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Measuring priorities of sustainable post-pandemic tourism policy factors using novel fuzzy multi-criteria decision making approach

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ABSTRACT
In recent years, research on tourism risks and public health safety has emerged as one of the most pressing issues in the tourism industry. This issue arose as a result of the unanticipated calamity that shook the entire world, affecting several businesses, conspicuously the travel industry, and causing nations throughout the world to experience severe and catastrophic economic collapse. The multiple interwoven elements of this industry, that is, the direct and indirect effects of the global outbreak on tourism, notably on opportunities for employment, gathered traction in the interim. Considering this, our research intends to effectively deal with the aforementioned difficulties by laying out sustainable policies that can perhaps be utilized to mitigate risks in such unforeseen situations, which could be highly beneficial in the near future. In order to achieve this goal, a knowledge-based fuzzy multi-criteria decision making (MCDM) strategy was utilized to prioritize and enhance the important networks within the travel industry. Furthermore, to deal with uncertain information, a newly developed spherical fuzzy set was combined with the analytical hierarchy process and weighted aggregated sum product assessment to examine and evaluate the five different dimensions considered.

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Introduction

At a time when concerns about climate change, pollution and the overall sustainability of contemporary forms of tourism were already prominent, travel demand dropped as a result of the recent unprecedented outbreak. The high levels of infection and fear led to a decline in both domestic and international travel, which in turn led to a domino effect that reduced the number of jobs in the travel industry and also disrupted the economic output by lowering the

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total number of visitors (Miao et al., 2022). In order to stop the spread of the virus and preserve lives, rapid closure of borders and planes were taken into action. This cataclysmic situation not only had a significant detrimental effect on aviation but also on hospitality, shipping, travel agencies, restaurants (Chang et al., 2022) and on the lives of people whose sole source of livelihood was the travel sector (Gautam, 2023). Even the flow of medical workers and supplies (Devi, 2020) to treat the infected patients were affected during this period. The countries that were reliant on tourism for a significant portion of their economies (Khalid et al., 2021) were also greatly disturbed by this disaster due to the severe declines in domestic and international travel, undermining the viability of this industry.

According to study reports by the international travel and tourist council and the inimical impact of this virus on people's health care (Godovykh & Ridderstaat, 2020), 75 million individuals worldwide were immediately at risk for losing their jobs. For instance, according to estimates from the united nations world tourism organization, the abundant natural resources, hospitality, culture, customs and ethnic diversity in India generated about 2.7% of the world's tourism-related gross domestic product and based on the third tourism satellite account, the travel sector contributed 5.2% of the nation's gross domestic product and 12.4% of all jobs. But the gross domestic product loss from tourism turned out to be $2.1 trillion in 2020 worldwide. This staggering loss of one million jobs per day in this sector is another projection made by world travel and tourism council (Yang et al., 2021). These details made it clear how the direct and indirect shares play a significant role in the economic sectors of the expanding demand for tourism (Xiang et al., 2020).

Guan-dong Province faced a similar risky situation in 2004 as with the pandemic. The province faced a severe SARS outbreak, which threatened to spread to other parts of the country. The government of the province took immediate steps to contain the spread of the virus, including quarantining people who had been exposed to the virus and limiting the movement of individuals. Later, Pine and McKercher (2004) examined and studied the economic performance of the nations in three different periods namely, prior, during and following the outbreak and found that the nation's economy had experienced a severe decline. Subsequently, Mao et al. (2010) determined that the SARS outbreak had a large and enduring impact on the region's economic performance by analyzing recovery trends using a catastrophic cusp model.

Therefore, it is essential for policymakers to evaluate the pandemic's economic effects in real time to support programs for restoring and strengthening household livelihoods (Estiri et al., 2022). It was also necessary to prioritize a concerted and coordinated recovery to ensure the survival of the economy as well as the lives of several people. Pertinent advancements, tactics and measures are some of the active tourist policies for a swift recuperation of this industry. Sheller (2021) offered the theoretical concept of mobility justice as a way to think about the difficulty of sustainability transitions in the context of tourism mobilities, and disaster response. The announcement of progressive unlocking, severe protective standards for restarting productive operations were also put in place to guarantee the populace's safety (Estiri et al., 2022).

Sustainable tourism

Transforming conventional tourism into sustainable tourism implements long-term policies to address unforeseen problems. Tourism must take into account all its historical, current and potential economic, social and environmental impacts. Tourism is a controversial approach to sustainable development because it can negatively impact ecosystems and, occasionally, reinforce anthropocentric power. Discussions of overt efforts to position tourism as a specific activity separate from sustainable tourism development are key achievements in the bottom-up approach to development (Sharpley, 2020). A social innovation-centered approach to sustainable development offers a cross-cultural development agenda and critical institutions (Thomsen et al., 2020). This becomes narrower in their focus when they advocate for the inclusion and protection of rights within recipient cultures' social norms (Thomsen et al., 2021) and development processes (Wang et al., 2022). However, a research study is needed to assess the financial disparity and health-related policy measures in sustainable tourism.

In order to forecast how the tourism industry would regain its pre-pandemic setting through policy interventions, the national council of applied economic research documented the economic losses caused by the changes experienced throughout the pandemic as well as the likely recovery phases of the sector after the pandemic. Furthermore, scientific sectors like healthcare and medicine began to employ social network analysis techniques and community discovery algorithms in order to regain their lost status (Rostami et al., 2023). Additionally, a survey of the opinions of numerous researchers results that, we also fail to consider the tourist industry's sustainability. Because sustainable development modifies the social constructions that exist between social interactions and socio-technical systems (Bramwell et al., 2017), its primary goals are to encourage community involvement and capacity building. Efforts to address socioeconomic and ecological situations while improving both human and nonhuman species' quality of life are made through global sustainable development programs like the United Nations sustainable development goals (Copeland, 2020; Thomsen & Thomsen, 2021).

