	Level/Indicator	Score
Project and Entity Max 35 scores	Project Consistency Max 15 scores	Consistency with priorities and objectives of programming documents	**5**	**High** (total consistency with the whole programming objectives)	**1**
				Medium (partial consistency with some objectives)	**0.7**
				Low (consistency with alone objective)	**0.3**
		Coherence	**5**	**High**	**1**
				Low	**0.5**
		Integration with (realized and none) tourist communication and promotion instruments/activities of public bodies	**5**	Integration with more than 1 Instrument/activity	**1**
				Integration with only 1 instrument/activity	**0.5**
				Integration with no instrument/activity	**0**
	Features of applicant entity Max 10 scores	Tourist promotion financial investments in the last 3 years	**3**	> € 300.000,00	**1**
				<= € 300.000,00	**0.5**
		N. of private funding tourist promotion projects in the last 3 years.	**2**	> 5 private funding	**1**
				<= 5 private funding	**0.5**
		Public partnership composition	**3**	More than 4 public bodies involved	**1**
				From 2 to 3 public bodies involved	**0.7**
				1 public body involved	**0.3**
				No public body involved	**0**
		Level of cooperation with public and/or private entities	**2**	More than 4 entities involved	**1**
				From 2 to 3 entities involved	**0.7**
				1 entity involved	**0.3**
				No entity involved	**0**
	Requested financial aid Max 10 scores	Deviation from the maximum value of financial aid (requested financial aid/max aid value to be requested)	**10**	<= 50%	**1**
				> 50%	**0.5**
				100%	**0**

Table 3
Environmental, social and economic criteria (B).

Dimension	Criteria	Objective	Weight	Level/Indicator	Score
Environmental sustainability (max 35 scores)	Energy management (max 10 scores)	Energy consumption	5	Low (> 1 energy - efficient equipment)	**1**
				High (<= 1 energy - efficient equipment)	**0.5**
		Potential energy consumption from renewable resources	5	High (>50% from RES)	**1**
				Medium (50% > from RES <= 20%)	**0.7**
				Low (< 20% from RES)	**0.3**
	Water availability and conservation (max 10 scores)	Water consumption	5	Low (> one equipment for decreasing water consumption)	**1**
				High (<= two equipment for decreasing water consumption)	**0.5**
		Possibility to reuse water	5	Yes	**1**
				No	**0**
	Solid waste management (max 10 scores)	Waste production	5	Low (promotion of awareness campaigns)	**1**
				High (no awareness campaigns)	**0**
		Potential percentage of waste recycled	3	High (>50% of recycled waste)	**1**
				Medium (20% < of recycled waste <= 50%)	**0.7**
				Low (< 20% of recycled waste)	**0.3**
		Existence of domestic composting installations	2	Yes	**1**
				No	**0**
	Environmental management (max 5 scores)	Existence of an environmental administrative unit	2	Yes	**1**
				No	**0**
		Quality certification	3	Yes	**1**
				No	**0**
Social sustainability (max 15 scores)	Effects on local community (max 15 scores)	Existence of engagement activities for local community	10	Yes	**1**
				No	**0**
		Existence of integrated transportation mode	5	Yes	**1**
				No	**0**
Economic sustainability (max 15 scores)	Economic benefits (max 15 scores)	Potential tourist demand	4	>= 3,000 visitors	**1**
				< 3,000 visitors	**0.5**
		Occupancy rates for official accommodations	3	>50%	**1**
				<= 50%	**0.6**
				0%	**0**
		Potential (direct and indirect) employment	8	High (> = 100 employees)	**1**
				Medium (30 < employees <100	**0.7**
				Low (<= 30 employees)	**0.3**

However, modern computing power avoids resorting to this kind of shortcuts. In short:

- a multi-objective problem has been transformed into a mono-objective one, by selecting one objective and including the other ones as a constraint;
- the possibility of considering all the impacts has reduced - or deleted - the necessity of resorting on “shadow” prices;
- the decision-maker is not required to set an ex-ante system of weights to be assigned to the different objectives.

In this way the objective function consists in the maximization of the aggregate score built as the weighted sum of the scores assigned to each alternative included in the optimal solution, in accordance with a set of constraints – exogenously determined by the decision-maker.

It is given by:

$$\max f(x) = \sum_j PT_j {}^*(s.ct.)_j {}^* x_j$$

Where:

- x is the vector of decision variables;
- PT is the total score achieved by the j-th alternative;
- x_j is a binary variable of existence [0,1]: if the alternative is excluded from the “optimum”, x_j takes value 0 and the product is zero. Subsequently, it is excluded from the computation of the Objective function;
- s.ct. is the impact coefficient, relative to the total cost threshold.

In the description of the Objective Function, the total cost threshold (s.ct.) has been introduced in order to allow a more balanced evaluation of the alternatives, preventing the most or the least expensive initiatives from being be advantaged in the final selection.

