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Multicriteria Decision Making in Sustainable Tourism and Low-Carbon Tourism Research: A Systematic Literature Review

Abstract

Multicriteria Decision Making (MCDM) is increasingly being utilized as an analytical research tool for sectors that require decision-making with specific objectives and constraints, such as the tourism industry. Sustainable tourism, which examines the balance of numerous aspects, including stakeholders' interests, is the critical feature propelling the increased usage of MCDM. This paper explores the use of Multicriteria Decision Making (MCDM) methods applied in studies of sustainable tourism and its derivative term, low-carbon tourism, using a systematic literature review (SLR) search from the Scopus database. The analysis has identified 189 relevant studies published between 1987 to April 2022. After selection, screening, and synthesizing processes, we selected 135 pertinent studies, which were analysed in general descriptive data, citation impacts, geographical categorization, categorization of the methodologies' objectives, and possible trajectories of similar research in the future. We find that highly cited authors and articles are related to sustainable tourism indicators' development and case studies. Furthermore, most relevant studies are concentrated in Asia and Europe rather than other regions. We also categorize the reviewed studies into six classifications depending on each method's intended usage and further suggest four contexts for the studies' future trajectory.

Keywords: sustainable tourism, low-carbon tourism, systematic literature review, multicriteria decision making, multicriteria decision analysis

1. Introduction

Tourism is an important industry that has grown significantly during the last 70 years. During this period, the average number of global tourists increased by more than 50 times (Goebel et al., 2020), while over the last decade, the rise of the tourism sector has resulted in 8% of global greenhouse gas emissions, or four times the estimated results (Lenzen et al., 2018). Consequently, the role of sustainable tourism has become increasingly important. Sustainable tourism has undergone conceptual refinement in its implementation from the Brundtland Report by the World Commission on Environment and Development (1987), the Triple Bottom Line concept by Elkington (1994; 1997), the elaboration of its goals by United Nations World Tourism Organization (UNWTO, 2013), and its integration to the Sustainable Development Goals (SDGs) (Shoeb-Ur-Rahman et al., 2020). The number of publications on sustainable tourism topics has also vastly

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increased since 2008 and reached its highest in 2019 (Zhang et al., 2022). This advance is inextricably linked to the increasing recognition of the complexities of issues in sustainable tourism.

Sustainable tourism is connected to socioeconomic well-being, environmental sustainability, and cultural empowerment. The three objectives frequently face a trade-off situation during implementation (Colapinto et al., 2020), and therefore stakeholders must contextualize the optimal balance among the three. Characteristics that fulfil sustainability requirements can be more measured and maintained with the participation of stakeholders in each tourism destination, allowing them to be monitored and evaluated. Some well-known references are those published by UNWTO (2004) and the Global Sustainable Tourism Council (GSTC) in 2013 and 2019. Since indicators are tied to tourist destination management, the development of comprehensive and contextual indicators following the features of tourist destinations is required. This is due to differences in governance priorities in each tourist destination (García-Melón et al., 2010; Partelow & Nelson, 2020; Paunović et al., 2020; Situmorang et al., 2019), comprehension of character and general concepts or beliefs in tourist destinations (Pharino & Pearce, 2020), and long-term adaptive management strategies (Giglio et al., 2020). Indicator systems must also be fundamentally and holistically comparable among destinations for long-term purposes (Coccossis & Koutsopoulou, 2020).

One of the most common methods often utilised in constructing the indicators used in the sustainable tourism framework is Multicriteria Decision Making (MCDM). This technocratic approach or method, which aims at identifying a combination of alternatives to be modified to achieve the best compromise solution – an equilibrium that cannot be changed without reducing the utility of at least one of the stakeholders involved, is considered essential in developing a strategy that is complex and multidisciplinary and involves many interested parties with various expertise and interests (Arbolino et al., 2021b; Geneletti, 2019; Michailidou et al., 2016). At the same time, MCDM is also able to reduce the bias and imbalance that occurs when evaluating sustainability performance (Büyüközkan & Karabulut, 2018; Doukas & Nikas, 2020; Khosravi et al., 2019), which is needed holistically (Kieżel et al., 2019). MCDM can also be instrumental in identifying and determining the most critical and influential criteria and systematic decision-making in a complex sector such as tourism (Yang et al., 2020), including environmental quality improvement such as low-carbon tourism (Yang & Wang, 2020).

Thus far, much research hasn't been conducted to determine the usage of a set of approaches within MCDM in connection with sustainability challenges in the tourism sector. This study attempts to fill that gap. The purpose of this study is to investigate the extent to which MCDM methods are used in the context of sustainable tourism, as well as in the context of low-carbon tourism, with various criteria, attributes, or objectives that respond to the characteristics of each tourist destination and the different interests and priorities of its stakeholders. The plethora of synonyms, as well as methods, within MCDM, particularly in the field of sustainable tourism, has received little attention.

2. Literature review

2.1. Sustainable tourism and low-carbon tourism

Along with the evolution of the word sustainable development, the term sustainable tourism is rapidly becoming a frequently referenced phrase. Since the release of the Brundtland Report, the amount of research and study on sustainable tourism has increased (Niñerola et al., 2019). As a result, the definition of sustainable tourism is continuously being refined and improved. One explanation that is frequently used is from UNWTO (2013), which defined sustainable tourism as a thorough consideration of tourism's current and future economic, social, and environmental repercussions while also serving the aspirations of tourists, industry, the environment, and local communities, which are elaborated further in 12 aims of sustainable tourism.