Literature review

Applications from various fields of study use fuzzy multi-criteria decision making (MCDM) in evaluating criteria and select optimal alternatives since the fuzzy MCDM technique blends fuzzy set theory and MCDM methods (Wu et al., 2009). In the MCDM process, there are several subjective approaches (Sahoo et al., 2016), for example, the flexible multi-stage hierarchical structure developed by Saaty (1988) named as analytic hierarchy process assesses the consistency of the judgments (Vaidya & Kumar, 2006). MCDM was even able to tackle difficulties that were complicated in nature, as well as when the systems were inconsistent due to a lack of information or in circumstances where there was presence of more than ten criteria (Liou & Tzeng, 2012). Therefore, the inclusion of fuzzy sets with MCDM assists to resolve its inability to handle uncertainty by managing with such ambiguous situations through fuzzy characteristics (Lai, 1995).

To this retrospective day, a lot of researchers are becoming interested in the topic of MCDM, particularly in operation research. Factors such as technological, economic, ecological, social, geographical are being studied with the limitations in MCDM (Narayanamoorthy et al., 2022). In general, high-dimensional data are produced as a result of improvements in data collection techniques, leads to the "curse of dimensionality" (Sheikhpour et al., 2023). In most of the previous studies, accuracy, accessibility, effectiveness and sustainability were the attribute that were usually being employed in the fuzzy analytical hierarchy process technique (Dhingra et al., 2022). This technique was used frequently to identify, compare the effectiveness and reduce the difficulties while determining the weights of the attributes (Kabir et al., 2022). Kabir et al. (2022) produced a propagation neural network-based model for the evaluation of safety and risk by finding criterion index values employing fuzzy MCDM techniques.

Until now, numerous techniques have been established for ranking the alternatives based on various kinds of approaches, such as the distance-based method, utility theory, the outranking strategy, etc. In our work, we employed the weighted aggregated sum product assessment technique, which was found to be a synthesis of the weighted sum model (Chourabi et al.,

2019) and the weighted product model (Mulliner et al., 2016) methods. In comparison to weighted sum model and weighted product model, weighted aggregated sum product assessment method was proven to be more effective in providing solutions as it incorporates a simple mathematical strategy. Table 1 examines some tourism-related research developed with MCDM techniques. Table 2 displays recent studies on the weighted aggregated sum product assessment technique in the MCDM field. The nomenclature is presented in Table 3.

Reasons for undertaking this study

A comprehensive description of the way the tourism sector will operate in risky situations like the 2019 pandemic has not yet been concisely found in any studies. There is not much information available on effects of the pandemic shock on lives that were fully dependent on the tourism industry. Quantification of the direct and indirect effects of tourism-related activities on various sectors of the economy, particularly household income is not clearly provided in literature. There has been no contrast or detailed study of how tourism was functioning during the three time periods, namely, pre-pandemic, pandemic and post-pandemic. The use of more sophisticated, sustainable and environmentally friendly approaches in the tourism sector is not readily apparent. Studies on how elements and aspects affect the management and implementation of sustainable tourism policies were lacking, despite the fact that this industry should continually be aware of the factors that need to be prioritized to properly manage such risk. As far as we are aware, there has been no study that utilized spherical fuzzy set, analytical hierarchy process and weighted aggregated sum product assessment methodologies in the tourist business to offer a fresh, consistent technique of decision-making analysis on issues relating to tourism that would be very useful to decision-makers for risk preparedness. To determine which factors are crucial for developing sustainable policies that will prevent uncertainty in the tourist sector is unclear.

Contribution and novelty

Therefore, this article aims to examine dimensions in three different contexts: (a) prepandemic – to comprehend how the factors function (Pine & McKercher, 2004); (b) pandemic – to identify the factors that were affected and their significance (Wang et al., 2022); and (c) post-pandemic – to investigate the factors that should be prioritized for sustainability (Miao et al., 2022). This was done since tourism must take into account all its historical, current and potential economic, social and environmental impacts. A hybrid MCDM problem was constructed and put into action using a total of five dimensions and eighteen associated criteria. A unique knowledge-based hybrid fuzzy MCDM technique was utilized to manage dependent relationships among the various criteria in fuzzy environment. The goal of the MCDM problem was to help the decision-maker decide which dimension is the most important based on the characteristics of the criteria. The analytic hierarchy process technique is an effective tool for solving decision-making difficulties, due to its benefits, such as its simplicity of use and capacity to concurrently examine benefit and cost criteria. Analytic hierarchy process makes things easier to grasp by demonstrating weighing using pairwise comparisons, in addition to being a strategy that may be used to simplify even complicated situations. Analytic hierarchy process also does sensitivity analyses and enables the decision-maker to gauge the consistency of their choices (Toksari & Toksari, 2011). The weighted aggregated sum product assessment approach is used to analyze the many dimensions taken into consideration (Deveci et al., 2018; Xiong et al., 2020). The data values in the decision matrix were filled using a newly advancing fuzzy set dubbed spherical fuzzy set since it can manage the data uncertainty and its vagueness at several levels. The assessment model was designed based on expert opinion and real-world performance.

Table 1. Review on tourism sector.

Author	Model/Method	Description
Nguyen et al. (2020)	Grey DEMATEL	Explored the sustainable indices to gauge the unemployment issue
Khalid et al. (2021)	CESI	The magnitude of the tourism industry is a strong predictor of monetary and fiscal responses to the outbreak
Yeh (2021)	SPSS Modeler	Qualitative study approach was investigated at the Tourism Crises and Disaster Disaster Management in the context of the current crises
Ghosh and Bhattacharya (2022)	MEREC + Grey CoCoSo	Examined COVID-19's effects on the tourism and hospitality sectors' financial performance
Shabani et al. (2022)	BMW + FTOPSIS	Builded up a framework for assessing Tehran's public transportation system in the face of the Corona outbreak
Wang et al. (2022)	CGE Model	In the midst of a pandemic, many policies pertaining to public health were evaluated
Khajiyan Sheini Pour and Hemati (2022)	FAHP + FVIKOR	Examined the outcomes of various marketing initiatives for hotels in tourism

Table 2. Literature survey of WASPAS method.