Once the Objective Function has been described, it is possible to identify the “best compromise” solution, according to a non-adjustable set of exogenous constraints. These latter have been introduced in order to make the different allocation choices as close as possible to the “decision-maker” preferred solution. These constraints are divided into two groups: constraints on impacts and constraints on alternatives.

According to the constraints imposed, it generates different solutions based on the level of achievement of the considered objectives. On the basis of these initial results, the analyst requires new information by the policy maker, in order to implement new proposals and try to identify a more “satisfactory solution”.

Therefore, new constraints on the budget have been imposed in the 2 different scenarios, as follows:

- Scenario 1 has been obtained by maximizing the aggregate score and, simultaneously, meeting the constraint that the overall contribution has to be less than or equal to funding availability.
- Scenario 2 is built, by choosing “Environmental sustainability score” as Objective Function to be maximised, within the financial and policy constraints already defined.

In both the scenarios, another constraint has been introduced that is the financial amount to be allocated to called “in growth tourism destination” (at least to 50% of total available budget), based on the policy objective to encourage the tourism development in high-potential areas.

4. Optimization model results

The matrix - Table 4 - of inputs describes 12 tourist project alternatives, labelled as A_j where $j = 1, 2, \ldots 12$. These projects represent the alternatives the decisionmaker has to choose from.

Following, the matrix describes the main features of each proposal: the total cost, the public financial aid could be required to any Administration – both in absolute terms and in the percentage of the total amount: a maximum threshold of 50% of public cofounding for each project has been assumed. In addition, the kind of destination is shown – whether it is an area in the stage of tourist congestion or an area with potential tourism growth. This matrix will be used for applying all the three methodologies.

The multi-objective decision problem is analysed as a mono-objective one: the maximization of the aggregate score. It is calculated as the weighted sum of the scores assigned to each alternative included in the optimal solution, in accordance with a set of constraints – exogenously determined by the decision-maker. On the other hand, considering the score assigned as the social value of each alternative, the aggregate score can be considered as the total social value to be maximised, conditional on the budget constraint, according to the methodology explained in Section 4.

Once the Objective Function has been described, it is possible to identify the “best compromise” solution, according to a non-adjustable exogenous constraint, corresponding to a hypothetical amount of available public resources (€ 1,000,000.00). The optimization model allows the comparison of different scenarios, providing a set of formulations and related solutions. For the purposes of the current analysis, two Scenarios have been developed (Table 5).

Scenario 1 – shown in Table 5 - has been obtained by maximizing the aggregate score and, simultaneously, meeting the constraint that public contribution has to be less than or equal to total funding availability (i.e., € 1,000,000.00). The allocation of at least 50% of total available budget to “in growth tourism destination” has been introduced as second constraint. The inclusion of this criteria is based on the policy objective to encourage the tourism development in high-potential areas. Indeed, despite the potential economic and social benefits for local community (i.e., enriching people cultural heritage, improving societies lifestyle, strengthening local cultural identity, as well as creating employment and income), there are areas with a huge unexploited artistic and cultural heritage. In order to enhance tourism development of these areas, the preservation local cultural heritage must be ensured.

Even though the first Scenario (Scenario 1) allows the selection of projects, which are potentially quite careful in ensuring positive environmental impact, if we consider sustainable tourism as an institutional definition (eg: World Tourism Organization - WTO), the evaluation process should be focused on environmental issues. This issue highlights the necessity of a decision system allowing to select only tourist activity with low negative impacts on environment. From this perspective, Scenario 2 is built (Table 6), by choosing “Environmental sustainability score” as Objective Function to be maximised, together the financial and policy constraints already defined.

Scenario 1 construction results in the selection of 9 projects funded by allocating the 90.33% of total resources. The aggregate score is equal to 625.25). The introduction of a “new” objective function in scenario 2 has led to different – improved – results. First, 10 projects have can be financed in this scenario: that is, four projects in developed tourism destinations and six (one more than Scenario 1) in area with unexploited tourism potential. The increased number of projects awarded results in increased resource allocation. In fact, Scenario 2 resource expenditure amounts to the 97.89% of the available budget (€ 978,895), thus exceeding Scenario 1 expenditure (€ 903,289). Furthermore, the aggregate score is larger (755.35), meaning that projects with higher performance level in terms of the indicators selected have been funded. Noticeably, increased performance is provided by the focus on efficient resources management aimed at limiting environmental implications of funded projects. In this Scenario, the Environmental score value is higher. The selected project generates a relevant positive environmental impact because their realization is based on environmental- oriented activities. This result implies that a tourism policy must necessarily encompass the ecological dimension as it emphasizes the need to

Table 4
Matrix of inputs (partial).

