Establishing a Sustainable Sports Tourism Evaluation Framework with a Hybrid Multi-Criteria Decision-Making Model to Explore Potential Sports Tourism Attractions in Taiwan

Abstract:

In recent years, the awareness of sustainable tourism has gradually risen around the world. Many tourism industries combine sports events to attract more customers to facilitate the development of local economy and the promotion of local culture. However, it is an important task to establish a comprehensive and complete tourism evaluation framework for sustainable sports. This study proposes a Multi-Criteria Decision-Making (MCDM) model to discuss the above issues, using the Bayesian Best Worst Method (Bayesian BWM) to integrate multiple expert opinions to generate the group optimal criterion weights. This method overcomes some limitations of original BWM. Next, the modified Visekriterijumska Optimizacija i Kompromisno Resenje (VIKOR) technology combined with the concept of aspiration level to determine the performance of sports attractions and their priority ranks. In addition, this study adds a perspective of institutional sustainability to emphasize the importance of government support and local marketing. The effectiveness and robustness of the proposed model is demonstrated through the potential sports tourist attractions in Taiwan. Comparisons of sensitivity analysis with other MCDM methods were also performed in this study. The results show that the proposed evaluation framework is feasible in practical applications and effectively provides some management implications to support decision makers in formulating improvement strategies.

Keywords: Sustainable sports tourism, MCDM, Bayesian BWM, modified VIKOR

1. Introduction

Since the 20th century, the development of transportation and communication technology has promoted the development of tourism globalization. Although the vigorous development of tourism has brought many economic benefits and cultural exchanges, it has also negatively affected the environment, society, and traditional culture. Many adverse effects have led environmental groups and organizations in various countries to pay more and more attention to the protection and preservation of natural resources and cultural assets (López-Bonilla and López-Bonilla, 2012; Lee and Jan, 2019). In recent years, the governments of various countries have realized that mass tourism will bring environmental pollution, garbage accumulation, and disruption of social order. Therefore, the concept of sustainable development has been introduced into the tourism industry in order to seek more environmentally friendly tourism planning, management and development (López-Bonilla and López-Bonilla, 2016; Choi and Sirakaya, 2006; Hall, 2011; Gkoumas, 2019; Hsu et al., 2020; Musavengane et al., 2020). The concept of sustainable development is "the process by which people maintain environmental balance and harmony in resource development, investment direction, technological development, and institutional change while meeting human needs and future development, and the benefits they bring are in line with social expectations." (Pope et al., 2004). Many studies have divided sustainability into three main aspects: economic, social, and environmental aspects. The three aspects complement each other to construct a complete sustainability framework. The World Tourism Organization (UNWTO) and the United Nations Environment Program (UNEP) advocate that sustainable tourism must promote social and cultural prosperity, environmental protection responsibilities, and economic development (Hall, 2011).

However, there are many studies suggesting different sustainable tourism evaluation frameworks. For example, Gkoumas (2019) proposed a comprehensive evaluation index for sustainable tourism for the Mediterranean tourism. The study shows that culture, politics, and economy are the main factors affecting the region's sustainable development. It is emphasized that the tourism industry must establish a complete sustainability certification process, strengthen local governance and improve operating technology in order to provide passengers with better services. Nunkoo et al. (2012) pointed out that the support of government departments and nonprofit organizations can further promote sustainable tourism. In addition, the establishment of public trust and local governance are the successful factors for the development of environmental protection policies. Hsu et al. (2020) proposed an intercultural sustainable tourism attitude assessment scale to explore tourism quality of the island environment. The study shows that people living on islands often want to develop fisheries into tourism, but that will also cause environmental damage and decline in food productivity. The authors believe that maintaining the stability of the ecosystem and the support of residents can develop tourism in the long run. Musavengane et al. (2020) considered the risks of tourism areas in African countries, and their inclusion, safety, resilience, and environmental protection are listed as important tourism assessment items. It shows from the review of the above literatures that the current sustainable tourism assessments not only consider economic, social and environmental aspects, but government regulations and relevant local management policies, which are also on the list of the necessary elements (Asmelash and Kumar, 2019). These studies have contributed to the issues related to sustainable tourism.

In recent years, sports tourism has gradually risen in various countries, and major cities and local small towns have established specialized sports tourism agencies (Pouder et al., 2018). In response to the Taiwanese government's promotion of sports tourism, this study proposes a novel concept that incorporates sports elements into travel itineraries with sustainable development on mind. It is called "sustainable sports tourism." The concept of sports tourism is derived from the research of Knop (1987), who identified three types of sports tourism: (i) pure sports holidays, such as skiing in the mountains in winter and swimming by the sea in summer; (ii) travelling to a resort, and the site has sports facilities and outdoor environment, such as fitness equipment and extensive grassland; (iii) unorganized sports activities, allowing tourists to participate freely during the tourism process, such as beach volleyball, rock climbing, river tracing, etc. Sports tourism is a low-cost leisure activity all right , but it also can improve the physical and mental health of the people. Many countries have paid more and more attention to sports tourism, creating many sports activities in scenic spots and resorts, including mountaineering, cycling, road running, river tracing, rock climbing, swimming, etc. (Cho et al., 2019). The integration of sports and tourism requires sufficient integration time to establish an effective sports tourism activity, and governments' supports and promotion can accelerate the development of sports tourism (Gibson et al., 2012).

The four dimensions of sustainable sports tourism evaluation proposed in this study include economic sustainability, environmental sustainability, socio-cultural sustainability, and institutional sustainability. The following questions are examined based on the four perspectives: (i) What are the evaluation criteria under the four dimensions? (ii) How important are the dimensions and the criteria of the evaluation? (iii) How to assess the performance of alternatives for sustainable sports tourism? (iv) How can it be improved? These problems are a typical multi-criteria decision-making (MCDM) problem. The MCDM method has excellent evaluation performance in complex environments. It does not require traditional statistics and basic assumptions, and only requires a small sample of expert interview data. The goal of MCDM is to integrate objective survey data with subjective expert judgments and provide effective management information to support decision makers in formulating optimal strategies (Chang et al., 2019). The procedures performed by MCDM include the determination of evaluation criteria, calculation of criterion weights, and integration of alternative performance. Common weight calculation methods are Analytic Hierarchy Process (AHP) (Rehman et al., 2019), Analytic Network Process (ANP) (Crimi et al., 2019), Best Worst Method (BWM) (Rezaei, 2015), and entropy (Zhou et al., 2016). The importance weights of criteria are necessary for evaluation, and they will significantly affect the outcome of alternative performance integration. In addition, the weights of the criteria may let decision makers know what factors must be considered and improved first (Lo et al., 2018). Popular alternative performance integration methods include: Technology for Order Preference by Similarity to an Ideal Solution (TOPSIS) (Dash et al., 2019), Visekriterijumska Optimizacija i Kompromisno Resenje (VIKOR) (Hsu et al., 2018), ELECTRE (Yu et al., 2018) and Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) (Vivas et al., 2019). MCDM has been widely used in evaluation and selection of various industries, such as green supplier evaluation and improvement (Lo et al., 2018), international airport operation management (Lu et al., 2018), and building construction risk detection. (Tamošaitienė and Gaudutis, 2013) and so on.

This paper proposes a novel evaluation framework for sustainable sports tourism, combining Bayesian BWM (Mohammadi and Rezaei, 2019) and modified VIKOR technology to evaluate the performance of sports tourism alternatives. First, according to the studies of relevant literatures, discussions were held with relevant government departments and private organizations of sports tourism to establish a complete evaluation criteria system. In particular, this study adds a perspective of institutional sustainability to optimize the system. Second, Bayesian BWM is used to obtain the importance weight of the criterion. This method is based on the concept of statistical distribution to strengthen the usability of original BWM and to more effectively integrate the judgments and opinions of multiple experts. Finally, the modified VIKOR technology is used to calculate the total evaluation score of each alternative, and then the priorities of the alternatives are ranked. In this study, the modified VIKOR improved the original VIKOR technology, introducing the concept of aspiration level into the calculation process of VIKOR, so as to avoid "choose a relatively good apple among the rotten apples". The traditional concept of "relative satisfaction" was replaced by "aspiration level" to meet the development trend of MCDM (Liou et al., 2016; Lo et al., 2019; Hu and

Tzeng, 2019). In the process of implementing VIKOR, we regard the aspiration level and the worst level as two alternatives. From this, we can know how much improvement room that each alternative has from the aspiration level, so that more management information can be obtained in actual application. This study takes a survey of potential sports tourism attractions in central Taiwan as an example. The research can help decision makers to be more systematic in the decision-making process and provide more reliable improvement implications for attractions. In summary, the model proposed in this study has five main features and contributions:

(i) Development of a complete sustainable sports tourism evaluation framework
Past studies have developed many sustainable tourism indicators, but few studies have proposed a sustainable evaluation framework for sports combined with tourism. This study integrates the sports elements promoted by various countries into tourist itineraries, which not only enable people to deeply experience the environment of the attractions, but also help with their physical and mental health.