The evolution of the sustainable tourism concept and its further applicable extensions affects numerous subcategories or concepts (Higgins-Desbiolles, 2008). Aside from these several concepts, one concept that intersects with sustainable tourism vocabulary is that of low-carbon tourism. A report titled Towards a Low Carbon Travel and Tourism Sector published during the World Economic Forum (2009) initially started an international movement aiming to achieve low-carbon tourism and travel industry activities. Low-carbon tourism, from an economic, tourist behaviour, and industrial sector standpoints, has the potential to successfully improve and enhance environmental quality while encouraging environmental protection due to its low resource use, high energy efficiency, and low carbon emission (Cho et al., 2016; Hsiao, 2016).

As a method, it also aims to lessen CO2 and other GHG emissions through policy management, technological innovation, and alterations in individual life activities in the combined efforts of the government, organizations, and individuals to make way for economic growth of low-carbon emissions (Mishra et al., 2022). As policies, sustainable tourism and low-carbon tourism necessitate stakeholders with decision-making capacities to formulate strategies and policy frameworks that resolve the shortcomings of the existing strategy, unsustainable tourism practices, unintended development activities, and overflow entrance of tourists (Chandra & Kumar, 2021), which at the same time must not be separated from the challenges of institutionalizing interests of multiple actors and the diverse nature of interests or conflicting goals in the policymaking process (Arbolino et al., 2021a; Becken, 2019). The technical complexity of sustainable tourism planning and the policymaking process genuinely requires the participation of stakeholders and the community (Arbolino et al., 2021b; Guo et al., 2019; Rahmafitria et al., 2020; Shasha et al., 2020) because the process not only produces legislation products as output, but also the implementation involves aspects of politics, culture, economy, society, psychology, values, and beliefs, as the outcome.

Equal communication, coordination, and relationships among stakeholders are a necessity in the development of sustainable tourism policies (Guo et al., 2019; Iazzi et al., 2020; Wanner et al., 2020); however, the use of mutually verifiable approaches, including most 'objective' methods that are measurable but less recommended in the context of social goals, and 'subjective' perceptions, in particular those based on attitudes, experiences, perceptions, and levels of stakeholder satisfaction, which are highly contextual for all tourism stakeholders in the area, is the optimal solution in planning sustainable tourism (Butowski, 2021; Rasoolimanesh et al., 2020; Rodríguez-Rodríguez & Hernández-Martín, 2020). The approach or method that meets these characteristics and criteria is MCDM.

2.2. Multicriteria decision making (MCDM)

As a multi-faceted methodology for compiling the factors involved and made available to improve the internal decision-making process, MCDM allows criteria to be considerably different and provides a framework to incorporate stakeholders' values transparently by helping to set priorities and allocate resources (Geneletti, 2019; Kurth et al., 2017). However, it is reasonably common for circumstances in the real world to generate uncertainty and distortion of information, which impedes selecting optimal solutions, leading MCDM to be extended in its development to provide a fuzzy environment (Mishra et al., 2022). Nevertheless, MCDM has certain frequently discovered flaws that may be addressed and expected. As Adem Esmail and Geneletti (2018) highlighted, the following faults should be expected when using MCDA: 1) improper setup; 2) a collection of options that are not representative; 3) an excessive and imbalanced number of criteria for diverse objectives; and 4) inadequate stakeholder participation. On the other hand, Soltani et al. (2015) and Arbolino et al. (2018, 2021b) emphasized three primary categories of fundamental shortcomings of MCDM: 1) oversimplification, particularly risks of excluding some relevant information and targets; 2) subjectivity, due to the decision-makers ex-ante assertion of weights requirements; and 3) feasibility bias, because some of these techniques are based on ranking, not based on best possible choices, which implicitly assumes their technical feasibility.

Throughout the decades, MCDM has undergone a lot of diversification, elaboration, and enrichment in its subsequent evolution, which results in multiple terms. At least nine terms were relevant to and substitutable for MCDM to use, including the most commonly used Multicriteria Decision Analysis (MCDA) (Belton & Stewart, 2002), which was first documented in Stewart (1984). The concepts or terms that have been used include, for instance, Multicriteria Analysis (MCA) (Beinat & Nijkamp, 1998; Nijkamp & Vos, 1977), Multicriteria Evaluation (MCE) (Voogd, 1982), Multicriteria Group Decision Making (MCGDM) (Hagmann & Unger, 1990), Multiple Attribute Group Decision Making (MAGDM) (J. K. Kim et al., 1998), Multicriteria Approval (MA), and Multicriteria Acceptability Analysis (MAA) (Kangas & Kangas, 2003). Further, Hwang and Yoon (1981) have classified MCDM into two groups based on their objectives and data formats: Multiple Attribute Decision Making (MADM) and Multiple Objective Decision Making (MODM).

The MCDM approaches are frequently classified based on their characteristics. Tecle (1988) was among the first classifiers, identifying 72 MCDM techniques and organizing them into four groups based on their features, which include: (1) outranking types of technique; (2) distance-based types of technique; (3) value or utility types of technique; and (4) mixed types of technique. Belton and Stewart (2002) classify MCDM into three groups: (1) value measurement models; (2) goal, aspiration, or reference level models; and (3) outranking models. Similarly, Arbolino et al. (2018), classified them into two categories: (1) ranking alternatives techniques; and (2) alternative elimination techniques. Spangenberg (2001), on the other hand, distinguishes MCDM (or, in this case, MCA) by vertical and horizontal approaches. As per Tecle (1988), other studies (Alinezhad & Khalili, 2019; Kizielewicz et al., 2020; Wątróbski et al., 2019; Wątróbski & Jankowski, 2016) also revealed that about 80 different types of MCDM approaches exist, and highlighted at least 17 MCDMs (Estêvão et al., 2019; Kandakoglu et al., 2019; Kurth et al., 2017) that are often applied in research connected to sustainable tourism.