Objectives			Tourist project alternatives				
			A1	A2	An	A11	A12
C1	Max	Consistency with priorities and objectives of programming documents	3.5	5	…	1.5	3.5
C2	Max	Coherence	5	5	…	5	5
C3	Max	Integration with (realized and none) tourist communication and promotion instruments/activities of public bodies	5	5	…	2.5	2.5
C4	Max	Tourist promotion financial investments in the last 3 years	1.5	1.5	…	1.5	3
C5	Max	N. of private funding tourist promotion projects in the last 3 years.	1	2	…	2	2
C6	Max	Public partnership composition	1.5	3	…	0.9	3
C7	Max	Level of cooperation with public and/or private entities	2.1	2	…	0.6	2
C8	Max	Deviation from the maximum value of financial aid	10	5	…	10	10
C9	Min	Energy consumption	2.5	5	…	2.5	5
C10	Max	Potential energy consumption from renewable resources	3.5	3.5	…	1.5	5
C11	Min	Water consumption	2.5	2.5	…	1	5
C12	Max	Possibility to reuse water	0	0	…	1	0
C13	Min	Waste production	0	5	…	1	5
C14	Max	Potenial percentage of waste recycled	2.1	3	…	2.1	3
C15	Max	Exsistence of domestic composting installations	0	2		0	0
C16	Max	Existence of an environmental administrative unit	0	2	…	2	0
C17	Max	Quality certification	3	3	…	3	3
C18	Max	Existence of engagement activities for local community	5	10	…	10	10
C19	Max	Existence of integrated transportation mode	0	5	…	0	5
C20	Max	Potential tourist demand	2	4	…	2	4
C21	Max	Occupancy rates for official accommodations	1.8	3	…	1.8	8
C22	Max	Potential (direct and indirect) employment	5.6	2.4	…	8	5.6
C23	Max	Total Score	57.6	78.9	…	59.9	89.6
C24	Max	Environmental sustainability	13.6	26	…	14.1	26
C25	Max	Social sustainability	5	15	…	10	15
C26	Max	Economic sustainability	9.4	9.4	…	11.8	17.6
C27	Min	Investment costs	82,000 €	46,890 €	…	120,000 €	189,000 €
C28	Max	Public aid	41,000 €	37,512 €	…	42,000 €	189,000 €
C29	Max	Public aid %	50%	80%	…	35%	100%
C30	Min	Public Aid - developed tourism destination	41,000 €	37,512 €	…	–	–
C31	Max	Public Aid - in growth tourism destination	–	–	…	42,000 €	189,000 €

incentive the cultural and tourist promotion by reducing the pressure on the physical environment (Konakoglu and Kurdoglu., 2019).

5. Discussion

In the following the different multicriteria approaches have been compared to the results by optimization model in order to evaluate the goodness of our proposal.

Through the "weighted sum" method, a final ranking is obtained, allowing a different selection of the project proposals (Scenario 3 in Table 6). Since the selection criteria represent the "social welfare function" associated with the allocation of public resources (Nannariello and Rostirolla, 2003), higher scores indicate increased social welfare. Therefore, alternatives with higher aggregate score should be preferred to lower score alternatives. Nonetheless, none of these criteria accounts for the scarcity of public resources to be allocated, that is placed under a given level (in this case, € 1,000,000.00).

It generates a first hypothetical allocation of the available resources: 6 out of 12 project proposals would be selected resulting in the allocation of 65.24% of the available resources.

Accordingly, Scenario 1 is socially preferred to Scenario 3 since it achieves a greater use of the total budget – 90.33% - and allows funding 9 projects – versus 6 of Scenario 3. The aggregate score (625.25) exceeds that obtained in the previous scenario (423.5). A further reason enhancing preference for Scenario 1 deals with performance of environmental indicators: the average environmental sustainability score is

Table 5
Scenario 1 Optimization with O.F. max Total score; Scenario 2 Optimization with O.F. max Environmental sustainability score.

Scenario	Scenario 1			Scenario 2		
Method	Optimization method 1			Optimization method 2		
Objective Function	Max Total score			Max Environmental sustainability score		
	Constraints		Impact	Constraints		Impact
Total score			625.25			755.35
N. Projects			9			10
N. Projects - developed tourism destination			4			4
N. Projects - in growth tourism destination			5			6
Environmental sustainability score (average value)			31.25			34.3
Social sustainability score (average value)			8.89			10
Economic sustainability score (average value)			10.5			12.5
Public Funding (€)	<=	1,000,000 €	903,289 €	<=	1,000,000 €	978,895 €
Public Funding- developed tourism destination (€)			330,405 €			377,462 €
Public Funding - in growth tourism destination (€)	>=	500,000 €	572,884 €	>=	500,000 €	601,433 €
% Public Funding on Available Public Budget (PF/APB)			90.33%			97.89%
% PF/APB - in developed tourism destination			36.58%			38.56%
% PF/APB - in growth tourism destination			63.42%			61.44%

Table 6
Scenario 3 – Weighted sum.

