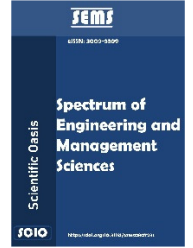




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## Achieving Sustainable Development Goals in the Tourism Industry: A Spherical Fuzzy Methodology for Choosing the Best Sustainable Marketing Strategy for Hotel Businesses

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### ABSTRACT

Hotel business can be designed with sustainability considerations by using proper marketing strategies. When evaluating sustainable marketing strategies, many factors should be considered, including economic, environmental, social, and operational engineering management components. Because of their diversified and dynamic nature, sustainable practices in hotel businesses generate complicated uncertainties deriving from sustainability concerns. This study aims to investigate the sustainability practices of hotel establishments, identify success factors, and highlight the most ideal strategy choices. The research introduces a spherical fuzzy decision-making methodology for stakeholders in hotel businesses. It is found that the most important strategy within the framework of sustainable practices in hotel businesses is the "auxiliary sustainable marketing strategy". The findings of the study not only identify the key success factors for implementing sustainability in the hospitality industry but also propose artificial intelligence-based strategic approaches for the most effective and efficient applications.

## 1. Introduction

Meadows *et al.* [1] provided an influential publication grounded in a systems-based model that utilized computer simulations to generate a range of scenarios through mathematical equations. At the heart of this theory lies the argument that the ongoing rise in human living standards, coupled with the increasing consumption of finite natural resources, is inherently unsustainable. Although technological progress has been made, the model underscores a critical concern: the annual

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depletion of resources continues to surpass their natural regeneration, thereby intensifying ecological pressures. Without prompt and significant action, this scenario is predicted to lead to a disastrous outcome.

A key milestone in advancing action was the release of the Our Common Future report [2], led by Gro Harlem Brundtland under the World Commission on Environment and Development (WCED). In this report, commonly referred to as the Brundtland Report, sustainable development is defined as fulfilling present needs without jeopardizing the ability of future generations to meet their own. The report promotes a global development approach that encourages more affluent nations to adopt lifestyles that remain within the ecological capacity of the Earth. Sustainable development is defined as a process in which technological progress, resource utilization, investment strategies, and institutional reforms must be harmonized with both present and future needs [2]. After the Brundtland Report, numerous developments took place within the realm of sustainability. A major turning point occurred in 2015 with the adoption of the 2030 Agenda for Sustainable Development by United Nations (UN) member states. This agenda introduced 17 Sustainable Development Goals (SDGs). In the understanding of global partnership, ending poverty and all deprivations, reducing inequality that envisages improvement in health and education, the idea of joint action of policies that encourage economic growth, mitigating climate change, protecting oceans and forests are targeted with the urgent call for action of all developed and developing countries [3].

Achieving the SDGs by 2030 will require the partnership of governments, private sector organizations, and citizens. It is expected that all sectors will make a significant effort and business will lead the way. It is especially important for companies to lead the change needed to achieve the SDGs [4]. In the past few decades, sustainability has made tremendous progress and has become a mandatory strategic policy in nearly every sector. In the global tourism industry, sustainability has also become a key area of evaluation, with industry stakeholders beginning to adapt it into their mainstream operations. It is likely that the tourism sector contributes directly or indirectly to all the SDGs. The tourism sector is specifically linked to SDGs such as Decent Work and Economic Growth (SDG 8), Responsible Consumption and Production (SDG 12), and Life Below Water (SDG 14).

In addition to the tourism sector, the hospitality industry, one of its key subsectors, has also become involved in sustainability initiatives. The industry's strong emphasis on sustainability arises from its ability to tackle global issues like climate change, as well as its economic, social, and environmental contributions, including its role in creating employment opportunities in countries alongside tourism [5]. The hospitality industry plays a crucial role in the sustainability process, given that hotel businesses have both direct and indirect effects on the areas they serve. Hospitality operations engage with a variety of sectors, and within hotel management, services like conferences, entertainment, leisure, and meeting spaces are pivotal in boosting the economic activities of local communities [6]. In short, the hospitality industry has a significant impact on the global economy, generating various economic and financial outcomes that contribute to its growing influence. These effects have prompted customers to encourage hotel companies to invest in sustainability and other social responsibility efforts.