Author	Application	Description
Pamucar et al. (2022)	Site selection for automobile industry	Proposed integrated fuzzy-based WASPAS model in a real-world case study.
Al-Barakati et al. (2022)	Renewable energy source selection	Using new similarity metrics, an expanded interval-valued pythagorean fuzzy WASPAS approach used and found optimal solution.
Masoomi et al. (2022)	Supplier selection	A strategic supplier selection process with characteristics weighting and ranking determined by an unified WASPAS methods.
Thanh and Lan (2022)	Location selection	In order to pick the best location, a fuzzy AHP model, and the WASPAS method been utilized well.
Aytekin et al. (2022)	Firm selection	An integrated fermatean fuzzy entropy and WASPAS approach utilized to evaluate the pharmaceutical distribution and storage company selection.
Alrasheedi et al. (2022)	Sustainable manufacturers selection	Evaluating sustainable manufacturing enterprises by employing multi-method integrated WASPAS technique.

Table 3. Nomenclature.

AHP	Analytic Hierarchy Process
BWM	Best-Worst Method
CESI	COVID-19 Economic Stimulus Index
CGE	Computable General Equilibrium
CoCoSo	COmbined COmpromise SOlution
DEMATEL	DEcision-MAking Trial and Evaluation Laboratory
IPA	Importance-Performance Analysis
MCDM	Multi-Criteria Decision Making
MEREC	MEthod based on the Removal Effects of Criteria
PiFS	Picture Fuzzy Set
SPSS	Statistical Package for the Social Sciences
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution
VIKOR	VlseKriterijumska Optimizacija I Kompromisno Resenje
WASPAS	Weighted Aggregated Sum Product Assessment

Methodology

The conceptual framework for the initiative to improve tourist policy is presented in Figure 1. After extensive research, a total of eighteen criteria were found in the literature, including green and clean environment, natural resources, ecology, eco-disaster, innovation, digital advancement, infrastructure, humanities, information exchange, human resources, law and amendment, local development, policy implementation, global marketing, household subsidies and stability assurance, sophisticated transportation network, safety and security and pandemic measures. These criteria have all been grouped into five dimensions: ecotourism resources, sustainable industries, social influence, economic influence and safe and secure environment. These characteristics are briefly described in Table 4. The data's for our research has entirely been taken from the review of literature. A fusion of analytical hierarchy process and weighted aggregated sum product assessment method under spherical fuzzy environment was used in this investigation.

Analytical hierarchy process was used to determine and investigate the impact and applicability of each criterion while weighted aggregated sum product assessment was used to examine the impact of tourist policies on the natural world and human civilization. Both the decision matrix and the pairwise comparison matrix are built using the spherical fuzzy linguistic preference scale (Table 5). Numerous writers have analyzed the theoretical and practical efficacy of the analytical hierarchy process and weighted aggregated sum product assessment method (Cheung et al., 2002), with the debate concentrating on four key topics: the axiomatic basis, the proper interpretation of priorities, the 9-point measuring scale and the ranking difficulty. However, for three-level hierarchical systems at least, the majority of the issues in these areas have been partially overcome (Chen et al., 2011). We have no additional suggestions for that conversation. Instead, the primary goal of this article is to provide a new method for the tourist management and policy-making sectors to address ambiguity and imprecision.

Spherical fuzzy set

Let $\mathfrak{R}$ denote an Universal set, then a spherical fuzzy set on $\mathfrak{R}$ is defined as:

$$\mathfrak{I} = \langle \omega, (\alpha_{\mathfrak{I}}(\omega), \beta_{\mathfrak{I}}(\omega), \gamma_{\mathfrak{I}}(\omega)) \mid \omega \in \mathfrak{R} \rangle \quad (1)$$

where $\alpha_{\mathfrak{I}}(\omega) : \mathfrak{R} \to [0,1], \beta_{\mathfrak{I}}(\omega) : \mathfrak{R} \to [0,1]$ and $\gamma_{\mathfrak{I}}(\omega) : \mathfrak{R} \to [0,1]$ signifies the membership, neutral and non-membership of ω to $\mathfrak{I}$, respectively, having the condition $0 \leq (\alpha_{\mathfrak{I}}(\omega))^2 + (\beta_{\mathfrak{I}}(\omega))^2 + (\gamma_{\mathfrak{I}}(\omega))^2 \leq 1$.

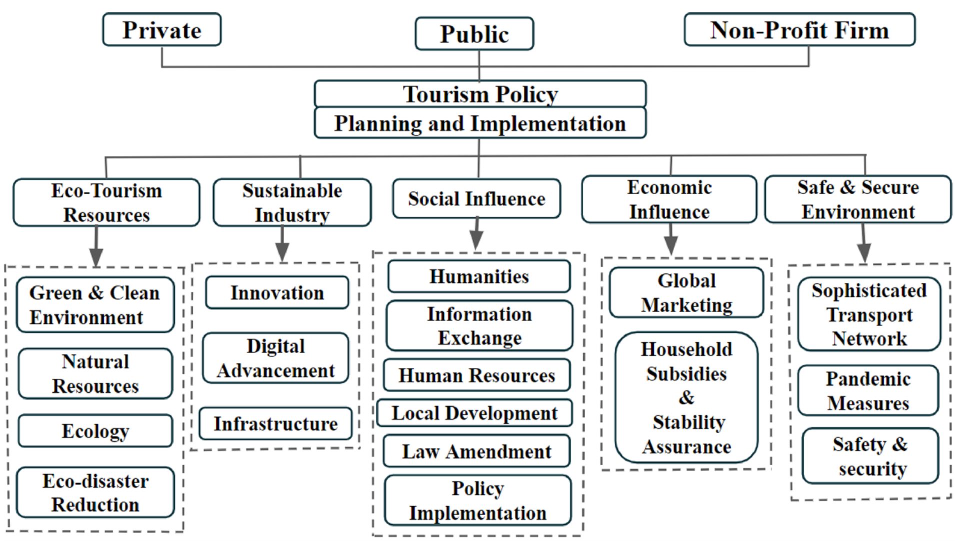

Figure 1. Conceptual framework.

Table 4. Tourism policy dimensions and criteria for periodic assessment.