Scenario	Scenario 3
Method	Weighted Sum
Objective Function	Max Total score Impact
Total score	423.5
N. Projects	6
N. Projects - developed tourism destination	3
N. Projects - in growth tourism destination	3
Environmental sustainability score (average value)	29.3
Social sustainability score (average value)	8.5
Economic sustainability score (average value)	9.6
Public Funding (€)	652,352 €
Public Funding- developed tourism destination (€)	336,614 €
Public Funding - in growth tourism destination (€)	315,738 €
% Public Funding on Available Public Budget (PF/APB)	65.24%
% PF/APB - in developed tourism destination	51.60%
% PF/APB - in growth tourism destination	48.40%

slightly large than in Scenario 3. It means that the nine tourist projects selected in Scenario 1 are “more sustainable” than those selected through the weighted sum procedure (Scenario 3). The preference for Scenario 2 over Scenario1 – both based on optimization models – is maintained also when comparing it with Scenario 3. In fact, it allows to either finance more projects, achieve a higher aggregate score and, above all, allocate almost all the resources.

The main criticism related to the application of the Weighted Sum procedure is that a relatively large share of resource is still unused. This is a crucial point since both allocation and efficient expenditure of all the available resources are among the main goals to be achieved by the administration.

Consequently, financing the alternatives until all the resources have been allocated does not maximize social welfare. That is, in the absence of financial constraints, the alternative A_i is preferred to A_j, since it achieves a higher score, even though it is more expensive. This statement cannot be considered true when resources are scarce. These are further reasons supporting the inclusion of multi-objective optimization techniques within the framework of multicriteria analysis.

According to the results, any Multicriteria Analysis technique, providing a project selection by sliding a ranking until budget is exhausted, such as the “Weighted Sum”, neither leads to maximize “social welfare function”, nor provides an ‘optimal’ allocation of financial resources. This happens when the decision problem is very complex. The complexity of sustainable tourism requires that both evaluation and selection processes are carried out by considering all the elements linked to the three dimension of sustainability – environmental, social and economic. This could be achieved by using DSS techniques able to assess each evaluation elements, such as AHP.

To demonstrate that none of the multicriterial analysis methodologies allows the inclusion of budget constraints among the selection criteria and the right or “compromise” consideration of all evaluation element, a Scenario 4 is built by using AHP (Table 7). This method is based on cross-comparison of elements by ensuring greater stability of the priorities, against inconsistent judgement. It is very used in tourism decision-making process because it assesses both many evaluation criteria, and the relevance of each factor affecting decision.

We argue that AHP can better assist multi-objective decision process than Weighted Sum: first, at the same number of tourist project could be funded, in Scenario 3 a greater use of the total budget could be achieved; furthermore, the selected tourist activities are more environmental –oriented. However, Scenario 4 cannot be preferred to Scenario 2, because of Optimization method better assist decision maker, in allocation of financial resources, in achievement to policy target in order to improve social, economic and territorial development. In Scenario 2, also environmental performance of tourist activities presents a higher average score.

Then, in order to obtain “Pareto efficient” solutions (Niu and Zhang, 2013), it is worth introducing some constraints in the project selection process, following a model like the one previously described. By ‘Constrained’ Optimization Model, different project alternatives can be assessed uniformly, by using some criteria as inherent features of each project and others as explicit conditions (i.e constrains).

Among the constraints defined as control variables for the selection of the projects to be financed, our model evaluates the environmental implications of tourist activity. In this way, our approach includes the environmental variables as well. The choice of giving an important weight (50 scores) to the green factors is linked to the great importance of sustainable policy in the development of the society.

This model is very complex, but provides relevant advantages, such as:

- Several choices (in terms of criteria, weights and indicators) are clear and explicit, by an interaction process between decision maker and analyst.
- It is a consistent and resilient profiling model able to show any impact of each alternative.
- A well-functioning allocation of (financial, environmental, social, technical, etc.) resources by considering constrains and preferences on objectives.

This Decision Support System has been realized by using a ‘Lindo system’ software that works as a Microsoft Excel add-in. Moreover, this model can be considered as a new approach to draft call for tenders, allowing a better understanding of policy and economic needs. So, this optimization model is expected to lead to a better public resource allocation, and, likewise, to improved audit.