In sustainable tourism, MCDM has several applications ranging from broad-scale planning to event management, organization, and technical levels. MCDM can be used to improve service innovation in the hospitality industry sector of tourism development (Kitsios & Grigoroudis, 2020), determine ticket prices and locations of music festival events in tourism destinations (Lin & Chang, 2020), design tour packaging strategies for tourists (Lin & Kuo, 2019), and ideal hotel locations (Popovic et al., 2019) due to its capability of accommodating dynamic criteria for optimization (Yap et al., 2019). MCDM has also been frequently employed to generate composite indicators, an increasingly essential means of assessing the sustainable performance of nations, regions, or organizations since 2014 (El Gibari et al., 2019).

3. Method

3.1. Systematic literature review (SLR)

Systematic literature review (SLR) is locating and evaluating documents relevant to a given subject of study (Petticrew & Roberts, 2006). According to Torgerson (2003), it has nine aims: (i) to answer relevant questions; (ii) to seek, retrieve, and systematically organize results of the research; (iii) to reduce publication, selection, and other forms of bias; (iv) to evaluate research quality in the line of research questions; (v) to synthesize the results of the review explicitly; (vi) to increase the accessibility of knowledge database; (vii) to identify gaps and update existing knowledge; (viii) to recommend future research trajectory; and (ix) to publish all phases of the review in the final report to allow critical evaluation and replication.

In this study, we conducted a literature search discussing sustainable and low-carbon tourism using MCDM in the Scopus database. We searched it using keywords based on Boolean logic as the initial part of the selection process. We identified 189 studies published between 1987 and April 2022 mentioning the abovementioned themes or topics. For the screening and selection process, we used all combinations of the search terms as below:

4. Results and discussion

4.1. General findings

This section examines the search findings in general about the selection and synthesis process. The search found 189 documents and, after screening, identified three main classifications: 155 journal articles (82%), eight book chapters (4%), and 26 conference proceedings (14%). We limited them to journal articles and book chapters only.

Figure 1
Articles classification

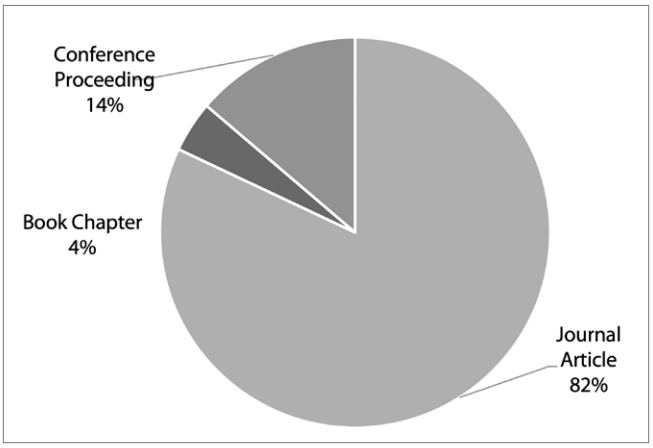
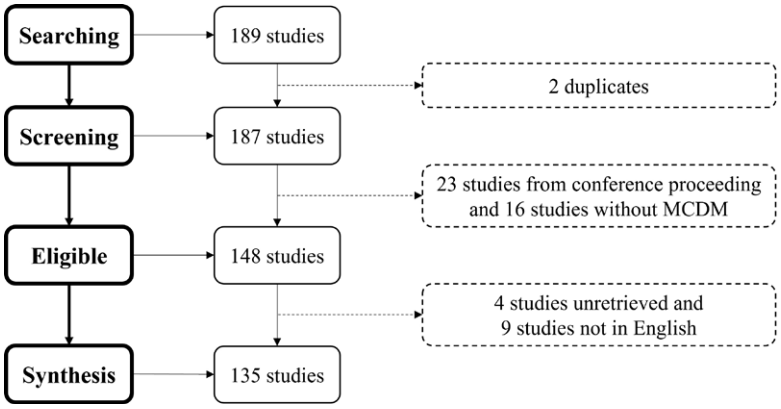


Figure 2
Screening process



We reclassified the 189 articles by omitting unretrieved documents (4), duplicates (2), documents in a language other than English (9), and documents not using MCDM as part of the analysis tools (17). However, we still addressed one of them, Colapinto et al. (2020), because it employs SLR. According to synthesis findings, the SLR analysis was conducted on 135 articles from journals (130) and book sections (5). We will also highlight some proceedings and non-English language articles that employ MCDM as an analytical tool.

4.2. Citations and authors

This section discusses articles organized based on citation numbers and authors' productivity from accumulated citations in research on related topics. We limit it to the ten articles with the most citations, as indicated in Table 1 below. Lozano-Oyola et al. (2012) received the most citations in this category, with 158 citations, followed

by Lee and Hsieh (2016), which received 109 citations, and Blancas et al. (2010), which received 90 citations.

Lozano-Oyola et al. (2012) are highly referenced since they are one of the works that examine the application of MCDM to sustainable tourism indicators' development from conception to implementation using a case study in Andalusia, Spain. This idea phase comprises factors that form the basis of the evaluation and are organized into social, economic, and environmental dimensions, indicators, and calculation formulae. This is similar to why Lee and Hsieh (2016) are also extensively mentioned, with four levels of sustainability indicator formulation in wetlands areas using 20 dimensions and 141 indicators. The formulation of sustainability indicators is also a significant factor that makes Blancas et al. (2010) widely used as a reference with the goal programming method, so the 88 selected indicators are based on secondary data – without involving stakeholder participation.