Periods	Dimensions	Criteria	Explanation	Cite code
Pre-pandemic	Eco-tourism resources	C11 – Green and clean environment	Creation of healthy and clean atmosphere	Wangzhou et al. (2023)
		C12 – Natural resources	Conserving, protecting and maintaining of natural resources while responding to tourism needs	Xiang et al. (2020)
		C13 – Ecology	Ecological maintenance and its training to ensure the tourism development	Heshmati et al. (2022)
		C14 – Eco-disaster reduction	Establishment of environmental disasters reducing strategy	Chang et al. (2022)
	Sustainable industries	C21 – Innovation	Merging the cultural and creative elements	Giotis and Papadionysiou (2022)
		C22 – Digital advancement	Implementation of contemporary techniques and leveraging virtual reality	Popkova et al. (2022)
Pandemic		C23 – Industrial infrastructure	Up-gradation of auxiliary and supportive systems, equipment, and facilities	Broo et al. (2022)
	Social influence	C31 – Humanities	Enhancement of the standard on humanities, resources, events and amenities	Hansen et al. (2023)
		C32 – Information exchange	Enhancement of information exchange to improve understanding between natives and visitors	Cong and Nam (2022)
		C33 – Human resources	Enhancement of the efficacy of human resources	?
		C34 – Local development	Reinvigorate rural development	Gautam (2023)
		C35 – Law amendment	Reformulation of the law to reflect global trends	Widiatedja and Suyatna (2022)
Post-pandemic		C36 – Policy implementation	Endorsement of the planned implementation of the policy	Niavis et al. (2022)
	Economic influence	C41 – Global marketing	Usage of strategic marketing to compete on the global stage	Kilipiri et al. (2023)
		C42 – Household subsidies and stability assurance	Offering domestic assistance and guarantees of stability during unanticipated turbulence	Estiri et al. (2022)
	Safety and security	C51 – Sophisticated transport network	Increasing the efficiency and safety of the transport network to enable it to reach all destination	Jamaluddin and Rahmat (2023)
		C52 – Pandemic measures	Efficient medical assistance and pandemic preparedness actions	Miao et al. (2022)
		C53 – Safety and security	Effective law enforcement to protect residents' safety and the security of visitors with health concern	Jiménez-Medina et al. (2022)

Basic operations on spherical fuzzy set

Let $\Im_A = (\alpha_{\Im_A}, \beta_{\Im_A}, \gamma_{\Im_A})$ and $\Im_B = (\alpha_{\Im_B}, \beta_{\Im_B}, \gamma_{\Im_B})$

1. Addition

$$\Im_A \oplus \Im_B = \langle \sqrt{\alpha_{\Im_A}^2 + \alpha_{\Im_B}^2 - \alpha_{\Im_A}^2 \alpha_{\Im_B}^2}, \beta_{\Im_A} \beta_{\Im_B}, \sqrt{\left(1-\alpha_{\Im_B}^2\right)\gamma_{\Im_A}^2 + \left(1-\alpha_{\Im_A}^2\right)\gamma_{\Im_B}^2 - \gamma_{\Im_A}^2 \gamma_{\Im_B}^2} \rangle \tag{2}$$

2. Multiplication

Table 5. Spherical fuzzy comparison linguistic 9-point scale.

Linguistic terms	Score index	SF scale
Absolutely high preferred	9	(0.9,0.1,0.1)
Very highly preferred	7	(0.8,0.2,0.1)
Highly preferred	5	(0.7,0.3,0.2)
Slightly more preferred	3	(0.6,0.4,0.3)
Equally preferred	1	(0.5,0.6,0.4)
Slightly low preferred	1/3	(0.4,0.7,0.3)
Low preferred	1/5	(0.3,0.8,0.2)
Very low preferred	1/7	(0.2,0.9,0.1)
Absolutely low preferred	1/9	(0.1,0.9,0.1)

$$\Im_A \otimes \Im_B = \langle \alpha_{\Im_A}\alpha_{\Im_B}, \sqrt{\beta_{\Im_A}^2 + \beta_{\Im_B}^2 - \beta_{\Im_A}^2\beta_{\Im_B}^2}, \sqrt{\left(1-\beta_{\Im_B}^2\right)\gamma_{\Im_A}^2 + \left(1-\beta_{\Im_A}^2\right)\gamma_{\Im_B}^2 - \gamma_{\Im_A}^2\gamma_{\Im_B}^2} \rangle \quad (3)$$

3. Scalar Multiplication ζ, $(\zeta > 0)$

$$\zeta\Im_A = \langle \sqrt{1-\left(1-\alpha_{\Im_A}^2\right)^{\zeta}}, \left(\beta_{\Im_A}\right)^{\zeta}, \sqrt{\left(1-\alpha_{\Im_A}^2\right)^{\zeta} - \left(1-\alpha_{\Im_A}^2 - \gamma_{\Im_A}^2\right)^{\zeta}} \rangle \quad (4)$$

4. Exponent of $\Im_A$, (ζ, where $\zeta > 0$)

$$\left(\Im_A\right)^{\zeta} = \langle \left(\alpha_{\Im_A}\right)^{\zeta}, \sqrt{1-\left(1-\beta_{\Im_A}^2\right)^{\zeta}}, \sqrt{\left(1-\beta_{\Im_A}^2\right)^{\zeta} - \left(1-\beta_{\Im_A}^2 - \gamma_{\Im_A}^2\right)^{\zeta}} \rangle \quad (5)$$

Score function for spherical fuzzy set (Toksari and Toksari, 2011)

Score $(\Im_A) = \frac{1}{3}(2 + \alpha_{\Im_A} - \beta_{\Im_A} - \gamma_{\Im_A})$

Algorithm for finding the criteria weights

As we seen in literature study about analytic hierarchy process, the decision problem is structured hierarchically with finite number of elements at different levels as in Figure 1. Analytic hierarchy process is used to decompose intricate decisions into a series of pairwise comparison matrix (PCM). The final pairwise comparison matrix can be structured as:

$$\mathbb{X} = \begin{bmatrix} 1 & \mathbb{X}_{12} & \cdots & \mathbb{X}_{1n} \\ \vdots & \vdots & \vdots & \vdots \\ \mathbb{X}_{n1} & \mathbb{X}_{n2} & \cdots & 1 \end{bmatrix}.$$

Step 1: Substitute the spherical fuzzy 9-point preference values for the respective compared score indexes and evaluate the score values.
Step 2: Each scored pairwise comparison matrix elements should be divided by the sum of the columns to normalize the matrix.
Step 3: Calculating the criteria weights by averaging row-wise elements of the normalized matrix.
Step 4: Considering the weight of each criterion, the components of the weighted sum vector are divided into groups. The average of the variables is then determined and represented by $\lambda_{\max}$.
Step 5: The consistency index $\mathbb{CI}$ of the n alternatives can be obtained by:

$$\mathbb{CI} = \left(\lambda_{\max} - n\right)/(n-1)$$

Step 6: The random index (RI) values can be fixed as in Table 6 and determine the consistency ratio, $\mathbb{CR} = \mathbb{CI}/\mathbb{RI}$. If $\mathbb{CI}/\mathbb{RI} < 0.1$, the degree of consistency is acceptable otherwise (Gautam & Kumar, 2021).