6. Conclusions

Reducing the negative externalities of human activities as well as enhancing environmental, economic and social sustainability is a main goal for decisionmakers (Arbolino et al., 2019). With reference to tourism, three main issues hamper the implementation of sustainable policies: (i) the number of actors involved, (ii) the presence of conflicting goals and (iii) the needs of resource rationalization. The involvement of a plurality of public and private subjects – representing

Table 7
Scenario 4 – AHP method

Scenario	Scenario 3
Method	**AHP**
Objective Function	**Max Total score** Impact
Total score	521.6
N. Projects	6
N. Projects - developed tourism destination	3
N. Projects - in growth tourism destination	3
Environmental sustainability score (average value)	30.56
Social sustainability score (average value)	11.2
Economic sustainability score (average value)	10.3
Public Funding (€)	754,692 €
Public Funding- developed tourism destination (€)	369,497 €
Public Funding - in growth tourism destination (€)	385,195 €
% Public Funding on Available Public Budget (PF/APB)	75.47%
% PF/APB - in developed tourism destination	48.96%
% PF/APB - in growth tourism destination	51.04%

different interests and objectives – in the implementation sustainable tourism programs makes the decision-making process articulated and complex, often resulting in a non-optimal allocation of resources (Önder et al., 2013). Moreover, when promoting sustainable tourism practices, public administrations face decision problems dealing with non-economic issues - e.g. social, environmental variables, etc. From a methodological point of view, this implies that either mono-criteria optimization or cost-benefit techniques are no more enough.

In order to overcome these features, that become crucial for strategic planning, we proposed a methodological approach able to support public administrations in pursuing their objectives – namely, rationalizing expenditure and defining priorities for action – whilst promoting sustainable practices.

Using the multi-objective optimization model, the decision problem is formulated in terms of mono-objective optimization. In doing so, we chose a single aggregate objective function, to be maximised or minimised, following a set of constraints on other objectives, as measured by the relative indicators. In order to strengthen our approach, a subsequent comparison with multi-criteria evaluation techniques – trying to solve decision problems through different nature evaluation criteria (economic, environmental, social, etc.) – have been developed. They allow to analyse simultaneously variables with different nature – thus, measurable through different units. These techniques help to identify the solutions which could support policymakers in reaching their determinations, following the stated objectives and values. Furthermore, they provide a way to manipulate the huge mass of data available, despite its complexity. In general, based on these techniques, no action is better than the others, concerning all the criteria considered.

In the present research, two different MCDA techniques are applied: Weighted sum and Analytic Hierarchic process. The application of these decision support techniques leads to conclude that multi-criteria techniques are not always enough, since none of them deals with budget constraints when used individually. These ordering techniques develop a final ranking consistent with the scores of the evaluation criteria and with their direction (maximization and/or minimization). Notwithstanding, they are not able to encompass other relevant factors for the final decision, such as the financial ones. For these reasons, we suggest the integration of multi-criteria assessments techniques with constrained analytical optimization tools.

The two application of the optimization models presented in the paper allows to cope with several relevant issues concerning sustainable tourism policymaking. In particular, the optimization model allows to allocate a larger share of funds (ranging between 90.33% and 97.89%) in comparison with AHP (75.47%) and Weighted Sum (65.24%). The ability of properly allocating as many public resources as possible is particularly relevant when we consider the necessity on the part of Public administration for expenditure rationalization, forcing decision-makers to define reduced set of priorities to be funded. Furthermore, Scenario one and two (built by exploiting optimization models) select a set of projects achieving higher levels of environmental sustainability, as measured by the Environmental Sustainability Scores: i.e., 34.3 average score versus 29.3 (Weighted Sum) and 30.6 (AHP). Thus, increased environmental sustainability is achieved, while preserving the degree of social and economic sustainability.

The main limitation of the current research refers to its scope. Indeed, being a first application to a generic call for tender, the model is built by exploiting hypothetical weights, not representing the preferences of a real decisionmaker. The collection of this kind of information should be carried out through surveys, interviews, and expert meetings. Thus, future avenues for research might involve the application of the optimization model within a broader Decision Support System, involving the previously mentioned aspects. Furthermore, concerning the specific context where the model is applied, the set of criteria and objectives included in the model could be modified.

Finally, there are several advantages in implementing these kinds of analysis: firstly, it proposes a better allocation of public resources and, at the same time, a better evaluation of the expected results. Secondly, the modifications to the constraints to be imposed for defining "best compromise" resource allocation is, mainly, a political choice, thus requiring an active and continuous involvement of policymakers. In doing so, these methods enhance interactive and cooperative behaviours among the different stakeholders and, in particular, between analysts and decision-makers.

Author statement

Roberta Arbolino: Conceptualization, Methodology, Supervision; Raffaele Boffardi: Conceptualization, Data curation, Writing – original draft, Visualization, Writing- Reviewing and Editing; Luisa De Simone: Writing – original draft, Formal analysis, Software, Writing- Reviewing and Editing; Giuseppe Ioppolo: Conceptualization, Supervision, Writing-Reviewing and Editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Traditional multicriteria analysis

Weighted sum

In order to solve our decision process, each decision criterion has been divided into objectives, whose weights have been established ex-ante. Subsequently, each objective – established based on the above described tourism project (Tables 1 and 2) – has been associated with the indicators aimed at assessing its achievement. The assignment of weights, that are discretionary and reflect the judgement value of the policy maker, is necessary to allow the selection of alternatives (Keeney and Raiffa, 1976). The vector of scale coefficients associated with each objective – i.e. the weights – has to be provided by the decisionmaker according to its preferences, reflecting its marginal rate of substitution.