Consistent growth in hotel visitors creates opportunities to enhance operational efficiency and service quality. However, this increase also brings about detrimental environmental consequences. Hotel operations, by nature, tend to have a more significant environmental footprint than similarly sized commercial buildings. These effects include high levels of water and energy use, air pollution, waste challenges, and environmental degradation. The influence of these factors on brand reputation and cost burdens is unquestionable [7].

The COVID-19 pandemic has brought sustainability back into focus, intensifying the call for action and increasing pressure on implementing sustainable practices. Meanwhile, governments and

regulatory agencies worldwide have started to demand sustainability action plans or reports [8]. It has become crucial for hotels to develop sustainability policies to improve their competitiveness and secure their long-term survival. By incorporating sustainability into their business models, hotels can take advantage of the opportunity to engage with global environmental, social, and economic frameworks, while strengthening their relationships with customers. However, despite the increasing interest in sustainability within the hospitality sector, research on sustainable hospitality remains limited. In other words, there is a gap in the literature regarding studies that examine sustainability practices in the hospitality sector.

### *1.1 Study Aims*

This study aims to investigate the sustainability practices of five-star hotel establishments operating in Istanbul, identify success factors, and highlight the most ideal strategy choices. The research employs the r,s,t-spherical fuzzy sets (SFSs), nearest solution to references (REF), and step-wise weight assessment ratio analysis (SWARA) methods from multi-criteria decision-making techniques. The main motivating questions of this study can be listed as follows:

- i. What are sustainability practices in hospitality businesses?
- ii. What are the factors affecting the success of sustainability practices in hospitality businesses?
- iii. What is the ideal strategy for sustainable hotel businesses?

### *1.2 Study Contributions and Advantages*

In line with the objectives outlined above, this study provides a comprehensive theoretical explanation of sustainability and sustainability-oriented practices and their impact on hotel enterprises. To this end, it includes an extensive review of the relevant literature. The findings of the study not only identify the key success factors for implementing sustainability in the hospitality industry but also propose strategic approaches for the most effective and efficient applications. The fact that the research is conducted specifically in Istanbul is noteworthy, as the city is a major tourism hub both in Türkiye and globally. The findings offer valuable insights into how Istanbul can evolve into a greener hospitality destination. The study serves as a guiding resource for stakeholders in the hotel industry. Furthermore, the results present solutions aimed at enhancing performance in hotel operations and offer indications regarding the areas in which hospitality management training should be concentrated.

This approach provides significant advantages and contributions to hotel businesses in terms of sustainability. Firstly, hotel managers do not have unlimited budgets when designing their operations and processes. In this context, it is necessary to utilize existing resources effectively and efficiently and to optimize operations within a limited budget. Therefore, examining practices from the perspective of economic sustainability in hotel businesses requires consideration of economic factors such as energy consumption, waste management, and recycling. However, the potential contributions of each sustainability practice vary and should be evaluated collectively. For example, although sustainability practices such as recycling have relatively low operating costs, their investment costs can be significantly higher compared to other types.

The social dimension of sustainability practices is another crucial perspective that policymakers and decision-makers need to consider. This user satisfaction-oriented perspective enhances social benefits and contributes to the more effective adoption of sustainability in hotel businesses. Evaluating and selecting the most appropriate types of marketing strategies also involves considering the operational and managerial aspects of sustainability, which is another critical factor for

policymakers and decision-makers. These evaluations play a significant role in ensuring long-term sustainability in hotel operations. Therefore, they can be considered as a vital and strategic roadmap that guides hotel managers and users in making strategic decisions regarding sustainable practices.

Due to the highly volatile and dynamic nature of the hospitality industry, there are significant and structural limitations and challenges in managing and modeling the existing uncertainties regarding sustainability and marketing strategies. Moreover, most studies have not adequately considered the linear and non-linear relationships and interactions among the criteria, and the contradictions between them have not been effectively or satisfactorily managed. In addition, current and potential integrations between sustainability practices and marketing strategies are often overlooked, and future-oriented projections are generally excluded from the scope of these studies.

More importantly, previous studies, particularly in the context of large metropolises like Istanbul, where highly complex local dynamics play a significant role, have remained theoretically and methodologically inadequate. This inadequacy stems from the fact that the decision-making models preferred or recommended in these studies often lack clear and comprehensible algorithms and fall short in evaluating multidimensional sustainability performance, especially under the uncertainties caused by various interrelated factors.