Meanwhile, the authors with the highest citations are occupied three authors who are mutually affiliated with each other and have the same number of publications, i.e., five articles; Caballero, R. had the most citations at 351 citations, followed by Blancas, F.J. and Lozano-Oyola, M. with a total of 330 citations. The articles written by these three are also dominated mainly by themes related to developing sustainable tourism indicators and case studies as their implementation.

Table 1
Most cited documents

No.	Title	Author(s)	Year	Journal	Publishers	Cit.
1	Sustainable tourism indicators as planning tools in cultural destinations	Lozano-Oyola, M., Blancas, F.J., González, M., & Caballero R.	2012	Ecological Indicators	Elsevier	158
2	Indicators of sustainable tourism: A case study from Taiwan's Wetland	Lee, T.H. & Hsieh, H.-P.	2016	Ecological Indicators	Elsevier	109
3	Goal programming synthetic indicators: An application for sustainable tourism in Andalusian coastal counties	Blancas, F.J., Caballero, R., González, M., Lozano-Oyola, M., & Pérez, F.	2010	Ecological Economics	Elsevier	90
4	The effects of UNESCO World Heritage List inscription on tourism destinations performance in Italian regions	Cuccia, T., Guccio, C., & Rizzo, I.	2016	Economic Modelling	Elsevier	90
5	Interactions between climate change and the tourism sector: Multiple-criteria decision analysis to assess mitigation and adaptation options in tourism areas	Michailidou, A.V., Vlachokostas C., Moussiopoulos N.	2016	Tourism Management	Elsevier	85
6	A combined ANP-Delphi approach to evaluate sustainable tourism	García-Melón M., Gómez-Navarro T., Acuña-Dutra S.	2012	Environmental Impact Assessment Review	Elsevier	79
7	Evaluating regional low-carbon tourism strategies using the fuzzy Delphi- analytic network process approach	Zhang J.	2017	Journal of Cleaner Production	Elsevier	71
8	An operational method to supporting siting decisions for sustainable rural second home planning in ecotourism sites	Jeong J.S., García-Moruno L., Hernández-Blanco J., Jaraíz-Cabanillas F.J.	2014	Land Use Policy	Elsevier	63
9	Preference learning for eco-friendly hotels recommendation: A multicriteria collaborative filtering approach.	Nilashi, M., Ahani, A., Esfahani, M. D., Yadegaridehkordi, E., Samad, S., Ibrahim, O., Sharef, N. M., and Akbari, E.	2019	Journal of Cleaner Production	Elsevier	58
10	The evaluation of sustainable tourism development by Analytic Hierarchy Process and fuzzy set theory: An empirical study on the Green Island in Taiwan	Tsaur S.-H., Wang C.-H.	2007	Asia Pacific Journal of Tourism Research	Taylor & Francis	54

Table 2
Most productive authors

No.	Author	Number of publications	Total citations	Affiliations
1	Caballero, R.	5	351	Universidad de Málaga, Malaga, Spain
2	Blancas, F.J.	5	330	Universidad Pablo de Olavide, de Sevilla, Sevilla, Spain
3	Lozano-Oyola, M.	5	330	Universidad Pablo de Olavide, de Sevilla, Sevilla, Spain
4	Aminu, M.	5	57	National Space Research and Development Agency, Abuja, Nigeria
5	Matori, A.N.	5	57	Universiti Teknologi PETRONAS, Seri Iskandar, Malaysia

4.3. Geographical aspect

Practically all research on sustainable and low-carbon tourism that use MCDM is concentrated in Asia (53%) and Europe (36%), with the remainder conducted in other regions worldwide. A total of 71 studies were undertaken in Asia, the bulk of which were conducted on a regional and national scale in China (23), with study locations in Tibet and several in Taiwan designated as part of China – although we still separate them. Although numerous European studies were restricted to one nation area, at least four papers made several country areas (4, 23, 29, and 32 countries) the locus of research. Six studies are classified as being on a global or worldwide scale not just because they do not involve specific locations as loci but also because they focus on universally recognized areas of discourse and coverage.

Figure 3
Region classification

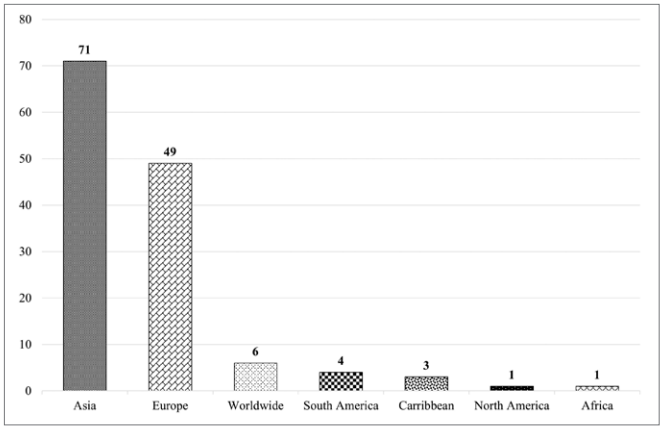


Table 3
Countries with the most publications

No.	Asia		Europe		South America	Caribbean	North America	Africa
1	China	23	Italy	14	Venezuela (2)	Cuba	Mexico	Mauritius
2	Taiwan	12	Spain	12	Ecuador	Haiti		
3	India	10	Turkey	6		Multiple		
4	Iran	6	Multiple	4				
5	Malaysia	6	Greece	3				
6	Indonesia	4	Bosnia and Herzegovina	3				
7	South Korea	3	Czech Republic	2				
8	Azerbaijan	2	Croatia	1				
9	Tibet	2	Macedonia	1				
10	Japan	1	Hungary	1				
11	Thailand	1	Poland	1				
12	Vietnam	1	Romania	1				

4.4. Types of methods used

Most of the 135 publications we analysed used more than one method, while some combined several methods, and some developed their approach, combining other methods. Based on the implementation of the MCDM method, as many as 79 articles (59%) featured several or a mixture of methods, at least one of which was part of the MCDM. The remaining 56 (41%) articles performed just one MCDM method per article. Moreover, based on how frequently a technique is used in the series of papers examined using SLR, we describe the ten most used methods – MCDM and non-MCDM.