(ii) Adding institutional sustainability as an evaluation aspect
The promotion of sustainable sports tourism must be supported by governments and protected by relevant laws and regulations. Therefore, this study adds institutional sustainability to strengthen the evaluation model.

(iii) The innovativeness of combining Bayesian BWM and modified VIKOR technology
The original BWM has successfully overcome the shortcomings of AHP, including significantly reducing the number of pairwise comparisons of questionnaires and obtaining better consistent results. Bayesian BWM has further optimized the original BWM and used the concept of statistical distribution to integrate multiple expert opinions to obtain more reliable group weights. Besides, the concept of aspiration level was added to improve the applicability of VIKOR in practice, and thus to obtain more improvement information and management implications.

(iv) A case study on the potential tourist attractions in central Taiwan
Under the policies of the Tourism Bureau and the Sports Administration in Taiwan aiming to promote sports tourism, this study uses four attractions in central Taiwan that are suitable for the development of sports tourism as alternatives. The evaluation results of this study can provide the basis for the government and the tourism industry to promote sustainable sports tourism.

(v) Reproducibility and expansion of the proposed evaluation framework
The evaluation indexes and methods proposed by this research are not limited to the use

of scenic spots in central Taiwan, and thus can be used to analyze sports tourism evaluation in other regions based on this model. In addition, other countries can increase their evaluation indexes to meet local tourism needs based on their cultural background and other considerations.

The rest of this article is organized as follows. Section 2 introduces the evaluation criteria for sustainable sports tourism. Section 3 describes the proposed hybrid model method and the basic concepts of its method. Section 4 describes a real application to prove the feasibility and practicability of the proposed model. Section 5 summarizes the discussion of the whole article and provides future research directions.

2. Dimensions and criteria of sustainable sports tourism evaluation

Sports tourism should emphasize the active participation of tourists in sports, not just attending and watching some sports events. Sports tourism is a way to consume physical energy and experience the culture and features of the place through sports. This approach will definitely deepen the memory of the attractions' culture (Gibson, 1998). For example, Hokkaido Skiing, Mount Fuji Marathon, Bali Streaming, etc. As the research on the introduction of sustainability in sports tourism has not yet been developed, this study worked with tourism-related government departments and private organizations (including tourism operators, sports organizations, research institutes) to establish the initial evaluation criteria for sustainable sports tourism based on relevant academic literatures. The relatively important criteria were then selected into the evaluation system to reflect the characteristics and connotation of sustainable sports tourism. The main framework includes four dimensions, namely Economic Sustainability (D_1), Environmental Sustainability (D_2), Socio-cultural Sustainability (D_3), and Institutional Sustainability (D_4). Each of these dimensions can be divided into several criteria, and a total of 18 assessment criteria constitute the evaluation framework, as shown in **Table 1**. The proposed guidelines for sustainable sports tourism in this study can test whether tourist attractions conform to sustainable sports development.

Table 1. Proposed dimensions and criteria for sustainable sports tourism evaluation

Dimensions	Criteria	References
Economic sustainability (D_1)	Local employment opportunities (C_{11})	Liu et al. (2018), Rashidi and Cullinane (2019), Asmelash and Kumar (2019)
	Economic feasibility (C_{12})	Rashidi and Cullinane (2019), Asmelash and

		Kumar (2019), Zhang et al. (2019)
	Promotion of local sports culture (C_{13})	Pouder et al. (2018), Gkoumas (2019), Cho et al. (2019)
	Sports diversity (C_{14})	Pouder et al. (2018), Gkoumas (2019), Cho et al. (2019)
Environmental sustainability (D_2)	Sports facility integrity (C_{21})	Sun et al. (2017), Asmelash and Kumar (2019)
	Biodiversity (C_{22})	Sun et al. (2017), Santarém et al. (2020), Wu et al. (2019), Asmelash and Kumar (2019)
	Waste recycling (C_{23})	Sun et al. (2017), Rashidi and Cullinane (2019)
	Low environmental pollution (C_{24})	Lou et al. (2019), Rashidi and Cullinane (2019)
Socio-cultural sustainability (D_3)	Social equity (C_{31})	Trudeau (2018), Rashidi and Cullinane (2019), Asmelash and Kumar (2019)
	Tourist services (C_{32})	Rashidi and Cullinane (2019), Gkoumas (2019), Pouder et al. (2018)
	Protection of residents' basic rights (C_{33})	Nunkoo et al. (2012), Gkoumas (2019), Asmelash and Kumar (2019)
	Social Welfare (C_{34})	Guillen-Royo (2019), Rashidi and Cullinane (2019), Gillam and Charles (2019)
	Enrichment of local features (C_{35})	Rashidi and Cullinane (2019), Santarém et al. (2020)
	Emergency response and rescue (C_{36})	Rashidi and Cullinane (2019), Musavengane et al. (2020)
Institutional sustainability (D_4)	Regional ordinance protection (C_{41})	Rashidi and Cullinane (2019), Gkoumas (2019)
	Policy promotion and marketing (C_{42})	Rashidi and Cullinane (2019), Asmelash and Kumar (2019)
	Sports tourism land planning (C_{43})	Liu et al. (2018), Asmelash and Kumar (2019)
	Local government involvement (C_{44})	Wu et al. (2019), Asmelash and Kumar (2019)

2.1 Economic Sustainability

Economic sustainability (D_1) is defined as the ability to create stable income for organizations and members at all levels of society without jeopardizing the economy and resources. In other words, economic growth is based on morality and conscience, and its economic activities do not affect the sustainable development of society and nature (Pires et al., 2017; Chelan et al., 2018). Economic sustainability is a necessary condition for the development of sports tourism to maintain the revenue of tourism attractions and local residents. Its criteria include local employment opportunities (C_{11}), economic feasibility (C_{12}), local cultural promotion (C_{13}), and sports diversity (C_{14}) (Liu et al., 2018; Rashidi and Cullinane, 2019; Asmelash and Kumar, 2019; Zhang et al., 2019; Pouder et al., 2018; Gkoumas, 2019, Cho et al., 2019) .

Local employment opportunity (C_{11}) aims at the development of sports tourism which can bring more employment opportunities for local residents. The government should promote equal employment opportunities, so employees can be men or women of all ages, and even disabled people. Economic feasibility (C_{12}) is the use of local natural resource conditions to construct profitable economic activities in which organizers can spend the lowest planning and maintenance costs to create higher returns. The promotion of local sports culture (C_{13}) can attract more sports-loving travelers; for example, the seasonal flower season will attract mountain-going tourists who like to watch flowers and birds. The development of sports culture combined with tourism will increase the length of stay of tourists. Sports diversity (C_{14}) can attract more tourists of different ages to participate in scenic activities, and promote local prosperity and recreational diversity.

2.2 Environmental Sustainability

Environmental sustainability (D_2) is one of the most important factors for maintaining the stability of regional ecosystems. In addition to reducing carbon and waste, it also attaches importance to the recyclability of consumables and biodiversity. Many sports tourism advocates the use of environmentally friendly tableware, and walking or non-carbon-emitting vehicles (skateboards and bicycles) for transportation (Gibson et al., 2012; Asmelash and Kumar, 2019). The environmental sustainability dimension consists of sports facility integrity (C_{21}), biodiversity (C_{22}), waste recycling (C_{23}), and low environmental pollution (C_{24}) (Sun et al., 2017; Santarém et al., 2020 Wu et al., 2019; Asmelash and Kumar, 2019; Lou et al., 2019, Rashidi and Cullinane, 2019).