Furthermore, significant and critical gaps persist in the existing literature. Our field studies indicate that no decision support system or structured decision-making framework has been employed in this domain, and that the decision-making processes are predominantly carried out using traditional evaluation methods. In addition, this study not only contributes to the relative reduction of sustainability-related costs in hotel businesses but also facilitates the optimal integration of marketing strategies, thereby enabling the provision of more efficient and effective services with higher profitability.

r,s,t, SFSs enable the modeling of uncertainty in a broad way using flexible components. SWARA simplifies the process of determining weight values for criteria, making it easy to use and applicable. REF (nearest solution to references) seeks to deliver the best overall solution by incorporating local references within the criteria. In this study, we will employ the r,s,t-SF-SWARA-REF methodology.

Finally, the decision-making framework proposed in this study to address the relevant decision problem contributes to closing existing theoretical and methodological gaps in the literature, offering valuable insights for researchers in the field. In this regard, the approach proposed for evaluating hotel businesses from a sustainability perspective provides a robust and reliable theoretical foundation for both academic research and practical applications. From this perspective, the study and the proposed model may serve as a critical reference point for researchers focusing on solving decision-making problems in this domain.

## **2. Literature Review**

The advent of the Industrial Revolution precipitated profound transformations in economic and social structures on a global scale, ushering in a society that prioritized consumption over production. This transition concomitantly led to an augmentation in people's disposable income and leisure time. In short, the Industrial Revolution, which affected all spheres of life, and the increased accessibility of people, also had an effect on the phenomenon of tourism and travel. This transformation, which paved the way for mass tourism to emerge, has also resulted in significant advancements in the tourism and travel sector. The economic resources for regions that are visited by tourists have been generated, and socio-cultural and environmental impacts have been had, as a result of the spending of visitors in the destinations they visit and their multiplier effects. While the positive impacts of mass tourism are indisputable, it is equally important to acknowledge the negative consequences,

particularly in terms of the environment. Therefore, there is a necessity for greater responsibility towards sustainability to mitigate these adverse impacts [9].

The concept of sustainability, which is concerned with both the present and the future, is considered to have great potential as a means of addressing the negative impacts of tourism and ensuring the long-term viability of scarce resources [10]. The concept of sustainability has the potential to provide solutions not only for environmental protection in the tourism sector but also for problems that may arise in the social and economic dimensions of the tourist region. A considerable number of destinations that have become centers of tourist attraction implement plans and projects with all stakeholders to ensure that the tourism sector reaches its current balance. Hotel establishments, which meet many of the needs of people, such as accommodation, food, and drink in the tourist destinations visited, are also included in sustainable plans. These plans guide various criteria for hotel establishments, including the reduction of energy, water consumption, and waste [11].

The development of environmental management practices, in conjunction with the implementation of sustainability projects for hotels, which represent a significant proportion of tourism activities and travel, and the integration of these practices with sustainable marketing strategies, contribute to the creation of a clean and green environment. The primary objective of this study is to establish a ranking of the most significant sustainability criteria and to identify the most effective marketing strategies for ensuring the sustainability of hotels. In addition to the sustainability criteria applied in the management process of the hotel business, determining which of the marketing strategies is the most effective (e.g., the auxiliary sustainability marketing strategy, the transformative sustainability marketing strategy, the remedial sustainability marketing strategy, the segmentation and positioning strategy, and the competitive advantage strategy) will be of great importance in the implementation of the decisions to be taken and in the creation of awareness among consumers. In this context, numerous studies have been conducted to address the gap in the academic literature concerning hotel businesses, where the concept of sustainability is of great importance. Table 1 provides a concise overview of the literature on sustainability in the hotel industry.

By reviewing the studies in Table 1, it can be seen that the determination of sustainable criteria and the promotion of these criteria through sustainable marketing strategies will provide significant benefits in both the short and long term in terms of creating environmentally friendly practices and achieving sustainability policies. This study will contribute to filling the gap in the literature, as there is no other study that both ranks the criteria for hotels to be sustainable in order of importance as well as determines the most ideal sustainable marketing strategies accordingly. In addition, the results obtained with the methods used in this study will show the originality and difference of the study.