Algorithm for attributes ranking evaluation

The weight-dependent alternative ranking method weighted aggregated sum product assessment being improved with spherical fuzzy set preferences from Table 5. Accuracy of the integrated weighted aggregated sum product assessment model is higher than weighted sum model and weighted product model. The basic steps of the weighted aggregated sum product assessment method can be given as follows:

Step i: Constructing the decision matrix $\mathbb{G}$ by an expert, as follows:

$$\mathbb{G} = \left[\mathbb{G}_{ij}\right]_{m \times n} = \begin{bmatrix} g_{11} & g_{12} & \cdots & g_{1n} \\ g_{21} & g_{22} & \cdots & g_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ g_{m1} & g_{m2} & \cdots & g_{mn} \end{bmatrix} \tag{6}$$

where $\mathbb{G}_{ij}$ denotes the performance value of ith dimension on j^{th} criterion assigned by the professional, $1 \le i \le m,\ 1 \le j \le n$.

Step ii: Normalization of the decision matrix carries through two cases based on cost and beneficial category of the attributes by using,

$$\bar{\mathbb{G}}_{ij} = \begin{cases} \mathbb{G}_{ij} \oslash \max_i \left\{\mathbb{G}_{ij}\right\} & forbeneficialcriteria \\ \min_i \left\{\mathbb{G}_{ij}\right\} \oslash \mathbb{G}_{ij} & forcostcriteria \end{cases} \tag{7}$$

Step iii: The performance of the alternatives is computed as weighted sum model approach using,

$$\mathbb{S}_i^{(1)} = \sum_{j=1}^{n} \bar{\mathbb{G}}_{ij} w_j \tag{8}$$

where w_j stands for analytic hierarchy process criterion weights.

Step iv: Evaluate the performance characteristics of the alternatives as weighted product model approach using,

$$\mathbb{S}_i^{(2)} = \prod_{j=1}^{n} \left(\bar{\mathbb{G}}_{ij}\right)^{w_j} \tag{9}$$

Step v: The final utility function values (S_i) represent the postures of alternatives in a broad ranking and is calculated by adding the variety of data derived by Equations (8) and (9),

$$\mathbb{S}_i = \lambda \mathbb{S}_i^{(1)} + (1-\lambda)\mathbb{S}_i^{(2)} \tag{10}$$

where λ is a parameter with values ranging from 0 to 1.

Table 6. RI values.

n	RI	*n*	RI
4	0.900	12	1.480
6	1.240	14	1.570
8	1.410	16	1.605
10	1.490	18	1.615

Step vi: Arrange the derived S_i values in descending order to determine the final rankings of the alternatives.

Results and discussion

The estimated consequences on several aspects of the tourism-related activities are described. For three eras, the independent decision matrix has been built by the expert. Additionally, the method of data accumulation and its specifics are presented.

Annotation of data

For our research, the hybrid MCDM technique requires data in two distinct formats for each period: First, a pair-wise comparison matrix of the criteria and secondly, a decision matrix created by comparing all of the criteria to all possible alternatives. For this reason, a thorough literature review was undertaken to determine the significance of each component, its influence on the tourist business, and the status of criteria in each dimension. Here, the comparison value between each criterion was taken from the linguistic scale presented in Table 5 and the respective score indexes for all the three periods are shown in Tables 7–9. The values from these preference tables are taken as the input values for the analytic hierarchy process technique. Similarly, the decision matrix for the three distinct periods is presented in Tables 10–12. These data in these matrices are further analyzed using the weighted aggregated sum product assessment techniques for finding which dimension required more attention for risk preparedness.

Mathematical evaluation

The score indexes of the spherical fuzzy linguistic scale were used as input values for the pair-wise comparison matrix to derive the most accurate weights of the criterion. This 9-point spherical fuzzy scale was useful to deal with the decision environment's inherent complexity, imperfect knowledge, and ambiguity. The spherical fuzzy number was calculated to a single real number using the scoring function. The matrices were then normalized in step 2, and step 3 was used to compute the criteria weights. The computation of this analytic hierarchy process approach was done using Microsoft Excel software. Steps 4 and 5 were used for checking the

Table 7. PCM for pre-pandemic era.

	C11	C12	C13	C14	C21	C22	C23	C31	C32	C33	C34	C35	C36	C41	C42	C51	C52	C53
C11	1	1/3	5	5	7	5	5	7	7	7	9	9	9	3	9	3	9	3
C12	3	1	5	5	7	5	5	7	7	7	9	9	9	3	9	3	9	3
C13	1/5	1/5	1	5	5	5	5	7	7	7	7	9	9	1/5	9	5	9	1/7
C14	1/5	1/5	1/5	1	5	3	3	5	5	7	7	7	9	1/5	9	5	9	1/7
C21	1/7	1/7	1/5	1/5	1	1/3	1/3	5	5	7	7	7	9	1/5	9	1/5	9	1/7
C22	1/5	1/5	1/5	1/3	3	1	1/3	5	5	7	7	7	9	1/5	9	1/5	9	1/7
C23	1/5	1/5	1/5	1/3	3	3	1	5	5	7	7	7	9	1/5	9	1/3	9	1/7
C31	1/7	1/7	1/7	1/5	1/5	1/5	1/5	1	5	5	7	7	9	1/5	9	1/3	9	1/7
C32	1/7	1/7	1/7	1/5	1/5	1/5	1/5	1/5	1	5	5	7	7	1/5	9	1/3	9	1/7
C33	1/7	1/7	1/7	1/7	1/7	1/7	1/7	1/5	1/5	1	5	7	7	1/5	9	1/3	9	1/7
C34	1/9	1/9	1/7	1/7	1/7	1/7	1/7	1/7	1/5	1/5	1	5	7	1/5	7	1/3	9	1/7
C35	1/9	1/9	1/9	1/7	1/7	1/7	1/7	1/7	1/7	1/7	1/5	1	5	1/5	7	1/3	9	1/7
C36	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/7	1/7	1/7	1/5	1	1/3	5	1/3	7	1/7
C41	1/3	1/3	5	5	5	5	5	5	5	5	5	5	3	1	5	3	7	1/3
C42	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/7	1/7	1/5	1/5	1	1/3	5	1/5
C51	1/3	1/3	1/5	1/5	5	5	3	2	3	3	3	3	3	1/3	3	1	5	1/3
C52	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/7	1/7	1/5	1/5	1	1/3
C53	1/3	1/3	7	7	7	7	7	7	7	7	7	7	7	3	5	3	3	1