Sports facility integrity (C_{21}) assesses whether the local area is suitable for developing sports tourism activities and keeps current status as much as possible without destroying any natural environment and facilities. At the same time, the local biodiversity (C_{22}) is also one of the assessment items of the sports environment. The more species of animals and plants indicate that the ecological environment of the region is diverse. Waste recycling (C_{23}) and low environmental pollution (C_{24}) are the most initial environmental protection assessment items. The main appeal of the word "green" is to minimize environmental pollution and waste reduction as much as possible, and use recyclable materials to achieve recycling of resources.

2.3 Socio-cultural Sustainability

Socio-cultural sustainability (D_3) expresses the importance of sustainable development of social activities and culture. Many industries pay special attention to corporate social responsibility (Hu and Tzeng, 2019; Asmelash and Kumar, 2019). The significance of this dimension needs to be promoted in sports tourism, because many tourism attractions are operated and managed by non-profit organizations. This study divides socio-cultural sustainability into six criteria, including social fairness (C_{31}), tourist services (C_{32}), protection of residents' basic rights (C_{33}), social welfare (C_{34}), enrichment of local features (C_{35}) and emergency response and rescue (C_{36}) (Trudeau, 2018; Rashidi and Cullinane, 2019; Asmelash and Kumar, 2019; Gkoumas, 2019; Pouder et al., 2018; Nunkoo et al., 2012; Gkoumas, 2019; Guillen-Royo, 2019; Gillam and Charles, 2019; Santarém et al., 2020; Musavengane et al., 2020).

Established sports tourist attractions should not be limited to target passengers, and passengers should not be treated differently due to social status and household income. Besides, hardware facilities and buildings should provide barrier-free access for people with disabilities to maintain social equity (C_{31}). Tourist services (C_{32}) refers to the fact that regional operators should establish a complete sports tourism guide system and customer service center so that tourists can enjoy the services in the area quickly and happily. Protection of residents' basic rights (C_{33}) guarantees the residents' basic right to life, and educates the residents about the history and features of local cultural relics and cultures, so that residents can introduce and guide their culture to tourists. Social welfare (C_{34}) is a preferential scheme that gives residents extra living subsidies and related facilities, and meanwhile maintains their living style as it is.. Enrichment of local features (C_{35}) refers to keeping the local culture and combining external themed activities or commodities to enhance the richness of sports tourism. Emergency response and rescue (C_{36}) is one of the indispensable assessment items, and it is a basic element of the safety of sports tourism.

2.4 Institutional Sustainability

According to the literature review of Section 1, we can see that Institutional sustainability (D_4) is a new dimension of sustainability assessment. Government commitment and public trust are often based on the integrity of regulations and institutions. The key factor for the success of sports tourism promotion is policy support (Gkoumas, 2019; Asmelash and Kumar, 2019; Hsu et al., 2020). This study extends the concept of institutional sustainability proposed by Asmelash and Kumar (2019) to formulate four guidelines: regional ordinance protection (C_{41}), policy promotion and marketing (C_{42}), sports tourism land planning (C_{43}) and local government involvement (C_{44}) (Rashidi and Cullinane, 2019; Gkoumas, 2019; Liu et al., 2018; Asmelash and Kumar, 2019; Wu et al., 2019).

Regional ordinance protection (C_{41}) includes the formulation of local regulatory measures, the management of knowledge and culture. The development speed of sports tourism depends on policy promotion and marketing (C_{42}). Seasonal or recurring events are held to maintain the stability of local visitor traffic to prevent the tourism attractions from falling into the off-season/peak-season rotation. Sports tourism land planning (C_{43}) is the zoning of sites at attractions to develop a proper area protection and development plan. Local government involvement (C_{44}) refers to the fact that the local government organizes sports events from time to time, and sponsors the resources required in activities, which can enhance residents and tourists' willingness to participate in sports tourism.

3. Proposed approach: combining Bayesian BWM with modified VIKOR

This section describes the evaluation method used and its detailed calculation process, including Bayesian BWM, entropy and modified VIKOR technologies. Bayesian BWM determines the weights of the criteria based on expert opinions and judgments. And the weighted results calculated by Bayesian BWM are substituted into the execution process of the modified VIKOR to obtain performance value and rank of each alternative.

3.1 Bayesian BWM technique

BWM is a relatively new MCDM method proposed by Rezaei (2015). It improves the disadvantages of using AHP. AHP needs to compare all n criteria in pairs, that is, n (n-1)/2 pairwise comparisons. In contrast, BWM requires only 2n-3 pairwise comparisons. BWM has this advantage, and its consistent test is usually better than AHP. The execution steps of BWM are simple. First, the best and worst criteria are selected, and then all other criteria are compared with these two criteria to form two groups of structured vectors. This structure helps decision makers to provide more reliable pairwise comparison results. In addition, the special structure of BWM forms two vectors containing only positive integers (A_B and A_W), thereby avoiding the basic distance problem of AHP in the form of fractions (such as 1/a).

Due to the different opinions provided by each decision maker in BWM, there are differences in the two vector information (the different best and worst criteria are selected). Therefore, it is not a good way to use the arithmetic mean to aggregate the opinions of multiple experts. Many studies have proposed different approaches for group decision making in BWM. However, no method has been proposed to find the final weight of the group based on the probability distribution environment. The typical weight vector of the MCDM method is $w_j = (w_1, w_2, \ldots, w_n)$ and requires $\sum_{j=1}^{n} w_j = 1$ and $w_j \geq 0$. Each w_j is expressed as a weight value of the corresponding criterion c_j. From the perspective of probability, the criterion c_j can be regarded as a random event, and the weight w_j is their probability of occurrence. With mathematical derivations, $\sum_{j=1}^{n} w_j = 1$ and $w_j \geq 0$ are also like this based on the probability theory. Therefore, it is meaningful to construct probabilistic models from the perspective of decision science (Mohammadi and Rezaei, 2019). Next, the detailed implementation steps and inference steps of Bayesian BWM are as follows:

Step 1. Determine the set of evaluation criteria for the decision system

A decision maker or a decision group develops n evaluation criteria $\{c_1, c_2, \ldots, c_n\}$ used in the decision issues.

Step 2. Choose the best and worst criteria

According to the n criteria developed in Step 1, select the best (i.e., most satisfied, preferred, or most important) and worst (i.e., least satisfied, disliked, or least important) criteria. The best and worst criteria chosen are the key factors affecting the results of the analysis.

Step 3. Take the best criterion as the benchmark, and perform pairwise comparison with other criteria to generate the BO (Best-to-Others) vector

Decision makers assess the relative importance of the best and other criteria. The evaluation scale ranges from 1 to 9 (as shown in **Table 2**), and the BO vector can be generated. The scale 1 indicates that it is equally important, and the scale 9 is absolutely important and belongs to the highest level of scale. It is expressed as:

$$A_{Bj} = \left(a_{B1}, a_{B2}, \ldots, a_{Bn}\right) \tag{1}$$

Where a_{Bj} indicates the importance of the best criterion B relative to the criterion j, and the comparison between the best criterion and itself must be 1, that is, $a_{BB} = 1$.

Step 4. The rest of the criteria are used as benchmarks, and pairwise comparisons with the worst criterion yield the OW (Others-to-Worst) vector

Similar to Step 3, the decision maker evaluates the relative importance of the other criteria and the worst criterion to generate the OW vector

$$A_{jW} = \left(a_{1W}, a_{2W}, \ldots, a_{nW}\right)^T \tag{2}$$

Where a_{jW} indicates the importance of the remaining criteria j relative to the worst criterion W, and the comparison between the worst criterion and itself must be 1, that is, $a_{WW} = 1$.