### **3. Methodology**

When modeling uncertainty-based problems, fuzzy sets have significant advantages. This study will employ  $r,s,t$ -SFs, which enable the processing of ambiguous information over a broad range. In this case, a subjective weighting technique based on the  $r,s,t$ -SF-SWARA is introduced. The rankings of the options will be determined using the novel  $r,s,t$ -SF-REF approach. The following subsections explain the methodology.

**Table 1**  
 Literature on sustainable hotel criteria

Author(s)	Objective(s)	Method(s)
Mihalič <i>et al.</i> [12]	In order to investigate the sustainability orientation of the Slovenian hotel industry, a sustainable hotel business model was developed.	Expert opinions, Delphi method
Berezan <i>et al.</i> [13]	It examined how sustainable hotel practices affected the satisfaction and return intentions of hotel guests of different nationalities.	Multiple regression, multinomial logistic regression
Jones <i>et al.</i> [14]	By evaluating the latest sustainability information published on the corporate websites of the world's leading hotel chains, the approach of global hotel chains to sustainability was examined.	Content analysis methods, discussion, literature review
Robin <i>et al.</i> [15]	It assessed the attitudes, perceptions, and preferences of hotel guests in Chile towards sustainable practices and analyzed how these factors influence their choice of hotel.	Exploratory factor analysis, correlation analysis, discussion, literature review
Hornig <i>et al.</i> [16]	An integrated theoretical model was developed to examine the relationship between sustainability innovations, environmental marketing strategies, and innovation diffusion in eco-friendly hotels, and the impact of these innovations on hotel managers.	Structural equation modeling (SEM)
Alameeri <i>et al.</i> [17]	A framework was developed to identify, categorize, and prioritize sustainable management practices in the hotel sector.	Analytical hierarchical process, discussion, literature review
Alipour <i>et al.</i> [18]	The perceptions of employees of four- and five-star hotels on a Mediterranean Island towards sustainable practices in social, economic, and environmental dimensions were investigated.	ANOVA test, descriptive statistics, SEM
Boronat-Navarro & Pérez-Aranda [19]	Consumers' willingness to pay more for sustainable hotels, their search for information about sustainability, the importance they place on sustainability certifications, their past experiences, and whether socio-demographic variables influence consumers' intentions are examined.	Univariate analysis, independent t-test, ANOVA test, multiple regression analysis
Pereira <i>et al.</i> [20]	To understand the social and environmental sustainability practices employed by luxury hotels, and to examine how managers perceive the beneficial outcomes of these practices.	Case study
Guruge [21]	The environmental sustainability strategies, policies, and practices of 10 major hotel groups in New Zealand were examined.	Content data analysis, case study
Langgat <i>et al.</i> [22]	The determinants of innovation, organization, and external environmental factors in the adoption of sustainable practices in hotel businesses were examined, and how these practices affected the overall performance of hotels.	Exploratory factor analysis, correlation analysis, partial least squares (PLS)-SEM
Guerra-Lombardi <i>et al.</i> [23]	The implementation of corporate sustainability strategies in hotels and the identification of the drivers, barriers, and key practices that influence their successful execution were explored.	Qualitative research methods (initial and in-depth interviews)
López-Gamero <i>et al.</i> [24]	The relationship between environmental, economic, and social sustainability practices with each other and with hotel performance.	PLS-SEM
Khan & Mahadevan [25]	Sustainability practices implemented by hotels in Dubai were reviewed and evaluated in terms of effectiveness, challenges, and future trends.	PRISMA method, systematic review of literature

### 3.1 *r,s,t*-Spherical Fuzzy Sets

Assume that  $X$  be a universe of discourse. A  $r,s,t$ -SFS  $H$  in the  $X$  is defined as  $H = \{ \langle x, \alpha_H(x), \beta_H(x), \gamma_H(x) | x \in X \rangle \}$ , where  $\alpha_H(x), \beta_H(x), \gamma_H(x): X \rightarrow [0,1]$  and  $0 \leq \alpha_H^r(x) + \beta_H^s(x) + \gamma_H^t(x) \leq 1; r, s, t \geq 1, \forall x \in X$ . Here,  $\alpha_H(x)$ ,  $\beta_H(x)$ , and  $\gamma_H(x)$  denote the membership degree, the neutral degree, and the non-membership degree, respectively. On the other hand, the indeterminacy degree is expressed as  $\pi_H(x) = \sqrt[l]{1 - \alpha_H^r(x) - \beta_H^s(x) - \gamma_H^t(x)}$ , where  $l$  is the least