Figure 5 shows that AHP is the most often used method, followed by Data Envelopment Analysis (DEA), the fuzzy approach, and others. A'WOT, which combines AHP and SWOT, is one of the methods frequently used in the papers we analysed. Due to its simplicity and practicality, AHP can easily be found as a standalone method, for instance, in Suryawardani and Wiranatha (2016) and Jiang et al. (2019), while at the same time, it is also accessible for combination with other methods, including non-MCDM, such as Delphi (Tsaur & Wang, 2007; Wang et al., 2019, 2020; Wu et al., 2022) and SWOT (Mandal & Chakrabarty, 2021; Sasana et al., 2019). Furthermore, a spatial approach is frequently integrated with MCDM, such as Spatial Decision Support Systems (SDSS) or Multicriteria Spatial Decision Support Systems (MC-SDSS), combining MCDM with GIS.

Figure 4
Classification by methods

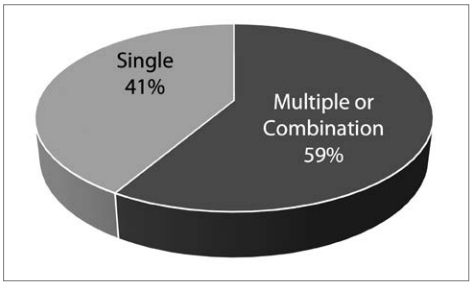
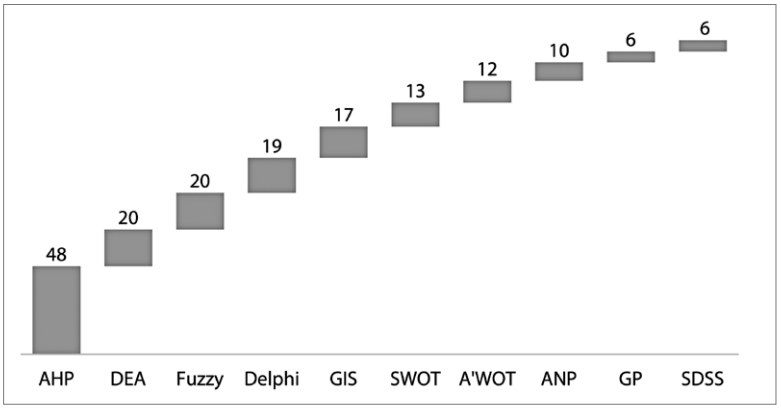


Figure 5
Most used methods



The findings also revealed several research articles that used the MCDM method but are not shown in the Figure. We categorized them into at least three categories: papers that (i) employ methods which are well-established but rarely used in the sustainable tourism themes; (ii) develop pre-existing methods; and (iii) apply a relatively novel method. More than 20 methods were discovered in the first and second categories, with more than a dozen in the third.

The first category includes PAPRIKA (Romão et al., 2017), Pareto-based approach (Ko & Song, 2019; Wen et al., 2019), Multi-Attribute Value Theory (Laniado et al., 2004), EVAMIX (García-Melón et al., 2012), Grey Relational Analysis (Shao et al., 2013; Škrinjarić, 2021), VIKOR (Yang et al., 2020), PROMETHEE (Bottero et al., 2019; Oppio & Bottero, 2018), ELECTRE (Işik & Demir, 2017; Michailidou et al., 2016), TOPSIS (Martín et al., 2020), DEMATEL (Selcuk et al., 2021; Wu et al., 2019), DEX (Prevolšek et al., 2020), and Taxonomy Method (Wei et al., 2020). Some articles include multiple methods or draw comparisons with other MCDM methods, such as between FUCOM, ARAS, and CRITIC (Puška et al., 2019), FUCOM, and MARCOS, which were in comparisons with SAW, WASPAS MABAC, ARAS and TOPSIS (Mijajlović et al., 2020), as well as the best worst method (BWM) with ORESTE (Tian et al., 2022).