Table 2. BWM evaluation scales

Linguistic variable	Crisp value
Equally important	1
Equal to moderately more important	2
Moderately more important	3
Moderately to strongly more important	4
Strongly more important	5
Strongly to very strongly more important	6
Very strongly more important	7
Very strongly to extremely more important	8
Extremely more important	9

Step 5. Calculate the optimal weight of the criterion group

The input values A_B and A_W of the original BWM can be constructed as a probability model of multinomial distribution. Since the contents of both vectors are positive integers, the probability mass density function of a multinomial distribution of A_W is

$$P\left(A_W \middle| w\right) = \frac{\left(\sum_{j=1}^{n} a_{jW}\right)!}{\prod_{j=1}^{n} a_{jW}!} \prod_{j=1}^{n} w_j^{a_{jW}} \tag{3}$$

Where w is the probability distribution. According to the multinomial distribution, the probability of event j is proportional to the number of experiments.

$$w_j \propto \frac{a_{jW}}{\sum_{j=1}^{n} a_{jW}}, \quad \forall j = 1,2,\ldots,n \tag{4}$$

Similarly, the worst criterion c_W can be written as

$$w_W \propto \frac{a_{WW}}{\sum_{j=1}^{n} a_{jW}} = \frac{1}{\sum_{j=1}^{n} a_{jW}} \tag{5}$$

Integration of Eqs. 4 and 5 can be obtained as follows,

$$\frac{w_j}{w_W} \propto a_{jW}, \quad \forall j = 1,2,\ldots,n \tag{6}$$

This is the same concept as original BWM, which is converted into a set of optimized weights based on the values evaluated by experts. In addition, A_B is modeled using multinomial distribution. However, the generation concepts of A_B and A_W are different. The former is the best criterion B compared with other criteria j. The larger the evaluation value, the smaller the weight of the criterion j being compared; for criterion W, the larger the evaluation value, the greater the weight of the criterion j. Therefore, the conversion of A_B's assessment content into weights should be an inverse function.

$$A_B \sim multinomial\left(\frac{1}{w}\right) \tag{7}$$

Which can be written as

$$\frac{1}{w_j} \propto \frac{a_{Bj}}{\sum_{j=1}^{n} a_{Bj}}, \quad \forall j = 1,2,\ldots,n \tag{8}$$

Similarly, the best criterion c_B can be written as

$$\frac{1}{w_B} \propto \frac{a_{BB}}{\sum_{j=1}^{n} a_{Bj}} = \frac{1}{\sum_{j=1}^{n} a_{Bj}} \Rightarrow \frac{w_B}{w_j} \propto a_{Bj}, \quad \forall j = 1,2,\ldots,n \tag{9}$$

We can use statistical inference to find the best weight value w_j. Because MCDM requires each weight to be greater than or equal to 0, and the total weight must be equal to 1. Therefore, the model is constructed using Dirichlet Probability Distribution (Forbes et al., 2011), and the function is

$$Dir(w|\alpha) = \frac{1}{B(\alpha)} \Pi_{j=1}^{n} w_j^{\alpha_j - 1} \tag{10}$$

Where α is the vector parameter, and w satisfies the constraints required by MCDM.

Bayesian BWM is a way of estimating approximate parameters through Bayesian, instead of using statistical maximum likehood method. First, the Dirichlet probability distribution model is used as the prior distribution of the weight vector, where α is set to 1, because this parameter does not affect the prior probability. Then, based on the w parameter assigned by Dirichlet to perform Bayesian estimation, the posterior distribution model is

$$\mu_j = \frac{\alpha_{post,t_j} - 1}{\sum_{j=1}^{n} \alpha_{post,t_j} - n} = \frac{1 + a_{jW} - 1}{\sum_{j=1}^{n}(a_{jW} + 1) - n} = \frac{a_{jW}}{\sum_{j=1}^{n} a_{jW}} \tag{11}$$

Where $\alpha_{post} = \alpha + A_W = 1 + A_W$ and $A_W = (a_{jW}) = (a_{1W}, a_{2W}, \ldots, a_{nW})$.

The posterior distribution model will provide an accurate maximum likelihood estimator. So far, only A_w has been considered to estimate the weight. But for BWM, both the A_B and A_W vectors must be considered simultaneously, and the integration of the survey data of multiple experts is needed. Bayesian BWM solves the two problems mentioned above, and its steps are as follows:

Step 5.1. Construction of joint probability distribution for group decision making

Suppose there are k decision makers, $k = 1, 2, ..., K$; the evaluation criterion $c_j = c_1, c_2, \ldots, c_n$; and the individual optimal weight after each decision maker is evaluated is w^k, then the group weight after integration is w^{agg}. $A_B^{1:K}$ indicates the vector that all experts evaluate the best criterion compared to other criteria. The same $A_W^{1:K}$ indicates the vector that all experts evaluate other criteria compared to the worst criterion. The two vectors are required information to construct a joint probability distribution. The joint probability distribution of group decision is

$$P\left(w^{agg}, w^{1:K} \left| A_B^{1:K}, A_W^{1:K}\right.\right) \tag{12}$$

The calculation of each individual variable can use the following probability rules (marginal probability function concept).

$$P(x) = \Sigma_y P(x, y) \tag{13}$$

Where x and y are arbitrary random variables.

Step 5.2. Bayesian hierarchy model development and calculation

The optimal weight of each expert w^k depends on the two sets of vectors A_B and A_W, and the group optimal weight w^{agg} depends on the optimal weight of each expert w^k. The calculation logic of the Bayesian hierarchy model is based on an iterative method, which means that the vector values A_B and A_W after each expert evaluation will generate w^k, and the new group's optimal weight w^{agg} will be continuously updated after new evaluation data is added. Based on the above concepts, there is conditional independence between variables. Considering the independence between different variables, the joint probability of the Bayesian model

$$P\left(w^{agg}, w^{1:K} \left| A_B^{1:K}, A_W^{1:K}\right.\right) \propto P\left(A_B^{1:K}, A_W^{1:K} \left| w^{agg}, w^{1:K}\right.\right) P\left(w^{agg}, w^{1:K}\right) \tag{14}$$

Eq. 14 can be further deduced as follows

$$P\left(A_B^{1:K}, A_W^{1:K} \left| w^{agg}, w^{1:K}\right.\right) P\left(w^{agg}, w^{1:K}\right) = P\left(w^{agg}\right) \prod_{k=1}^{K} P\left(A_W^k \left| w^k\right.\right) P\left(A_B^k \left| w^k\right.\right) P\left(w^k \left| w^{agg}\right.\right) \tag{15}$$

According to Eq. 15, we need to specify the distribution of each element, and we can find the corresponding probability. According to the inference process of Eqs. 3-9, $A_B^k \left| w^k\right.$ and $A_W^k \left| w^k\right.$ can be defined as

$$A_B^k \left| w^k\right. \sim multinomial\left(\frac{1}{w^k}\right), \ \forall_k = 1, 2, \ldots, K;$$

$$A_W^k \left| w^k\right. \sim multinomial\left(w^k\right), \ \forall_k = 1, 2, \ldots, K \tag{16}$$

And w^k under w^{agg} condition can be constructed as Dirichlet distribution.

$$w^k \left| w^{agg}\right. \sim Dir\left(\gamma \times w^{agg}\right), \ \forall_k = 1, 2, \ldots, K \tag{17}$$

Where w^{agg} is the average value of the distribution and γ is a non-negative parameter. According to Eq. 17, it can be known that the weight w^k of each expert will approximate w^{agg}

to the average value of probability distribution, and the degree of approximation is determined by the parameters. This method is a common operation method of the Bayesian model (Kruschke, 2014). It is reasonable for the distribution of the parameter γ to obey the gamma distribution, because it has a non-negative limit.

$$\gamma \sim gamma\left(a,b\right) \tag{18}$$

Where *a* and *b* are the shape and scale parameters of the gamma distribution.
Finally, the group optimal weight w^{agg} obeys the Dirichlet distribution, and α the parameter is set to 1.

$$w^{agg} \sim Dir\left(\alpha\right) \tag{19}$$

After the construction of probability distribution of all parameters is completed, the Markov-chain Monte Carlo (MCMC) technique is used to calculate the posterior distribution (Gilks et al., 2015). Therefore, the group optimal weight w^{agg} can be obtained according to the above-mentioned calculation process, which only needs each expert to provide BO and OW vectors.