Table 8. PCM for pandemic era.

	C11	C12	C13	C14	C21	C22	C23	C31	C32	C33	C34	C35	C36	C41	C42	C51	C52	C53
C11	1	3	5	7	9	5	7	3	3	5	7	9	5	3	9	5	1/3	1/3
C12	1/3	1	3	9	5	3	5	3	5	7	9	3	7	5	3	7	1/9	1/5
C13	1/5	1/3	1	7	3	5	5	7	7	5	9	3	5	5	3	5	1/5	1/7
C14	1/7	1/9	1/7	1	7	3	3	5	3	9	5	7	3	3	7	9	1/3	1/9
C21	1/9	1/5	1/3	1/7	1	5	9	3	5	7	5	3	5	9	3	3	1/5	1/5
C22	1/5	1/3	1/5	1/3	1/5	1	5	7	3	5	3	3	5	7	5	3	1/3	1/7
C23	1/7	1/5	1/5	1/3	1/9	1/5	1	5	5	3	9	5	7	5	9	5	1/5	1/3
C31	1/3	1/3	1/7	1/5	1/3	1/7	1/5	1	7	5	9	3	5	7	3	5	1/7	1/3
C32	1/3	1/5	1/7	1/3	1/5	1/3	1/5	1/7	1	7	5	5	3	5	7	3	1/9	1/5
C33	1/5	1/7	1/5	1/9	1/7	1/5	1/3	1/5	1/7	1	3	9	7	5	5	7	1/3	1/7
C34	1/7	1/9	1/9	1/5	1/5	1/3	1/9	1/9	1/5	1/3	1	7	5	3	9	5	1/7	1/9
C35	1/9	1/3	1/3	1/7	1/3	1/3	1/5	1/3	1/5	1/9	1/7	1	9	7	5	3	1/5	1/5
C36	1/5	1/7	1/5	1/3	1/5	1/5	1/7	1/5	1/3	1/7	1/5	1/9	1	5	3	7	1/3	1/3
C41	1/3	1/5	1/5	1/3	1/9	1/7	1/5	1/7	1/5	1/5	1/3	1/7	1/5	1	7	9	1/7	1/9
C42	1/9	1/3	1/3	1/7	1/3	1/5	1/9	1/3	1/7	1/5	1/9	1/5	1/3	1/7	1	5	1/5	1/5
C51	1/5	1/7	1/5	1/9	1/3	1/3	1/5	1/5	1/3	1/7	1/5	1/3	1/7	1/9	1/5	1	5	1/7
C52	3	9	5	3	5	3	5	7	9	3	7	5	3	7	5	1/5	1	1/5
C53	3	5	7	9	5	7	3	3	5	7	9	5	3	9	5	7	5	1

Table 9. PCM for post-pandemic era.

	C11	C12	C13	C14	C21	C22	C23	C31	C32	C33	C34	C35	C36	C41	C42	C51	C52	C53
C11	1	3	7333	3	9	9	3	5	9	5	5	5	7	7	3	7	1/3	1/5
C12	1/3	1	7	1/3	7	9	3	3	9	5	5	5	5	7	3	7	1/7	1/9
C13	1/7	1/7	1	1/7	5	7	1/7	1/5	9	1/5	1/3	1/3	1/3	3	1/5	3	1/9	1/9
C14	1/3	3	7	1	7	9	3	3	9	3	5	5	5	7	3	7	1/3	1/5
C21	1/9	1/7	1/5	1/7	1	3	1/7	1/7	5	1/5	1/5	1/5	1/3	1/3	1/7	1/3	1/9	1/9
C22	1/9	1/9	1/7	1/9	1/3	1	1/7	1/7	3	1/5	1/5	1/5	1/3	1/3	1/7	1/3	1/9	1/9
C23	1/3	1/3	7	1/3	7	7	1	3	7	3	5	5	5	7	3	7	1/5	1/7
C31	1/5	1/3	5	1/3	7	7	1/3	1	9	3	3	5	5	7	1/3	7	1/5	1/7
C32	1/9	1/9	1/9	1/9	1/5	1/3	1/7	1/9	1	1/5	1/5	1/5	1/3	1/3	1/7	1/3	1/7	1/9
C33	1/5	1/5	5	1/3	5	5	1/3	1/3	5	1	3	3	5	5	1/3	7	1/5	1/7
C34	1/5	1/5	3	1/5	5	5	1/5	1/3	5	1/3	1	3	5	7	1/3	9	1/5	1/7
C35	1/5	1/5	3	1/5	5	5	1/5	1/5	5	1/3	1/3	1	3	5	1/3	7	1/5	1/7
C36	1/7	1/5	3	1/5	3	3	1/5	1/5	3	1/5	1/5	1/3	1	3	1/3	5	1/5	1/7
C41	1/7	1/7	1/3	1/7	3	3	1/7	1/7	3	1/5	1/7	1/5	1/3	1	1/3	3	1/5	1/7
C42	1/3	1/3	5	1/3	7	7	1/3	3	7	3	3	3	3	3	1	3	1/3	1/5
C51	1/7	1/7	1/3	1/7	3	3	1/7	1/7	3	1/7	1/9	1/7	1/5	1/3	1/3	1	1/3	1/5
C52	3	7	9	3	9	9	5	5	7	5	5	5	5	5	3	3	1	1/3
C53	5	9	9	5	9	9	7	7	9	7	7	7	7	7	5	5	3	1

Table 10. DM for pre-pandemic era.