common multiple of  $r$ ,  $s$ , and  $t$ . For convenience,  $(\alpha, \beta, \gamma)$  is called a  $r,s,t$ -SF number ( $r,s,t$ -SFN). Ali & Naeem [26] recommended using the minimum  $r$ ,  $s$ , and  $t$  values that satisfy  $0 \leq \alpha^r + \beta^s + \gamma^t \leq 1$ .

Assume that  $h_1 = (\alpha_1, \beta_1, \gamma_1)$  and  $h_2 = (\alpha_2, \beta_2, \gamma_2)$  are two  $r,s,t$ -SFNs. Then, some basic operations, score function  $\mathcal{S}(h_1)$ , accuracy function  $\mathcal{A}(h_1)$ , Hamming distance measure  $d_H(h_1, h_2)$ , and Euclidean distance measure  $d_E(h_1, h_2)$  are given below, where  $\lambda > 0$ :

$$h_1 \oplus h_2 = \langle (\alpha_1^r + \alpha_2^r - \alpha_1^r \alpha_2^r)^{\frac{1}{r}}, \beta_1 \beta_2, \gamma_1 \gamma_2 \rangle, \quad (1)$$

$$h_1 \otimes h_2 = \langle \alpha_1 \alpha_2, (\beta_1^s + \beta_2^s - \beta_1^s \beta_2^s)^{\frac{1}{s}}, (\gamma_1^t + \gamma_2^t - \gamma_1^t \gamma_2^t)^{\frac{1}{t}} \rangle, \quad (2)$$

$$\lambda h_1 = \langle \alpha_1^\lambda, (1 - (1 - \beta_1^s)^\lambda)^{1/s}, (1 - (1 - \gamma_1^t)^\lambda)^{1/t} \rangle, \quad (3)$$

$$h_1^\lambda = \langle (1 - (1 - \alpha_1^s)^\lambda)^{1/s}, \beta_1^\lambda, \gamma_1^\lambda \rangle, \quad (4)$$

$$h_1^c = (\gamma_1, \beta_1, \alpha_1), \quad (5)$$

$$\mathcal{S}(h_1) = \frac{1 + \alpha_1^r - \beta_1^s - \gamma_1^t}{2}, \quad (6)$$

$$\mathcal{A}(h_1) = \frac{1 + \alpha_1^r + \beta_1^s + \gamma_1^t}{2}, \quad (7)$$

$$d_H(h_1, h_2) = \frac{|\alpha_1^r - \alpha_2^r| + |\beta_1^s - \beta_2^s| + |\gamma_1^t - \gamma_2^t|}{3}, \quad (8)$$

$$d_E(h_1, h_2) = \sqrt{\frac{|\alpha_1^r - \alpha_2^r|^2 + |\beta_1^s - \beta_2^s|^2 + |\gamma_1^t - \gamma_2^t|^2}{3}}. \quad (9)$$

Assume that  $h_j = (\alpha_j, \beta_j, \gamma_j)$  ( $j = 1, \dots, n$ ) is any collection of  $r,s,t$ -SFNs. With this regard, the  $r,s,t$ -spherical fuzzy weighted averaging operator ( $r,s,t$ -SFWAO) and the  $r,s,t$ -spherical fuzzy weighted geometric operator ( $r,s,t$ -SFWGO) are given below [26]:

$$r, s, t - \text{SFWAO}(h_1, \dots, h_n) = \langle (1 - \prod_{j=1}^n (1 - \alpha_j^r)^{w_j})^{1/r}, \prod_{j=1}^n \beta_j^{w_j}, \prod_{j=1}^n \gamma_j^{w_j} \rangle, \quad (10)$$

$$r, s, t - \text{SFWGO}(h_1, \dots, h_n) = \langle \prod_{j=1}^n \alpha_j^{w_j}, (1 - \prod_{j=1}^n (1 - \beta_j^s)^{w_j})^{1/s}, (1 - \prod_{j=1}^n (1 - \gamma_j^t)^{w_j})^{1/t} \rangle. \quad (11)$$

### 3.2 Proposed $r,s,t$ -Spherical Fuzzy–SWARA–REF Methodology

The SWARA and REF methods, which are defined under the  $r,s,t$  SF environment, will be used to solve the studied problem. The research incorporates novel extensions of the SWARA and REF methods defined under  $r,s,t$ -SFSs. The steps listed below describe how to apply the methodology.