Step 5.3. Ranking confidence test

Suppose there is a set of criteria $c_j = (c_1, c2,\ldots,c_n)$ being evaluated, two of which are c_i and c_j. We must understand whether the ranking results of the group weights are consistent with the evaluation of all decision makers. Therefore, the concept of Credal Ranking is used to examine its confidence. Then the probability that c_i is better than c_j will be

$$P\left(c_i > c_j\right) = \int I\left(w_i^{agg} > w_j^{agg}\right) P\left(w^{agg}\right) \tag{20}$$

Where $P\left(w^{agg}\right)$ is the posterior probability of w^{agg}, I is a conditional parameter, and can only be calculated when $\left(w_i^{agg} > w_j^{agg}\right)$ is held, otherwise it is 0. The confidence is calculated by the number of samples *Q* obtained by MCMC.

$$P\left(c_i > c_j\right) = \frac{1}{Q}\sum_{q=1}^{Q} I\left(w_i^{agg_q} > w_j^{agg_q}\right);$$
$$P\left(c_j > c_i\right) = \frac{1}{Q}\sum_{q=1}^{Q} I\left(w_j^{agg_q} > w_i^{agg_q}\right) \tag{21}$$

Where w^{agg_q} represents q w^{agg}'s from MCMC samples. When $P\left(c_i > c_j\right) > 0.5$, it means that criterion i is more important than criterion j, and the probability presented is the confidence. Furthermore, the total probability is 1, $P\left(c_i > c_j\right) + P\left(c_j > c_i\right) = 1$

3.2 Modified VIKOR method

The VIKOR method was developed to solve multi-criteria decision problems in complex systems (Opricovic and Tzeng, 2004). This method determines the performance and ranking of alternatives based on criteria weights and the evaluation of alternatives. After each alternative is scored according to each evaluation criterion, the eclectic ranking of alternatives can be defined by the closest degree compared to the ideal solution. The VIKOR method defines all evaluation parameters through L_p-*metric*, including S_i, Q_i and R_i. Assume that the evaluation value of alternative A_i obtained under the evaluation criterion c_j is f_{ij}, where i = 1, 2,.., m; j= 1, 2,.., n, then the L_p-*metric* is shown in Eq. 22 :

$$L_p^v = \left\{ \sum_{j=1}^{n} \left[w_j \left(\left| f_j^* - f_{ij} \right| \right) / \left(\left| f_j^* - f_j^- \right| \right) \right]^v \right\}^{1/v}, \quad 1 \le v \le \infty \qquad (22)$$

In order to overcome the shortcomings of VIKOR setting the current best solution as the benchmark solution during operation, this study adds the concept of aspiration level to VIKOR's calculation, and regards aspiration level and worst level as alternatives. In this way, the gap between each alternative and the aspiration level can be known, and more effective management implications can be discussed. The detailed VIKOR operation steps are explained as follows:

Step 1. Constructing the initial decision matrix

Each expert D^k obtains the evaluation values of all alternatives according to the semantic variables in **Table 3** and their corresponding evaluation scales. This article uses the arithmetic mean to aggregate the evaluation values of all experts to obtain the initial evaluation decision matrix, which is expressed as

$$\boldsymbol{F} = \left[f_{ij} \right]_{m \times n} = \begin{bmatrix} f_{11} & f_{12} & \cdots & f_{1j} & \cdots & f_{1n} \\ f_{21} & f_{22} & \cdots & f_{2j} & \cdots & f_{2n} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ f_{i1} & f_{i2} & \cdots & f_{ij} & \cdots & f_{in} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ f_{m1} & f_{m2} & \cdots & f_{mj} & \cdots & f_{mn} \end{bmatrix}, i = 1, 2,\ldots, m, j = 1, 2,\ldots, n. \qquad (23)$$

Where $f_{ij} = \frac{1}{p}\sum_{k=1}^{p} f_{ijk}$, $k = 1, 2,\ldots, p$.

Table 3. Evaluation Levels for Performance Evaluation

Linguistic variable	Crisp value
Very poor	1
Poor	2
Fair	3
Good	4
Very good	5

Step 2. Defining the best and the worst values

The regular VIKOR normalization method is to take the best performance value in the alternative as the denominator, that is,

$$f_i^* = \max_j \left\{ f_{ij} \right\} \tag{24}$$

$$f_i^- = \min_j \left\{ f_{ij} \right\} \tag{25}$$

This article introduces the concept of aspiration level into this step. The modified formula is

$$f_i^* = f^{aspire} = 5 \tag{26}$$

$$f_i^- = f^{worst} = 1 \tag{27}$$

Among them, f^{asprie} = 10 (the highest level of evaluation scale) and f^{worst} = 5 (the lowest level of evaluation scale).

Step 3. Calculating Si and Qi

The ranking of VIKOR is based on the group benefit (S_i) and individual regret (Q_i) to construct the ranking index (R_i), where the weight w_j is defined according to the calculation result of Bayesian BWM, and α is a preference function, usually set to 0.5. It can be seen that the smaller R_i is, the smaller the gap between the alternative and the aspiration level becomes. Conversely, when the larger Ri is, it means that the larger the gap between the alternative and the aspiration level becomes.

$$L_i^{v=1} = S_i = \sum_{j=1}^{n} \left[w_j \left(\left| f_j^{aspire} - f_{ij} \right| \right) / \left(\left| f_j^{aspire} - f_j^{worst} \right| \right) \right] \quad (28)$$

$$L_i^{v=\infty} = Q_i = \max_j \left\{ w_j \left(\left| f_j^{aspire} - f_{ij} \right| \right) / \left(\left| f_j^{aspire} - f_j^{worst} \right| \right) \right\} \quad (29)$$

$$R_i = \alpha(S_i - S^*) / (S^- - S^*) + (1-\alpha)(Q_i - Q^*) / (Q^- - Q^*) \quad (30)$$

Where $S^* = \min_i \{S_i\}$, $S^- = \max_i \{S_i\}$, $Q^* = \min_i \{Q_i\}$, $Q^- = \max_i \{Q_i\}$ 。

VIKOR is a useful soft calculation tool in multi-criteria decision analysis. Especially if decision makers do not know or are not sure how to express their preferences, this compromise solution can be used to obtain more scientific results because VIKOR provides the concept of maximum "group benefit" and minimum "individual regret".

4. Empirical example

This section introduces some well-known scenic spots in central Taiwan as a case study to demonstrate the effectiveness and practicality of the proposed evaluation model. First, we discuss the background of the case and the potential alternatives. Then, the Bayesian BWM method is used to obtain the weights of the criteria, and the modified VIKOR technology is used to calculate the performance and ranking of the alternatives.

4.1. Problem description

Since the development of sustainable tourism, Taiwan's domestic tourism industry and the Tourism Bureau have faced strong market challenges. Initially, some tourist attractions tried to reduce ticket prices to attract more customers, but they soon realized that this was an unsuccessful strategy. If low-cost sports can be added to tourist itineraries, it will not only promote the physical and mental health of passengers, but also increase the time spent by tourists at attractions to promote the local culture. In central Taiwan, the government is actively promoting sports tourism policies to attract more foreign tourists. Therefore, this study takes four well-known sports tourist attractions in central Taiwan as examples. These attractions have corresponding promotion sports programs and local cultural features. We show the four potential locations as A_1, A_2, A_3, and A_4, and their locations are described in **Table 4**.

Table 4. Introduction of potential sustainable sports tourist attractions

Alternative	Description of local features	Sports items
A_1	A_1 is located in Nantou County. Its biggest feature is that it has a vast lake with an altitude of 736 meters, an area of 7.93 square kilometers, and a maximum water depth of 27 meters. It is very rich in natural ecology. Starting in 1983, swimming competitions have been taking place here, and the whole route is about 3000 meters. In addition, a circular bicycle path is established around the lake to allow tourists to ride bicycles to enjoy the lake and the mountain.	Swimming, cycling, and hiking.
A_2	A_2 is located in the center of Taichung City, and it is the most complete green park in Taichung. The site has many perfect public buildings, museums, art galleries, etc., forming a network of green urban space architecture. The site has developed many popular sports, and the crowds on weekdays are not much different from the holidays.	Walking, frisbee, kite, rock climbing, parent-child group recreation activities, etc.
A_3	Located in the North District of Taichung City, A_3 is Taiwan's first dedicated bicycle path converted from an abandoned railway. There are various trees and flowers on both sides of the bicycle path, and business districts are formed around the attraction. Driven by the local government's tourism policies, many flower fairs are held at this attraction, bringing sports tourism to the local industry.	Cycling, hiking, and horse riding.
A_4	A_4 is located in the East District of Taichung City and is one of the most famous mountain climbing areas in the Central Region. The area has 12 well-planned hiking trails, and many tourism itineraries are developed in conjunction with hot spring operators. In particular, the local ecological protection is quite complete, with more than 30 deciduous tree species covered with golden leaves on both sides of the hiking trails.	Hot spring, and mountain climbing.