	C11	C12	C13	C14	C21	C22	C23	C31	C32	C33	C34	C35	C36	C41	C42	C51	C52	C53
Eco-tourism resources	9	7	9	1/7	3	9	9	1	3	1	7	5	9	1	1	1/3	5	9
Sustainable industry	7	3	5	1/5	7	9	9	1/3	1	7	5	5	9	9	1	3	7	7
Social influence	5	9	7	1/7	5	7	5	9	9	9	9	9	5	7	9	7	7	9
Economic influences	7	5	5	1/3	9	5	9	5	1/3	9	7	7	5	9	9	9	7	7
Safety and security	9	7	1	1/5	9	9	7	5	1	7	9	9	7	5	5	5	7	7

consistency and stability of the matrices. Table 13 shows the final weights of all eighteen criteria. Furthermore, the weighted aggregated sum product assessment evaluation was simulated using MATLAB Ra2020 to estimate the final results shown in Table 14. Through the following subsections, the findings of the three eras are discussed.

Table 11. DM for pandemic era.

	C11	C12	C13	C14	C21	C22	C23	C31	C32	C33	C34	C35	C36	C41	C42	C51	C52	C53
Eco-tourism resources	5	9	7	1/5	5	7	5	1	5	3	5	7	7	9	1	3	7	9
Sustainable industry	5	3	9	7	9	7	7	1/5	7	7	1	7	9	7	5	5	9	7
Social influence	3	5	5	1/5	7	9	7	7	9	7	9	9	5	1	5	7	9	7
Economic influences	5	5	1	1/3	5	5	1	7	1	3	7	5	9	9	9	7	5	9
Safety and security	7	7	5	1/5	7	9	9	5	1	9	9	7	7	1	9	9	5	9

Table 12. DM for post-pandemic era.

	C11	C12	C13	C14	C21	C22	C23	C31	C32	C33	C34	C35	C36	C41	C42	C51	C52	C53
Eco-tourism resources	9	9	9	1/3	7	5	7	1	3	5	1	5	9	5	5	9	3	9
Sustainable industry	5	5	9	1/5	9	9	9	1/3	3	3	7	1	7	9	1	7	7	5
Social influence	7	3	5	1/7	5	7	5	7	9	9	1	1	3	3	9	5	7	9
Economic influences	3	5	3	1/5	7	5	5	9	1	5	9	7	9	9	7	1	5	7
Safety and security	7	7	1	1/5	5	9	9	5	5	9	9	7	7	5	9	9	9	9

Table 13. Spherical fuzzy – AHP weights of attributes.

Criteria	Pre-pandemic	Pandemic	Post-pandemic
C11	0.0711	0.0677	0.0683
C12	0.0723	0.0637	0.0639
C13	0.0657	0.0622	0.0485
C14	0.0615	0.0591	0.0653
C21	0.0557	0.0579	0.0432
C22	0.0573	0.0557	0.0416
C23	0.0584	0.0560	0.0622
C31	0.0534	0.0534	0.0593
C32	0.0513	0.0517	0.0406
C33	0.0491	0.0508	0.0557
C34	0.0464	0.0476	0.0546
C35	0.0442	0.0482	0.0523
C36	0.0416	0.0461	0.0488
C41	0.0635	0.0450	0.0456
C42	0.0396	0.0428	0.0579
C51	0.0613	0.0435	0.0447
C52	0.0379	0.0665	0.0698
C53	0.0698	0.0821	0.0778

Table 14. Spherical fuzzy – WASPAS utility values of dimensions.

Dimensions	Pre-pandemic	Pandemic	Post-pandemic
Eco-tourism resources	0.8446	0.8296	0.8596
Sustainable industry	0.8171	0.8008	0.8110
Social indulgence	0.8810	0.8911	0.8341
Economic influences	0.8833	0.8240	0.8504
Safety and security	0.8822	0.9514	0.9134

Following the pandemic losses, it was essential to create a sustainable tourist business with the correct emphasis and advancements in tourism aspects to manage unpredictability and for risk preparedness in near future. The impact of the pandemic on pre-pandemic is depicted in

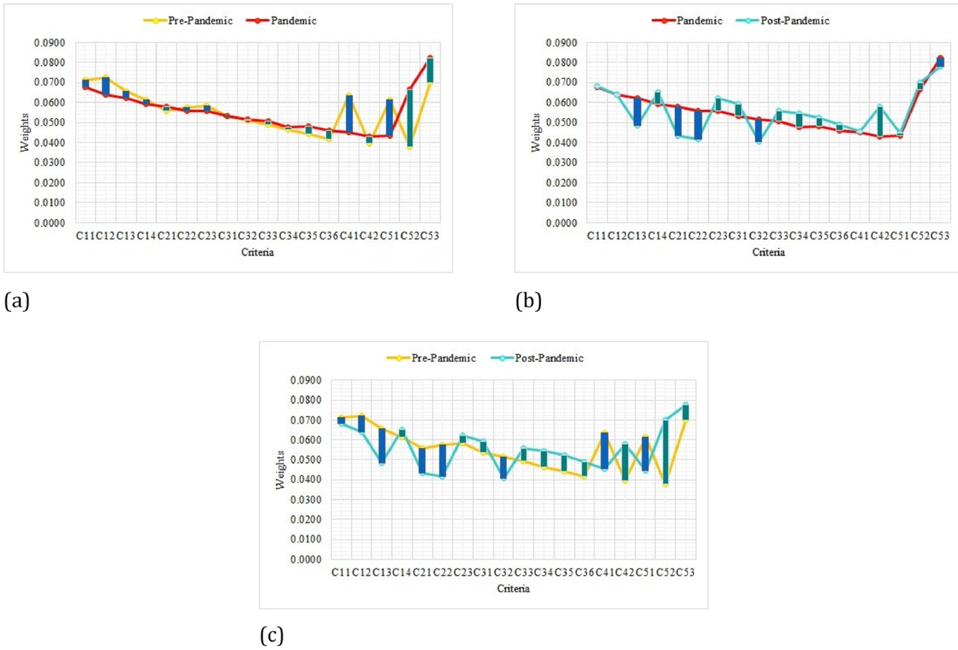

Figure 2. Comparison of criteria weights from different periods.