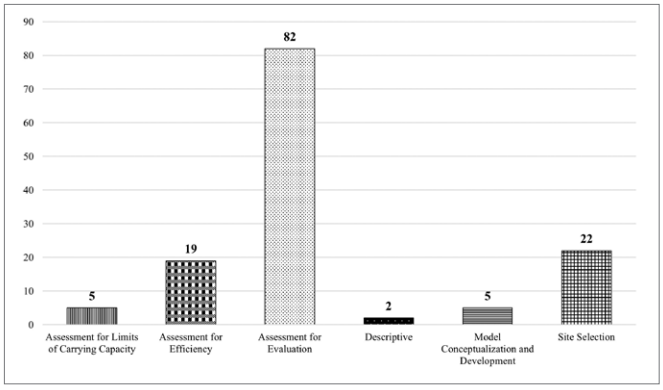
The authors further improved several pre-existing methods, including those from the first category. AHP integrated with the fuzzy approach as Fuzzy-AHP (FAHP) was found in several studies, such as Wang et al. (2016). Some are based on Goal Programming (GP) (Zhang & Zhang, 2019), such as the comparative approach in Weighted GP and absolute approach in Lexicographic GP (Zografos & Oglethorpe, 2004), Vectorial Dynamic Composite Indicator (VDCI) (Blancas et al., 2016), Differential Dynamic Index (DDI) (Blancas et al., 2018), and Goal Programming Synthetic Indicator (GPSI) which is commonly used for the development of indicators for sustainable tourism destinations (Blancas et al., 2010; Pérez et al., 2017). Furthermore, several articles also apply methods from the first category, such as VIKOR, which combines the Bayes approximation method, triangular intuitionistic fuzzy numbers (TIFNs), and improved best and worst method (IBWM) (Liu et al., 2019). A Bayesian-based BWM was also applied (Yang et al., 2020; Yang et al., 2020). Other commonly used methods from the last category include Z-number-based fuzzy TOPSIS and PROMETHEE (Nuriyev, 2022), unweighted TOPSIS (Benítez & Liern, 2021; Vicens-Colom et al., 2021), 2-Tuple DEMATEL (Ren, 2020), Fuzzy DEMATEL combined with Interpretive Structural Modelling (ISM) (Tseng et al., 2018) and Cooperative Game Theory (Bai & Chen, 2021). Several more methods incorporate the use of single-valued neutrosophic sets (SVNSs), as applied to MULTIMOORA and MEREC, which were then compared with SVN-TOPSIS, SVN-COPRAS, SVN-WASPAS, and Zhang method (Mishra et al., 2022), including those using fuzzy set-based including Interval-Valued Pythagorean Fuzzy Sets (IVPFSs) SWARA, MULTIMOORA and TOPSIS (He et al., 2021), as well as interval-valued Fermatean fuzzy numbers (IVFFNs) COPRAS and CRITIC (Rani et al., 2022).

In the third category, however, some are entirely developed for the original purpose. In contrast, others are created by merging numerous ways to make a relatively novel method. This third category includes the following methods: Principal Components Analysis (PCA) (Işik & Demir, 2017; Michalena et al., 2009); Linguistic multi-attribute group decision making (MAGDM) (Lin & Wang, 2017); Dive Site Risk Assessment Model (DSRAM), which combines AHP, Fuzzy set, and Evidential Reasoning (FER) (Anuar et al., 2020); Intuitionistic fuzzy preference relations (IFPRs) (Yang & Wang, 2020); Intuitionistic multiplicative UTASTAR method (IM-UTASTAR) (Zhang et al., 2020); and a thermodynamic feature-based method, the q-rung ortho-pair fuzzy set (q-ROFS) (Zhang et al., 2022). We also highlight the use of some relatively new method combinations from two different articles by the same primary author, which covers Adaptive Neuro-Fuzzy Inference Systems (ANFIS), Higher-Order Singular Value Decomposition (HOSVD), Self-Organizing Map (SOM), and Classification and Regression Tree Analysis (CART) (Nilashi et al., 2019) as well as ANFIS with Support Vector Machine (SVM) and Naïve Bayes, Support Vector Regression (SVR), Neural Network (NN), and Entropy weight method (EWM) (Nilashi et al., 2021); a Pareto-based method – the multi-objective orienteering problem with Time Windows, Restaurant Selection, and Compulsory POIs (MOPTW-RSCP) (Choachaicharoenkul et al., 2022) – and an unnamed method using compensatory and non-compensatory types of aggregation procedures with the Condorcet- and the Borda-type approach used to obtain a composite indicator value (Blancas & Lozano-Oyola, 2022); and lastly, a developed and generalized sustainable evaluation criteria system based on the effect of favourability (Pomucz & Csete, 2015).

4.5. Topic classifications

In this section, we classified the types of articles reviewed based on how the MCDM methods are used and for what purposes in the relevant articles. We made six categories based on the 135 articles we reviewed: (1) Assessment for Limits of Carrying Capacity; (2) Assessment for Efficiency; (3) Assessment for Evaluation; (4) Descriptive; (5) Model Conceptualization and Development; and (6) Site Selection. Articles aimed at conducting evaluation-related assessments dominated, as shown in Figure 6. We will now explain further the criteria for each of these categories.

Figure 6
Topics classifications



In the first category, four articles (3%) aim to determine the carrying capacity limits that meet sustainability standards in sustainable tourism. Parolo et al. (2009) employed human impact minimization for evaluating tourism thresholds in wilderness recreation areas using a combination of Stochastic Genetic Algorithms (GA) and GIS and measuring 18 quantitative criteria from ecological, logistical, and safety points of view. Malik and Bhat (2015) divided Kashmir Valley tourism into three potential areas using four sub-indicators and calculated the Tourism Carrying Capacity (TCC) using six correction factors. Pavón and Piña (2018) researched TCC and two other measurements, Limits of Acceptable Change (LAC) and Recreation Opportunity Spectrum (ROS), in a Mexican national park using a combination of AHP, SWOT, and GIS. AHP and SWOT were also applied by Ayuni and Priyana (2019) to conduct an assessment in the national park, measuring the environmental and resource-carrying capacity at Mount Rinjani, Indonesia. Meanwhile, in contrast to the previous four articles, Gallardo et al. (2019) assessed tourist-housing reception capacity for sustainable landscape use in urban areas in Spain.

The second category includes 19 articles (14%) which discuss MCDM methods used for measuring efficiency (or eco-efficiency). This category is dominated by the DEA method, which was used in 16 articles, such as Cuccia et al. (2016), Solana Ibáñez et al. (2017), Chen et al. (2018), Chiu (2018), Kuncová et al. (2018), Škrinjarić, (2018), Kim & Chung (2020), Radovanov et al. (2020), Zha, Tan, et al. (2020), Zha, Zhu, et al. (2020), Castilho et al. (2021), Caponi (2022), and Ghosh and Batabyal (2022), among others. The three non-DEA papers compared the Multi-objective Optimization model with weighted sum and AHP (Arbolino et al., 2021a), Cooperative Game Theory (Bai & Chen, 2021), and Grey Relational Analysis (Škrinjarić, 2021). More than half of the articles in this category (11) measured efficiency in the general context of sustainable tourism rather than a specific characteristic. In contrast, others focussed on nature, culture, or region-based (urban/rural) tourism. This category is also more flexible regarding intertemporal and longitudinal analysis, making the discussions more universally replicable.