According to the proposed evaluation model, the development performance of 4 potential sports tourist attractions was then discussed. In order to conduct a comprehensive evaluation, 10 experts were invited to form a decision-making group, including senior managers of practitioners, professors in the field of tourism, and government units related to tourism. The 10 experts had more than 10 years of working experience in tourism-related departments and industries. This study considers the importance of 10 experts to be equal. The following analysis process is performed in accordance with the sustainability criteria proposed in Section 2.

4.2. Obtaining criteria weights by using Bayesian BWM

The advantages of Bayesian BWM and its calculation process are detailed in Section 3.1. First, each expert was required to select the best and the worst dimensions/criteria in the proposed evaluation framework. Next, the evaluation scales in **Table 2** were used to obtain the BO and OW vectors of each expert. Because the proposed evaluation framework is a hierarchical structure, there are 5 BWM questionnaires in total, including the dimension part and the criteria under 4 dimensions. Taking the dimension part as an example, **Table 5** and **6** can be obtained through the professional feedback of nine experts. For example, in **Table 5**, the first expert thought that D_4 was the most important dimension. Therefore, the BO vector formed by comparing D4 with other dimensions was $A_{Bj,1}$ = (3, 3, 2, 1). Similarly, D_2 was selected as the least important dimension, and the OW vector was $A_{jW,1}$ = (1, 1, 2, 3), as shown in **Table 6**. All experts did the same, and the information about expert groups could be obtained. All BWM questionnaires were performed a consistency ratio (CR) test to review the logic and reliability of expert responses. The average CR value is 0.016, indicating high consistency (Rezaei, 2015).

Table 5. The most important dimensions and BO vectors selected by the nine experts

Expert	Best	D_1	D_2	D_3	D_4
No. 1	D_4	3	3	2	1
No. 2	D_4	3	5	2	1
No. 3	D_4	5	3	2	1
No. 4	D_1	1	4	3	2
No. 5	D_1	1	2	3	5
No. 6	D_1	1	2	2	3
No. 7	D_4	3	5	2	1
No. 8	D_4	3	4	2	1
No. 9	D_4	3	3	2	1

Table 6. The least important dimensions and OW vectors selected by the nine experts

Expert	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9
Worst	D_2	D_2	D_1	D_2	D_4	D_4	D_2	D_2	D_2
D_1	1	2	1	4	5	3	2	2	1
D_2	1	1	2	1	3	2	1	1	1
D_3	2	3	3	2	2	2	3	2	2
D_4	3	5	5	2	1	1	5	4	3

Unlike the original BWM, we do not need to individually calculate the BWM questionnaire data of nine experts. The Bayesian BWM used the statistical probability model to estimate the optimal criterion weight of the group. Through the solution process of Eqs. 1-19, we can determine the weight of each dimension and criterion. The calculation software used in this study to perform Bayesian BWM is the application provided by Mohammadi and Rezaei (2019). In order to check whether the best group weights are obtained and their ranking are reliable, a ranking confidence test was performed. Taking dimensions as an example, the ranking confidence matrix is established according to Eqs. 20 and 21, as shown in **Table 7**. For example, D_1 is more important than D_2 with a confidence of 0.906, and the average ranking confidence is 0.875, indicating that the ranking of the dimension has a high degree of confidence. In addition, Bayesian BWM also provides individual optimal weights for each expert. When the higher the experts' judgment consensus is, the smaller the gap between the generated individual weights becomes, as shown in Fig. 1.

Table 7. The ranking confidences of the dimensions

	D_1	D_2	D_3	D_4
D_1	-	0.906	0	0
D_2	0	-	0	0
D_3	0.645	0.952	-	0
D_4	0.913	0.995	0.841	-

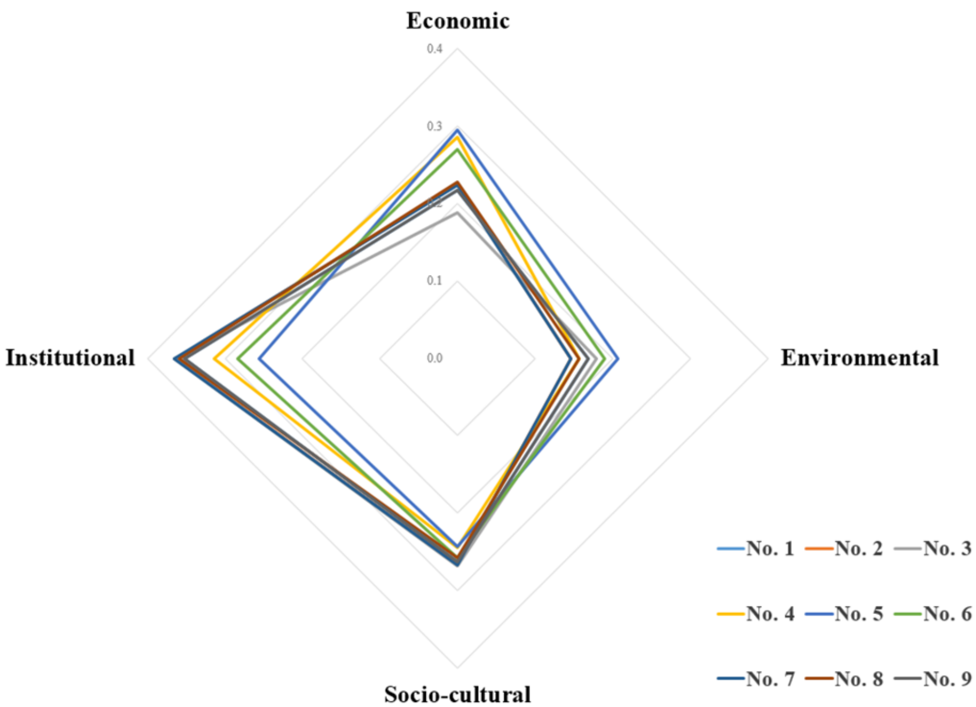

Fig. 1. Consensus on the importance of dimensions evaluated by nine experts

Table 8 lists the best group weights for the nine expert integrations. In terms of dimensions, institutional sustainability (D_4) is the most important factor in the development of sustainable sports tourism, emphasizing that governance and policies are more important than others. At the same time, as shown in the overall evaluation results, it can be seen that the top five rankings are local government involvement (C_{44}), policy promotion and marketing (C_{42}), local employment opportunities (C_{11}), economic feasibility (C_{12}) and enrichment of local features (C_{35}). Next, the modified VIKOR was applied to aggregate the values and criterion weights of each alternative.

Table 8. Weights of dimensions and criteria

Dimension	Local Weight	Rank	Criteria	Local Weight	Rank	Global Weight	Rank
D_1	0.237	3	C_{11}	0.340	1	0.081	3
			C_{12}	0.318	2	0.075	4
			C_{13}	0.161	4	0.038	13
			C_{14}	0.181	3	0.043	10
D_2	0.170	4	C_{21}	0.338	1	0.058	6
			C_{22}	0.155	4	0.026	18
			C_{23}	0.211	3	0.036	15
			C_{24}	0.295	2	0.050	7

D_3	0.260	2	C_{31}	0.122	5	0.032	16
			C_{32}	0.174	2	0.045	8
			C_{33}	0.118	6	0.031	17
			C_{34}	0.155	3	0.040	12
			C_{35}	0.287	1	0.075	5
			C_{36}	0.144	4	0.038	14
D_4	0.332	1	C_{41}	0.128	4	0.042	11
			C_{42}	0.357	2	0.119	2
			C_{43}	0.132	3	0.044	9
			C_{44}	0.383	1	0.127	1

4.3. Evaluating alternatives performance by using modified VIKOR

Assessing the development of sustainable sports tourism is both complex and difficult. An optimal compromise must be found among multiple constraints. VIKOR is one of the most effective methods to solve this kind of problem. It provides a lot of information with management value and can support decision makers to develop improvement strategies (Opricovic and Tzeng, 2004; Lo et al., 2019). In this study, the modified VIKOR method is used to calculate the performance of each alternative, and the concept of aspiration level is introduced into the method to avoid considering only the preference solution of the existing scheme.