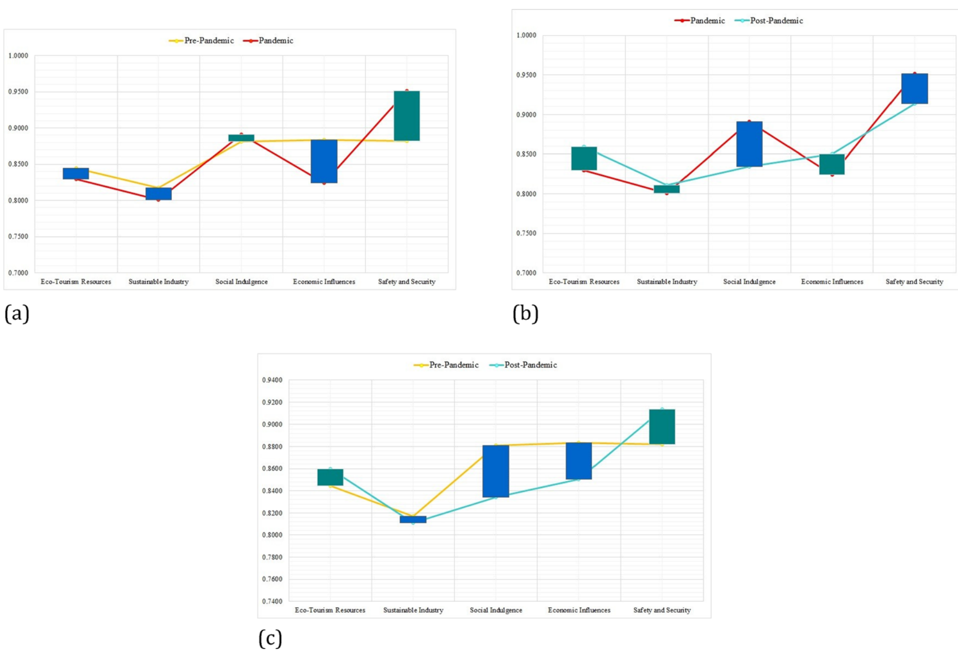

Figure 3. Comparison of dimensions ranking using WASPAS net ranking values.

the comparison graph (Figure 2), which also looks at weak point that needs to be strengthened. In this approach, post-pandemic examination of tourist factors with consideration of pandemic results shows that most of the elements are becoming more important than they were in the pre-pandemic condition. When establishing policy, it was important to give high priority to disaster prevention, household subsidies, local development, policy execution, infrastructure improvements, and legal modifications. Furthermore, compared to the pandemic scenario (Figure 3), economic impacts, eco-tourism resources and sustainable industries characteristics led in an increase in the significance of post-pandemic policy to prevent disasters, household suffering, and uncertain failures.

Since these results are reliable, these potent network interactions not only gave policymakers clever ideas for tourism policies, but they also made it easy to identify and address flawed or overlooked criteria, unfulfilled dimensions and low priority factors, which improves the challenging sustainability criteria. Because before executing projects or adjustments in the tourist sectors, multi-perspective analysis with clear outputs should assist the authorities in overcoming obstacles and making potential decisions/policies with thorough understanding. Moreover, our suggested spherical fuzzy – analytic hierarchy process – weighted aggregated sum product assessment technique has benefits over traditional methods such as computational simplicity, consistency of findings, realistic criterion priority, management of unclear or imprecise data and significant resistance to alternative rank reversal in any decision-making problems.

Nations have fought for economic stability with an array of regulations, policies and initiatives in an effort to prevent severe harm as a result of the economic downturn brought on by the pandemic. By 2024–2025, the tourist economy is predicted to return to its pre-pandemic level in terms of tourism spending, mostly propelled by domestic travel. By encouraging residents to travel domestically instead of abroad and focusing incentives on the companies that contribute the most to the tourism industry, the government started to promote domestic travel. In order to advance the tourism industry, some recommendations have also been made. These include the following: (1) Ensuring protocols, safety and security; (2) Strong tourism recovery plans; (3) Tax benefits, subsidies and incentives for households in the tourism sector; (4) Clean and healthy environment maintenance; (5) Digitization and technological innovation, and so forth. Also, these actions may be used to target the following aspects of India's new normal tourism: (1) Sustainable tourism; (2) Social welfare toward a larger purpose; (3) Climate change mitigation; and (4) Involving local people. Promoting the components of our research's findings can offer a chance to grow the sustainable tourism sector from a fresh angle that would satisfy the demands of the new normal or the new economic order by either enhancing or resolving the problems.

Conclusion

Spherical fuzzy information was crucial to this study's inclusion since it gives the expert a bigger working area within which to operate given their particular qualities. The aforementioned set along with the showed their effectiveness in finding the relative weights of the qualities, while weighted aggregated sum product assessment was helpful in indicating the crucial dimension that needed to be concentrated on and further enhanced. The 18 criteria that go along with the five dimensions form a network that were dependent on and impacted by one another. In the post-pandemic period, it has been discovered that safety and security, a green and clean environment, policy execution, international marketing, pandemic measures, household subsidies and technological progress are more successful at influencing the other factors.

The evaluation of the attributes and the data acquired based on a literature review on tourism policy and its execution greatly helped to solve this issue. This MCDM framework and the related study demonstrated the significance of evaluating factors that are based in nature, such as the environmental, economic and social attractiveness and recreational value of tourism resources. Furthermore, decision-making geared at the industry's long-term development was illustrated by the expansion of tourist management research. This provides strong quantitative and qualitative support for improvement for business professionals, policymakers, authorities and the government. In the future, if we are to face such kind of risky outbreaks, this study will provide a concise understanding of which factors to focus for the sustainable growth of the tourist sector.

Given that this framework has certain drawbacks as well, it is critical to expand simple computational techniques to meet the demands of varying MCDM issues. Stratified target analysis should be added to this method in further studies to examine the likelihood of achieving futuristic policy objectives. To learn about the consistency of the suggested MCDM approach, experiments including more challenging assessment issues or massive dimensional problems should be conducted.

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