The total score is calculated as the weighted sum of these scores, namely:

$$A_j = \sum_i w_{ij} * r_{ij}$$

Where:

- Aj is the j-th alternative, j = 1, 2, …n;
- w_{ij} is the weight assigned to each objective (as in Tables 1–4);

- r_{ij} is the value assigned to each indicator assessing the objective to which it refers.

The selection criteria listed in the call for tender represent the "social welfare function" associated with the allocation of Public Administration resources (Nannariello and Rostirolla, 2003). Therefore, higher scores indicate an increased level of social welfare that should be preferred compared to lower score alternatives.

Once the alternatives (projects) are ranked, the decisionmaker selects the number of projects to be funded subject to the total available budget. However, financing the alternatives until all resources have been allocated does not maximize the aggregate score measuring social welfare. In short, without imposing financial constraints, an alternative is preferable because of the higher score achieved, even though it is more expensive. When resources are scarce, this statement should not be considered true.

Analytic Hierarchy process (AHP)

This methodological approach, proposed by Saaty (1988), is based on values and judgements of individuals and groups. These judgements are defined on the basis of a multilevel hierarchical structure in order to obtain priorities.

The AHP consists of three main phases:

1. Hierarchical breakdown of the complex problem into elementary sub-problems;
2. Pair comparisons, for each level of the hierarchy, among all elements belonging to the same level, faced with the objectives from the higher level;
3. Summary of the priorities of the decision-making problem and determination of the arrangements for alternatives. At this stage all elements belonging to the same element of the hierarchical structure are compared between them (in pairs) in order to determine which is the most important in relation to the element of the higher hierarchical level to which they refer, and to what extent. The result of the comparison is the a_{ij} coefficient of dominance which represents the estimate of dominance of element i over element j.

Then, the sum of their overall weights (each obtained by multiplying their local weights with the weight of the criterion) allows to recover the weight of the criterion with respect to the product of these weights, as follows:

$$\sum_{i=1}^{n} a_i w_i$$

The advantage of a hierarchical structure is that it allows to obtain a detailed, systematic and structured decomposition of the general problem, in its both fundamental components and interdependencies, with a wide degree of flexibility. However, it should be noted that this methodology is not exempt from criticism that converge to some main aspects; the arbitrariness in the choice of the numerical scale and therefore the attribution of relative weights; the dependence of the result on the number of alternatives considered.

References

Adongo, C.A., Taale, F., Adam, I., 2018. Tourists' values and empathic attitude toward sustainable development in tourism. Ecol. Econ. 150, 251–263.

Aljerf, L., 2015. Change theories drift conventional tourism into ecotourism. Acta Tech. Corviniensis - Bull. Eng. 8 (4), 101.

Arbolino, R., De Simone, L., Yigitcanlar, T., Ioppolo, G., 2018. Facilitating solid biomass production planning: insights from a comparative analysis of Italian and German marginalized areas. J. Clean. Prod. 181, 819–828.

Arbolino, R., Boffardi, R., Ioppolo, G., 2019. The effectiveness of European energy policy on the Italian system: regional evidence from a hierarchical cluster analysis approach. Energy Pol. 132, 47–61.

Arbolino, R., Boffardi, R., De Simone, L., Ioppolo, G., 2020. Who achieves the efficiency? A new approach to measure "local energy efficiency". Ecol. Indicat. 110, 105875.

Baba, V.V., HakemZadeh, F., 2012. Emerald article: toward a theory of evidence based decision making. Manag. Decis. 50 (5), 832–867.

Ballantyne, R., Packer, J., Hughes, K., 2009. Tourists' support for conservation messages and sustainable management practices in wildlife tourism experiences. Tourism Manag. 30 (5), 658–664.

Behzadian, M., Kazemzadeh, R.B., Albadvi, A., Aghdasi, M., 2010. PROMETHEE: a comprehensive literature review on methodologies and applications. Eur. J. Oper. Res. 200 (1), 198–215.

Blancas, F.J., Caballero, R., González, M., Lozano-Oyola, M., Pérez, F., 2010. Goal programming synthetic indicators: an application for sustainable tourism in Andalusian coastal counties. Ecol. Econ. 69 (11), 2158–2172.

Blanco, E., Lozano, J., Rey-Maquieira, J., 2009. A dynamic approach to voluntary environmental contributions in tourism. Ecol. Econ. 69 (1), 104–114.

Brans, J.P., Vincke, P., Mareschal, B., 1986. How to select and how to rank projects: the PROMETHEE method. Eur. J. Oper. Res. 24 (2), 228–238.

Carrillo, M., Jorge, J., 2006. Multiobjective decision support for the tourist sector. Invest. Oper. 27 (2), 116–123.

Carrillo, M., Jorge, J.M., 2017. Multidimensional analysis of regional tourism sustainability in Spain. Ecol. Econ. 140, 89–98.