**Step 1.** The decision problem is defined. Accordingly, alternatives  $A = \{A_1, \dots, A_i, \dots, A_m\}$ , criteria  $C = \{C_1, \dots, C_j, \dots, C_n\}$ , and experts  $E = \{E_1, \dots, E_k, \dots, E_z\}$  are determined.

**Step 2.** The linguistic terms in Table 2 are used to determine the importance levels of the experts' evaluations. Accordingly,  $\tilde{\lambda}_k = (\tilde{\alpha}_k, \tilde{\beta}_k, \tilde{\gamma}_k)$  denotes the  $r,s,t$ -SF importance value of the  $k$ -th expert, where  $k = 1, \dots, z$ .

**Table 2**  
 T-SF linguistic scale for evaluations of criteria, experts, and alternatives

Code	Linguistic term for evaluating alternatives	Linguistic term for evaluating experts and criteria	r,s,t-SF number		
			$\mu$	$\eta$	$\zeta$
VVG	Very Very Good	Very Very High	0.95	0.15	0.15
VG	Very Good	Very High	0.85	0.2	0.2
G	Good	High	0.75	0.25	0.25
MG	Medium Good	Medium High	0.65	0.35	0.35
M	Medium	Medium	0.5	0.5	0.5
MB	Medium Bad	Medium Low	0.35	0.35	0.65
B	Bad	Low	0.25	0.25	0.75
VB	Very Bad	Very Low	0.2	0.2	0.85
VVB	Very Very Bad	Very Very Low	0.15	0.15	0.95

**Step 3.** The weight coefficient of each expert is computed using Eq. (12), where  $\mathcal{S}(\tilde{\lambda}_k)$  is the score function value of  $\tilde{\lambda}_k$ .

$$\lambda_k = \frac{\mathcal{S}(\tilde{\lambda}_k)}{\sum_{k=1}^K \mathcal{S}(\tilde{\lambda}_k)} \tag{12}$$

**Step 4.** The experts assess the importance levels of criteria and the performance rating of alternatives. For this purpose, the linguistic terms listed in Table 2 are employed. The r,s,t-SF importance value of the  $j$ -th criterion determined by the  $k$ -th expert is denoted as  $\xi_j^{(k)} = (\alpha_j^{(k)}, \beta_j^{(k)}, \gamma_j^{(k)})$ . Also, the r,s,t-SF performance rating of the  $i$ -th alternative determined by the  $k$ -th expert is represented as  $x_{ij}^{(k)} = (\alpha_{ij}^{(k)}, \beta_{ij}^{(k)}, \gamma_{ij}^{(k)})$ . Experts also determined each criterion's reference. The ideal solution for each criterion will be represented by these references. The linguistic terms indicated in Table 2 are employed in all evaluation procedures. Accordingly,  $x_{gj}^{(k)} = (\alpha_{gj}^{(k)}, \beta_{gj}^{(k)}, \gamma_{gj}^{(k)})$  is the r,s,t-SF reference of the  $j$ -th criterion determined by the  $k$ -th expert. If the reference has been defined as an interval,  $x_{gLj}^{(k)} = (\alpha_{gLj}^{(k)}, \beta_{gLj}^{(k)}, \gamma_{gLj}^{(k)})$  denotes the lower bound and  $x_{gUj}^{(k)} = (\alpha_{gUj}^{(k)}, \beta_{gUj}^{(k)}, \gamma_{gUj}^{(k)})$  indicates the upper bound. When experts differ about whether a reference should be considered an interval or a point, the references that are decided to be points are recognized as both the lower and upper bounds.

**Step 5.** The r,s,t-SF integrated subjective importance of each criterion  $\xi_j$  is formed. Then, the score function value  $\mathcal{S}(\xi_j)$  is obtained by applying Eq. (6).