We summarise the categories that are essentially the authors' primary alternative in using MCDM for their articles: to determine criteria and/or indicators to conduct assessments and evaluate tourism destinations and/

or attractions following the sustainable tourism framework. This category contains 82 articles (61%). In this category, criteria or indicators were determined deductively, i.e., using previous research as references, as well as inductively, involving the participation of various stakeholders or a combination of both. This category also has the most variations in the use of the MCDM method, particularly AHP (Yuan et al., 2015; Nesticò & Maselli, 2020), combining methods and incorporating some of them into hybrid and even new techniques.

Furthermore, two articles (2%) are descriptive without further analysis, including SLR (Colapinto et al., 2020) and Dark Tourism in Haiti (Séraphin, 2017), while in the fifth category, five articles (4%) are aimed at developing and/or conceptualizing models. Laniado et al. (2004) and Shcherbina and Shembeleva (2010) acquired Spatial Decision Support Systems (SDSS) and Multicriteria Spatial Decision Support Systems (MC-SDSS) as spatially-integrated and interactive computer-based systems, intending to achieve tourism sustainability standards. The GPSI method, a goal-programming-based synthetic measure to define the relative importance of each indicator and the aspiration levels, which evaluates the sustainability of each destination by measuring the level of fulfilment of the goals established, was also developed (Blancas et al., 2010; Lozano-Oyola et al., 2012).

Lastly, 22 articles (16%) are related to choosing the optimum location or site based on specified criteria. This category also has a variety of method options and relatively varied objectives. Half of the articles in this category use a GIS spatial approach to determine location, frequently combined with other MCDM methods. Such combinations include, for instance, AHP (Acharya et al., 2022; Adamczyk & Wałdykowski, 2022; Chaudhary et al., 2022; Jeong & Ramírez-Gómez, 2017; Rezvani et al., 2022), which also underpins the SDSS above (Beedasy & Whyatt, 1999), followed by ANP (Aminu, Matori, et al., 2013; Aminu et al., 2014) and ANP-based SDSS (Aminu et al., 2017; Della Spina & Giorno, 2021), PROMETHEE (Oppio & Bottero, 2018), EVAMIX (Crecente et al., 2012), and Information value method (IVI) (Dey et al., 2018). On the other hand, the other ten articles partially used methods without combining them with a spatial approach.

4.6. Future trajectories

This section discusses the expected trajectory of similar future studies focused on the excerpts we obtained from the reviewed articles. At the very least, we were able to condense four contexts that we believe will be the future of the topics under discussion. To begin with, we highlight the future need for a web-based Decision Support System that makes it easier to monitor and evaluate tourism destinations using a spatial and real-time approach. Second, the importance of stakeholders' roles in participating and collaborating ensures that decision-making in a series of sustainable tourism management processes within the industry and public policy frameworks is carried out holistically and sustainably. Third, we believe that a set of methods in MCDM can be used in a replicative manner for case study-based research that potentially can be developed with other techniques, integrative into a hybrid, a combination of several methods, including those outside of MCDM, as well as wholly new ways. Finally, we acknowledge that the geographical scale provides a perspective on the depth of MCDM-based sustainable tourism research analysis. The four trajectory directions are then discussed in detail.

4.6.1. Real-time and spatial-based monitoring and evaluation system

The development of a web-based decision system to support the supervision and evaluation of tourism destinations in meeting sustainability standards has been discussed for quite some time. Such a system is thought to provide long-term benefits through various advantages (Lee et al., 2021; Lee & Hsieh, 2016), from planning to evaluation (De Montis & Nijkamp, 2006). The system would be capable of recapitulating and disseminating information (De Montis et al., 2007), as well as encouraging online-based sales and marketing (Andreopoulou et al., 2014; Shcherbina & Shembeleva, 2010) by optimizing tourist paths (Parolo et al., 2009), tourist plans (Blancas et al., 2018), or tourist circuits as well as identifying infrastructure gaps (Ganguly

et al., 2020). The system would also be able to depict multiple scenarios intended to measure the degrees of risk (Rezvani et al., 2022) to encourage the development of industrial networks and clusters (Andreopoulou et al., 2014). This system could also become a biodiversity database centre regarding environmental sustainability (Aminu, Ludin et al., 2013).

4.6.2. Stakeholders' participatory collaboration

Stakeholder participation and collaboration are critical features of the complexities of sustainable tourism. Those representing various interests and points of view at the planning level assure compliance in preparing composite or synthetic indicators as discourse becomes more robust with coverage of an array of dimensions and weighting indexes. As a result, diverse groups are required to achieve group decision-making for assessing differences in opinion (Hsu et al., 2017; Kim et al., 2022; Liu et al., 2019; Mishra, Saha et al., 2022; Romão et al., 2017). The representation of groups with broader coverage (Liu & Suk, 2021a, 2021b) can be divided according to several types (S. Lee et al., 2021).

Several studies emphasize the importance of involving various groups, such as environmental groups (Hsiao, 2016), cross-countries/regions tourism industry experts (Chen et al., 2017; Vatansever et al., 2021), tourists (Pérez et al., 2017) including consideration of their various backgrounds, including purpose, motivations, and preferences (Romão et al., 2017), to stakeholders involved in technical implementation, such as hoteliers and restaurateurs (Martín et al., 2020). One of the concerns is the lower or operational level, particularly the lower levels of cooperation between stakeholders related to sustainability and environmental issues (Škrinjarić, 2021). The satisfaction of local communities as stakeholders (Crecente et al., 2012) is no less important and must be analysed continuously with a longitudinal approach (Selcuk et al., 2021).