Cinelli, M., Coles, S.R., Kirwan, K., 2014. Analysis of the potentials of multi criteria decision analysis methods to conduct sustainability assessment. Ecol. Indicat. 46, 138–148.

Dantzig, G.B., Thapa, M.N., 2003. Geometry of linear inequality systems & the simplex method. Linear programming. Theory and Extensions 2, 1–41.

Della Corte, V., Sciarelli, M., Cascella, C., Del Gaudio, G., 2015. Customer satisfaction in tourist destination: the case of tourism offer in the city of Naples. J. Invest. Manag. 4 (1–1), 39–50.

Douissa, M.R., Jabeur, K., 2020. A non-compensatory classification approach for multi-criteria ABC analysis. Soft Computing 24 (13), 9525–9556.

Emas, R., 2015. The Concept of Sustainable Development: Definition and Defining Principles. Brief for GSDR. http://www.academia.edu/download/43652555/5839GSDR_2015_SD_concept_definiton_rev.pdf.

Eren, Ö., Özarı, Ç., 2016. Evaluating ecoturism destination using Electre and PROMETHEE desicion model. International Research Journal of Natural and Applied Sciences 3 (7), 246–260.

European Commission, 2006. COMMUNICATION from the COMMISSION. A Renewed EU Tourism Policy: towards a Stronger Partnership for European Tourism. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52006DC0134.

European Commission, 2007. COMMUNICATION from the COMMISSION. Agenda for a Sustainable and Competitive European Tourism. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52007DC0621.

Fang, Y., 2017. Site selection of ecotourism: a case study of Zhejiang province. International Journal of Innovative Science, Engineering & Technology 4 (3), 321–323.

Farzanegan, M.R., Gholipour, H.F., Feizi, M., Nunkoo, R., Andargoli, A.E., 2020. International tourism and outbreak of coronavirus (COVID-19): a cross-country analysis. J. Trav. Res., 0047287520931593

Fishburn, P.C., 1967. Methods of estimating additive utilities. Manag. Sci. 13 (7), 435–453.

Fraiz, J.A., de Carlos, P., Araújo, N., 2020. Disclosing homogeneity within heterogeneity: a segmentation of Spanish active tourism based on motivational pull factors. Journal of Outdoor Recreation and Tourism 30, 100294.

Ganguly, S., Ghosh, M., Sen, J., 2020. Spatial evaluation supporting sustainable tourism development in riverine global south. In: Perception, Design and Ecology of the Built Environment. Springer, Cham, pp. 265–293.

García-Melón, M., Gómez-Navarro, T., Acuña-Dutra, S., 2012. A combined ANP-delphi approach to evaluate sustainable tourism. Environ. Impact Assess. Rev. 34, 41–50.

Hall, C.M., 2019. Constructing sustainable tourism development: the 2030 agenda and the managerial ecology of sustainable tourism. J. Sustain. Tourism 27 (7), 1044–1060.

Hollinshead, K., 1991. Scientific nature of anthropology. Ann. Tourism Res. 18 (4), 653–658.

Hua, J., 2016. Optimization for urban tourism product development system based on data mining. In: 2016 International Conference on Smart Grid and Electrical