Nine experts evaluated the performance of four potential sustainable sports tourism locations based on the semantic variables in Table 3. An initial decision matrix (Eq. 23) was obtained by integrating the information from nine expert surveys using an arithmetic mean, as shown in Table 9. This study introduces the concept of aspiration level into VIKOR to improve the adaptability of practical applications. Therefore, the highest and lowest evaluation scales are 5 and 1 (Aspiration level and Worst level). Bayesian BWM's weight calculation result is one of VIKOR's input information. Use Eqs. 26-30 to obtain the group benefit (S_i), individual regret (Q_i), and ranking index (R_i) of each alternative, as shown in **Table 10**. In practice, whether the government, business or organization should formulate management goals, through continuous improvement to move towards the aspiration level. According to the analysis results of Modified VIKOR, whether by S_i, Q_i or R_i, the priority ranking of the alternatives is $A_4 \succ A_1 \succ A_2 \succ A_3$. A_4 is the attraction with the best performance in developing sustainable sports tourism among all the alternatives (S_4 = 0.098, Q_4 = 0.01, R_4 = 0.09), indicating the smallest gap (0.09) from the aspiration level. Further discussions and management implications are presented in Section 5.

Table 9. Initial decision matrix

	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{21}	C_{23}	C_{24}	C_{25}	C_{26}	C_{31}	C_{32}	C_{33}	C_{34}	C_{41}	C_{42}	C_{43}	C_{44}
A_1	4.44	4.22	4.33	4.11	4.78	4.67	4.11	4.67	4.33	5.00	4.33	4.44	4.67	4.56	4.22	4.78	4.33	5.00
A_2	4.00	4.00	4.33	3.78	4.22	5.00	4.11	4.89	4.11	4.33	3.67	4.11	4.00	4.33	4.33	4.44	4.33	4.67
A_3	3.33	3.78	4.33	5.00	4.11	3.33	4.11	4.78	4.22	3.78	3.22	3.22	3.89	4.67	4.00	4.11	4.33	4.78
A_4	4.56	4.44	4.22	4.33	4.67	4.33	4.11	4.67	4.78	4.78	4.22	4.11	4.67	4.78	4.22	4.89	4.67	5.00
AL	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
WL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 10. Calculation results of the Modified VIKOR

	S_i	Rank	Q_i	Rank	R_i	Rank
A_1	0.108	2	0.015	2	0.112	2
A_2	0.179	3	0.020	3	0.169	3
A_3	0.224	4	0.034	4	0.244	4
A_4	0.098	1	0.010	1	0.090	1
AL	0.000		0.000		0.000	
WL	1.000		0.127		1.000	

5. Discussions and Conclusions

In the contemporary literature on sustainable tourism management, most of the research focuses on the three aspects of economics, society and environment, and few studies consider the necessity of institutions (Gkoumas, 2019; Asmelash and Kumar, 2019; Hsu et al., 2020). However, due to the rise of national sports awareness, many tourism practitioners have incorporated sports events into their travel itineraries. Therefore, the sustainable sports tourism evaluation framework proposed in this study is forward-looking. The proposed research method is a novel hybrid MCDM model, which can be transformed into a scientific quantitative analysis based on qualitative surveys by experts. In addition, the proposed model does not require statistical assumptions, and the semantic variables are extracted into values with management implications by a soft calculation method.

In terms of criterion weight calculation, Bayesian BWM is more effective than the original BWM in processing judgement information of multiple experts, which not only shortens the calculation time, but also adds many discriminative indicators (ranking confidence and expert consensus) to improve the BWM method. Practicality. According to the results of Bayesian BWM, institutional sustainability (D4) is the most important dimension for the development of sustainable sports tourism. This result echoes the research of Asmelash and Kumar (2019), whose research points out that national policies and local government support can promote the development of the tourism industry, including legislation of environmental protection, exposure of marketing media, and development of tourism maps. In terms of the overall evaluation criteria, local government involvement (C_{44}), policy promotion and marketing (C_{42}), and local employment opportunities (C_{11}) are the three most important factors in the evaluation system. Practitioners and governments should target them to enhance the development performance of tourist attractions. In addition, the Modified VIKOR provides a gap between alternatives and aspiration levels to understand how much improvement needs to be done to reach the benchmark. **Table 11** shows the calculated results and their differences between the modified VIKOR and the original VIKOR. Although the alternative ranking results of the two methods are the same, the management implications implied are different. In the modified VIKOR, R_4 is 0.09, which indicates that there is still room for improvement of 0.09 units from the aspiration level. Even though the performance of A_4 in all alternatives is the best, it still needs continuous improvement to pursue perfection. On the other hand, in the original VIKOR, R_4 is 0, which means that this alternative does not need any improvement. Therefore, the MCDM model used in this study can provide more management implications and relevant information to decision makers.

Table 11. Comparisons of the Modified VIKOR and the Original VIKOR

	Modified VIKOR		Original VIKOR	
	R_i	Rank	R_i	Rank
A_1	0.112	2	0.054	2
A_2	0.169	3	0.855	3
A_3	0.244	4	0.946	4
A_4	0.090	1	0.000	1
AL	0.000			
WL	1.000			

In order to check the robustness and reliability of the proposed model, we use sensitivity analysis to detect whether changes in the weights of the criteria significantly affect the ranking results of alternatives. The results of this study show that D_4 has the highest dimension weight, so the weight of D_4 was adjusted from 0.1 to 0.9, and then performed a total of 9 times by the modified VIKOR. **Table 12** shows the ranking results after conducting the sensitivity analysis nine times. It can be known that the weight change of D_4 will not affect the modified VIKOR analysis results. In addition, this study is compared with other MCDM methods, including SAW (Simple Additive Weighting), TOPSIS, PROMETHEE, and WASPAS (Weighted Aggregated Sum Product Assessment). The alternative ranking obtained by these methods is consistent with the method proposed in this study.

Table 12. Ranking results for 9 sensitivity analysis runs

	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9
A_1	2	2	2	2	2	2	2	2	2
A_2	3	3	3	3	3	3	3	3	3
A_3	4	4	4	4	4	4	4	4	4
A_4	1	1	1	1	1	1	1	1	1

In summary, this study has successfully explored four aspects of sustainable sports tourism development, including the establishment of evaluation criteria, the measurement of the importance of evaluation criteria, the integration of the performance of alternatives, and the formulation of management policies and improvement strategies. The awareness of sustainability has been involved in various industries, especially the development of sustainable tourism. In Taiwan, the Sports Administration actively promotes the integration of sports events in tourism planning, which helps the development of the tourism industry and the promotion of Taiwan culture. Based on the results of the study, several management implications are proposed: (i) The integration of sports events into tourism activities can foster the continued participation of citizens and the habit of sports. (ii) The government should encourage the combination of the sports service industry and the tourism industry to provide innovative and high-quality tourism services. (iii) In self-help tourism, Chinese people should be encouraged to incorporate sports elements into the travel itinerary planning, and then increase the proportion of sports consumption to increase the output value of the sports service industry.

Although this study provides a novel framework for sustainable sports tourism evaluation, there are still some limitations that should be addressed. At present, the interdependence and influence of evaluation criteria have not been explored. In the future, Decision Making Trial and Evaluation Laboratory (DEMATEL) can be combined to optimize the evaluation model. In addition, future work will carry out a development strategy that combines urban development and sports tourism, hoping to bring more sports environments to the entire people.

References

[1] Asmelash, A. G., & Kumar, S. (2019). Assessing progress of tourism sustainability: Developing and validating sustainability indicators. *Tourism Management*, *71*, 67-83.

[2] Chang, M. H., Liou, J. J., & Lo, H. W. (2019). A Hybrid MCDM Model for Evaluating Strategic Alliance Partners in the Green Biopharmaceutical Industry. *Sustainability*, *11*(15), 4065.

[3] Chelan, M. M., Alijanpour, A., Barani, H., Motamedi, J., Azadi, H., & Van Passel, S. (2018). Economic sustainability assessment in semi-steppe rangelands. *Science of the Total Environment*, *637*, 112-119.

[4] Cho, H., Joo, D., & Chi, C. G. (2019). Examining nostalgia in sport tourism: The case of US college football fans. *Tourism Management Perspectives*, *29*, 97-104.

[5] Choi, H. C., & Sirakaya, E. (2006). Sustainability indicators for managing community tourism. *Tourism management*, *27*(6), 1274-1289.

[6] Crimi, A., Jones, T., & Sgalambro, A. (2019). Designing a Web Spatial Decision Support System Based on Analytic Network Process to Locate a Freight Lorry Parking. *Sustainability*, *11*(20), 5629.