In the future, determining criteria and indicators as tangible outcomes of stakeholder participation and collaboration must consider several factors. It is critical to define a large number of measures (Mijajlović et al., 2020; Zhang & Zhang, 2020) with more diverse and representative evaluation indicators (Liu & Suk, 2021a, 2021b) to generate a more robust evaluation framework as the selection of such criteria will to some extent eliminate a particular subjectivity (Zhou et al., 2021). It is also essential to take into account synergy and redundancy (Bottero et al., 2019) as well as interdependence among the criteria (Wei et al., 2020) and to use sensitivity analysis to ensure the robustness of indicator selection (Zhang et al., 2020) using what-if-scenarios (Michailidou et al., 2016).

4.6.3. Integration of methodologies

Several articles we reviewed demonstrated integration and combination of MCDM methods, such as AHP and SWOT or A'WOT (Kişi, 2019; Moayedfar & Fatemi, 2021; Monavari et al., 2013; Tjaija et al., 2022); fuzzy-based approach with several other methods, and a combination of several MCDM methods with non-MCDM methods. Most studies are expected to result in the development of new techniques (He et al., 2021) that include a combination of quantitative and qualitative approaches (Latinopoulos & Vagiona, 2013) both in adaptations and in replication case studies of tourist destinations' contexts (Jeong et al., 2014). Several articles have mentioned a combination of methods used to plan tour packages with carbon footprint information (Cho et al., 2016), determine safe diving locations (Anuar et al., 2020), and identify environmental governance solutions as well as low-carbon supplier selection (Yang & Wang, 2020).

Over the coming years, methods will be combined and integrated, particularly those related to planning and evaluation, which necessitate the inclusion of criteria and indicators. As stated in the second point above, the trajectory will lead to a more holistic scale, where criteria and indicators on a large scale will be essential requirements. Other supportive requirements, for illustration, also include the scope of long-term criteria and indicators, such as technological advances and climate change (Zhang, 2016), addressing natural disasters (Jokar et al., 2021), cultural aspects and their transitions (Chen et al., 2017), gender aspects (Işik

& Demir, 2017), the transition towards renewable energies (Michalena et al., 2009), and issues concerning transitions in developing countries, such as local community quality of life (or poverty) and costs (or debt) for the conservation and management of tourist destinations (Hosseini et al., 2021). Another focus that will be a concern in the future is cross-sectoral interdependence (Zagonari, 2019), outside of considerations of spatial-based approaches and environmental and cultural aspects.

Furthermore, incorporating methodologies related to linguistic or semantic factors will be increasingly utilized. In the future, the use of fuzzy logic on semantic expressions (Liu & Hsu, 2015), mainly from expert circles or groups (Hsu et al., 2017) to reduce the degree of uncertainty (Cristache et al., 2022), as well as ambiguity (J. Zhang, 2017), will increase (Puška et al., 2019; Wei et al., 2020). The fuzzy approach can also be optimized through the use of neural networks (Andria et al., 2020) and machine learning, particularly for significant data-based decision-making in online travel platforms (Nilashi et al., 2019) which can combine deep knowledge with clustering techniques (Nilashi et al., 2021).

4.6.4. Geographical concerns

Finally, due to the scale of the discussion on sustainable tourism, we present a discussion of geographical constraints, which, while replicative, tends to have its sensitivity and bias. Going forward, we anticipate a series of comparisons across many other regions (Cracolici et al., 2008) and the current state of tourist offers in the different areas (Prevolšek et al., 2020) will be investigated more frequently, which, particularly when the same input/output combination is used (Önder et al., 2017), can monitor how the performance of the same cities changes over time.

The lack of discussion on continents other than Asia and Europe is also an issue that needs to be addressed, particularly the lack of research on small islands that are vulnerable to sea-level rise caused by climate change. We believe that focusing on creating alternative tourism destinations (Parte & Alberca, 2021) through micro-level evaluation (Chaudhary et al., 2022) for regional tourist destinations is critical. Furthermore, external shock factors in the economy, particularly the exchange rate vulnerability and geopolitical stability, which affect the dynamics and complexity of tourist destination promotion and marketing (Bampatsou et al., 2022), must also be considered.

5. Conclusions

This study aims to conduct surveys on using MCDM methods within sustainable and low-carbon tourism contexts. The search is carried out by combining search phrases using Boolean logic and incorporating over 80 techniques in MCDM. We have collected 135 relevant research studies from 1999 to April 2022 and assessed them using the SLR. The analysis is based on five contextual considerations, which include the selection process and general description of the articles, publications, and authors with the most significant impact, geographical aspects, frequency and types of methodologies, classification of discussion topics, and future research directions.

We discovered that relevant articles were limited and concentrated in Asia and Europe, with little debate of the same type in other regions. Concerning authors and publications, the substantial body of research frequently cited by other studies covers assessment for evaluation, particularly those that examine the formulation of case studies of synthetic or composite indicators of sustainable tourism and its variants. We further confirm prior studies' conclusions from Dos Santos et al. (2019), Yap et al. (2019), Colapinto et al. (2020), Nadkarni & Puthuvayi (2020), Gebre et al. (2021), and Sousa et al. (2021), that AHP is still the most commonly used approach, while the findings also revealed variances in the usage of other methods, as well as the development of novel combination methods that have the potential to be employed in future comparable studies.

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