Automation. ICSGEA), Zhangjiajie, pp. 284–287. https://doi.org/10.1109/ICSGEA.2016.68.
Hwang, C.L., Yoon, K., 1981. Methods for multiple attribute decision making. In: Multiple Attribute Decision Making. Springer, Berlin, Heidelberg, pp. 58–191.
Keeney, R.L., Raiffa, H., 1976. Decision with Multiple Objectives. Wiley, New York.
Konakoglu, Hełdak, Kurdoglu, Wysmułek, 2019. Evaluation of sustainable development of tourism in selected cities in Turkey and Poland. Sustainability 11, 2552.
Lozano-Oyola, M., Contreras, I., Blancas, F.J., 2019. An operational non-compensatory composite indicator: measuring sustainable tourism in andalusian urban destinations. Ecol. Econ. 159 (C), 1–10.
Michailidou, A.V., Vlachokostas, C., Moussiopoulos, N., 2016. Interactions between climate change and the tourism sector: multiple-criteria decision analysis to assess mitigation and adaptation options in tourism areas. Tourism Manag. 55, 1–12.
Miller, D.W., Starr, M.K., 1969. Executive Decisions and Operations Research. Prentice-Hall, Englewood Cliffs, NJ.
Nannariello, G., Rostirolla, P., 2003. Selezione dei progetti d'investimento: analisi e proposte per la redazione dei bandi di gara. In: Progetto NUVAL, Selezione dei progetti pubblici di investimento: Focus sulle esperienze a confronto, Naples, Italy. https://unora.unior.it/handle/11574/40551#.X7uyNrPSJPY.
Niu, B., Zhang, J., 2013. Price, capacity and concession period decisions of Pareto-efficient BOT contracts with demand uncertainty. Transport. Res. E Logist. Transport. Rev. 53, 1–14.
Önder, E., Yıldırım, B., Ozdemir, M., 2013. Multi-criteria decision-making approach for evaluating tourism destinations in Turkey. Academic Journal of Tourism and Management Researches 1 (1), 1–15.
Park, D.B., Yoon, Y.S., 2011. Developing sustainable rural tourism evaluation indicators. Int. J. Tourism Res. 13 (5), 401–415. https://doi.org/10.1002/jtr.804.
Petrosillo, I., Valente, D., Zaccarelli, N., Zurlini, G., 2009. Managing tourist harbors: are managers aware of the real environmental risks? Mar. Pollut. Bull. 58 (10), 1454–1461.
Qiu, R.T., Park, J., Li, S., Song, H., 2020. Social costs of tourism during the COVID-19 pandemic. Ann. Tourism Res. 84, 102994.
Ranjan, R., Chatterjee, P., Chakraborty, S., 2016. Performance evaluation of Indian states in tourism using an integrated PROMETHEE-GAIA approach. Opsearch 53 (1), 63–84.
Romão, J., 2020. Tourism, smart specialisation, growth, and resilience. Ann. Tourism Res. 84, 102995.
Rostirolla, P., 1998. La fattibilità economico-finanziaria: metodi e applicazioni, vol. 9. Liguori Editore, pp. 1–391.
Roy, B., 1991. The outranking approach and the foundations of ELECTRE methods. Theor. Decis. 31, 49–73.
Saaty, T.L., 1988. What Is the Analytic Hierarchy Process? Mathematical Models for Decision Support. G. Mitra, pp. 109–121.
Sahani, N., 2019. Assessment of ecotourism potentiality in GHNPCA, Himachal Pradesh, India, using remote sensing, GIS and MCDA techniques. Asia-Pacific Journal of Regional Science 3 (2), 623–646.
Shcherbina, O., Shembeleva, E., 2014. Modeling recreational systems using optimization techniques and information technologies. Ann. Oper. Res. 221 (1), 309–329.
Siakwah, P., Musavengane, R., Leonard, L., 2020. Tourism governance and attainment of the sustainable development goals in africa. Tourism Planning & Development 17 (4), 355–383.
Šimková, E., 2007. Strategic approaches to rural tourism and sustainable development of rural areas. Agric. Econ. 53 (6), 263–270.
Soltani, A., Hewage, K., Reza, B., Sadiq, R., 2015. Multiple stakeholders in multi-criteria decision-making in the context of municipal solid waste management: a review. Waste Manag. 35, 318–328.
Stevenson, N., 2007. Researching the experiences and perspectives of tourism policy makers. Developments in tourism research 185–197.
Sun, Y.Y., Lin, P.C., Higham, J., 2020. Managing tourism emissions through optimizing the tourism demand mix: concept and analysis. Tourism Manag. 81, 104161.
Swarbrooke, J., 1999. Sustainable Tourism Management. Cabi.
Tan, Z., Yang, H., Guo, X., 2010. Properties of Pareto-efficient contracts and regulations for road franchising. Transp. Res. Part B Methodol. 44 (4), 415–433.
Tan, W.J., Yang, C.F., Château, P.A., Lee, M.T., Chang, Y.C., 2018. Integrated coastal zone management for sustainable tourism using a decision support system based on system dynamics: a case study of Cijin, Kaohsiung, Taiwan. Ocean Coast Manag. 153, 131–139.
Ulkhaq, M.M., Akshinta, P.Y., Nartadhi, R.L., Nugroho, W.S., 2016. Assessing sustainable rural community tourism using the AHP and TOPSIS approaches under fuzzy environment. In: MATEC Web of Conferences, vol. 68. EDP Sciences, 09003.
United Nations Development Programme (UNDP), 2015. Sustainable Development Goals (SDGs). Nairobi.
United Nations World Tourism Organization (UNWTO), 2011. Tourism towards 2030/ Global Overview - Advance Edition Presented at UNWTO 19th General Assembly - 10 October 2011. UNWTO, Madrid. https://doi.org/10.18111/9789284414024.
Yadav, N., Sahu, N.C., Sahoo, D., Yadav, D.K., 2018. Analysis of barriers to sustainable tourism management in a protected area: a case from India. Benchmark: Int. J. 25 (6), 1956–1976. https://doi.org/10.1108/BIJ-09-2016-0149.
Yu, W., 2015. Multi-objective optimization model building and development on international metropolis tourism industry structure. In: 2015 Seventh International Conference on Measuring Technology and Mechatronics Automation, pp. 670–673. https://doi.org/10.1109/ICMTMA.2015.167.
Zhong, L., Deng, J., Song, Z., Ding, P., 2011. Research on environmental impacts of tourism in China: progress and prospect. J. Environ. Manag. 92 (11), 2972–2983.