[7] Dash, R., Samal, S., Dash, R., & Rautray, R. (2019). An integrated TOPSIS crow search based classifier ensemble: In application to stock index price movement prediction. *Applied Soft Computing*, *85*, 105784.

[8] Gibson, H. J. (1998). Sport tourism: a critical analysis of research. *Sport management review*, *1*(1), 45-76.

[9] Gibson, H. J., Kaplanidou, K., & Kang, S. J. (2012). Small-scale event sport tourism: A case study in sustainable tourism. *Sport management review*, *15*(2), 160-170.

[10] Gillam, C., & Charles, A. (2019). Community wellbeing: The impacts of inequality, racism and environment on a Brazilian coastal slum. *World Development*

Perspectives, *13*, 18-24.

[11] Gkoumas, A. (2019). Evaluating a standard for sustainable tourism through the lenses of local industry. *Heliyon*, *5*(11), e02707.

[12] Guillen-Royo, M. (2019). Sustainable consumption and wellbeing: does on-line shopping matter? *Journal of Cleaner Production*, *229*, 1112-1124.

[13] Hall, C. M. (2011). A typology of governance and its implications for tourism policy analysis. *Journal of Sustainable Tourism*, *19*(4-5), 437-457.

[14] Hsu, C. C., Liou, J. J., Lo, H. W., & Wang, Y. C. (2018). Using a hybrid method for evaluating and improving the service quality of public bike-sharing systems. *Journal of cleaner production*, *202*, 1131-1144.

[15] Hsu, C. Y., Chen, M. Y., Nyaupane, G. P., & Lin, S. H. (2020). Measuring sustainable tourism attitude scale (SUS-TAS) in an Eastern island context. *Tourism Management Perspectives*, *33*, 100617.

[16] Hu, S. K., & Tzeng, G. H. (2019). A Hybrid Multiple-Attribute Decision-Making Model with Modified PROMETHEE for Identifying Optimal Performance-Improvement Strategies for Sustainable Development of a Better Life. *Social Indicators Research*, 1-33.

[17] Knop, P. D. (1987). Some thoughts on the influence of sport on tourism. In *International seminar and workshop on outdoor education, recreation and sport tourism. Proceedings of an international seminar.* (pp. 38-45). Wingate Institute for Physical Education and Sport.

[18] Lee, T. H., & Jan, F. H. (2019). Can community-based tourism contribute to sustainable development? Evidence from residents’ perceptions of the sustainability. *Tourism Management*, *70*, 368-380.

[19] Liou, J. J., Tamošaitienė, J., Zavadskas, E. K., & Tzeng, G. H. (2016). New hybrid COPRAS-G MADM Model for improving and selecting suppliers in green supply chain management. *International Journal of Production Research*, *54*(1), 114-134.

[20] Liu, K. M., Lin, S. H., Hsieh, J. C., & Tzeng, G. H. (2018). Improving the food waste composting facilities site selection for sustainable development using a hybrid modified MADM model. *Waste management*, *75*, 44-59.

[21] Lo, H. W., Liou, J. J., & Tzeng, G. H. (2019). Comments on “Sustainable recycling partner selection using fuzzy DEMATEL-AEW-FVIKOR: A case study in small-and-medium enterprises”. *Journal of Cleaner Production*, *228*, 1011-1012.

[22] Lo, H. W., Liou, J. J., Wang, H. S., & Tsai, Y. S. (2018). An integrated model for solving problems in green supplier selection and order allocation. *Journal of cleaner production*, *190*, 339-352.

[23] López-Bonilla, J. M., & López-Bonilla, L. M. (2012). Environmental orientation in tourism: The RTEO scale. *Current Issues in Tourism*, *15*(6), 591-596.

[24] López-Bonilla, L. M., & López-Bonilla, J. M. (2016). From the new environmental paradigm to the brief ecological paradigm: a revised scale in golf tourism. *Anatolia*, *27*(2), 227-236.

[25] Lou, Y., Jayantha, W. M., Shen, L., Liu, Z., & Shu, T. (2019). The application of low-carbon city (LCC) indicators—A comparison between academia and practice. *Sustainable Cities and Society*, *51*, 101677.

[26] Lu, M. T., Hsu, C. C., Liou, J. J., & Lo, H. W. (2018). A hybrid MCDM and sustainability-balanced scorecard model to establish sustainable performance evaluation for international airports. *Journal of Air Transport Management*, *71*, 9-19.

[27] Mohammadi, M., & Rezaei, J. (2019). Bayesian Best-Worst Method: A Probabilistic Group Decision Making Model. *Omega*.

[28] Musavengane, R., Siakwah, P., & Leonard, L. (2020). The nexus between tourism and urban risk: Towards inclusive, safe, resilient and sustainable outdoor tourism in African cities. *Journal of Outdoor Recreation and Tourism*, *29*, 100254.

[29] Nunkoo, R., Ramkissoon, H., & Gursoy, D. (2012). Public trust in tourism institutions. *Annals of Tourism Research*, *39*(3), 1538-1564.

[30] Opricovic, S., & Tzeng, G. H. (2004). Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS. *European journal of operational research*, *156*(2), 445-455.

[31] Pires, A., Morato, J., Peixoto, H., Botero, V., Zuluaga, L., & Figueroa, A. (2017). Sustainability Assessment of indicators for integrated water resources management. *Science of the total environment*, *578*, 139-147.

[32] Pope, J., Annandale, D., & Morrison-Saunders, A. (2004). Conceptualising sustainability assessment. *Environmental impact assessment review*, *24*(6), 595-616.

[33] Pouder, R. W., Clark, J. D., & Fenich, G. G. (2018). An exploratory study of how destination marketing organizations pursue the sports tourism market. *Journal of Destination Marketing & Management*, *9*, 184-193.

[34] Rashidi, K., & Cullinane, K. (2019). A comparison of fuzzy DEA and fuzzy TOPSIS in

sustainable supplier selection: Implications for sourcing strategy. *Expert Systems with Applications*, *121*, 266-281.

[35] Rehman, A. U., Mian, S. H., Umer, U., & Usmani, Y. S. (2019). Strategic Outcome Using Fuzzy-AHP-Based Decision Approach for Sustainable Manufacturing. *Sustainability*, *11*(21), 6040.

[36] Rezaei, J. (2015). Best-worst multi-criteria decision-making method. *Omega*, *53*, 49-57.

[37] Santarém, F., Saarinen, J., & Brito, J. C. (2020). Mapping and analysing cultural ecosystem services in conflict areas. *Ecological Indicators*, *110*, 105943.

[38] Santarém, F., Saarinen, J., & Brito, J. C. (2020). Mapping and analysing cultural ecosystem services in conflict areas. *Ecological Indicators*, *110*, 105943.

[39] Sun, L. Y., Miao, C. L., & Yang, L. (2017). Ecological-economic efficiency evaluation of green technology innovation in strategic emerging industries based on entropy weighted TOPSIS method. *Ecological Indicators*, *73*, 554-558.

[40] Tamošaitienė, J., & Gaudutis, E. (2013). Complex assessment of structural systems used for high-rise buildings. *Journal of Civil Engineering and Management*, *19*(2), 305-317.

[41] Trudeau, D. (2018). Integrating social equity in sustainable development practice: Institutional commitments and patient capital. *Sustainable cities and society*, *41*, 601-610.

[42] Vivas, R., Sant'anna, Â., Esquerre, K., & Freires, F. (2019). Measuring Sustainability Performance with Multi Criteria Model: A Case Study. *Sustainability*, *11*(21), 6113.

[43] Wu, Y., Yan, Y., Wang, S., Liu, F., Xu, C., & Zhang, T. (2019). Study on location decision framework of agroforestry biomass cogeneration project: A case of China. *Biomass and Bioenergy*, *127*, 105289.

[44] Yu, X., Zhang, S., Liao, X., & Qi, X. (2018). ELECTRE methods in prioritized MCDM environment. *Information Sciences*, *424*, 301-316.

[45] Zhang, M., Gu, J., & Liu, Y. (2019). Engineering feasibility, economic viability and environmental sustainability of energy recovery from nitrous oxide in biological wastewater treatment plant. *Bioresource technology*, *282*, 514-519.

[46] Zhou, F., Lin, Y., Wang, X., Zhou, L., & He, Y. (2016). ELV recycling service provider selection using the hybrid MCDM method: a case application in China. *Sustainability*, *8*(5), 482.