**Step 6.** The criteria are ranked according to their  $\mathcal{S}(\xi_j)$  values. Then, the comparative importance coefficient  $c_j$  is calculated by comparing the  $\mathcal{S}(\xi_j)$  and  $\mathcal{S}(\xi_{j-1})$ .

**Step 7.** The adjusted comparative importance coefficient  $\kappa_j$  is computed using Eq. (13):

$$\kappa_j = \begin{cases} 1 & j = 1 \\ c_j + 1 & j > 1 \end{cases} \tag{13}$$

**Step 8.** The unnormalized weight coefficient  $q_j$  is determined by applying Eq. (14):

$$q_j = \begin{cases} 1 & j = 1 \\ \frac{q_{j-1}}{\kappa_j} & j > 1 \end{cases} \tag{14}$$

**Step 9.** The weight coefficient of each criterion is obtained via Eq. (15):

$$w_j = \frac{q_j}{\sum_{j=1}^n q_j}, \quad (15)$$

where  $0 \leq w_j \leq 1$  and  $\sum_{j=1}^n w_j = 1$ .

The ranking orders of alternatives are determined using the r,s,t-SF-REF detailed below.

**Step 10.** The integrated r,s,t-SF decision matrix  $X = [x_{ij}]_{m \times n}$  is constructed via Eq. (10). Also, the integrated r,s,t-SF reference of each criterion is obtained via Eq. (10). In light of this,  $x_{gj} = (\alpha_{gj}, \beta_{gj}, \gamma_{gj})$  is used to represent the integrated references. The reference lower limit is integrated as  $x_{g_{Lj}} = (\alpha_{g_{Lj}}, \beta_{g_{Lj}}, \gamma_{g_{Lj}})$  and the reference upper bound is integrated as  $x_{g_{Uj}} = (\alpha_{g_{Uj}}, \beta_{g_{Uj}}, \gamma_{g_{Uj}})$  in the expert evaluation process of the previous stage, if a reference is determined in an interval by at least one expert in a criterion.

**Step 11.** The distance from the reference in criterion  $j$  is calculated for each alternative. If the reference is in interval format, Eq. (16) calculates the distance from the reference in criterion  $j$  for each alternative. However, if the reference of the  $j$ -th criterion is determined as a point, Eq. (17) is applied:

$$d_{ij} = \begin{cases} \frac{|\alpha_{ij} - \alpha_{g_{Lj}}| + |\beta_{ij} - \beta_{g_{Lj}}| + |\gamma_{ij} - \gamma_{g_{Lj}}|}{3}, & \mathcal{S}(x_{ij}) > \mathcal{S}(x_{g_{Uj}}) \\ 0, & \mathcal{S}(x_{g_{Lj}}) \leq \mathcal{S}(x_{ij}) \leq \mathcal{S}(x_{g_{Uj}}), \\ \frac{|\alpha_{ij} - \alpha_{g_{Uj}}| + |\beta_{ij} - \beta_{g_{Uj}}| + |\gamma_{ij} - \gamma_{g_{Uj}}|}{3}, & \mathcal{S}(x_{ij}) < \mathcal{S}(x_{g_{Lj}}) \end{cases} \quad (16)$$

$$d_{ij} = \frac{|\alpha_{ij} - \alpha_{gj}| + |\beta_{ij} - \beta_{gj}| + |\gamma_{ij} - \gamma_{gj}|}{3}, \quad (17)$$

where,  $\mathcal{S}(x_{ij})$ ,  $\mathcal{S}(x_{g_{Lj}})$ , and  $\mathcal{S}(x_{g_{Uj}})$  are the score function value equivalents of the q-ROFNs given in parentheses.

**Step 12.** The weighted overall distance of each alternative is calculated via Eq. (18):

$$\varphi_i = \sum_{j=1}^n w_j d_{ij}. \quad (18)$$

Accordingly, the alternative with the smallest  $\varphi_i$  value is ranked first.

#### 4. Case Study

Sustainable practices implementation capability and environmental protection measures are among the most important issues that societies need to address. Because providing a sustainable future for societies and economies has become a global issue. In particular, humanity's perception of natural resources as infinite has caused environmental problems throughout history. The international dimension of these environmental factors has created the need for developing common policies between countries and establishing action plans accordingly, meaning that environmental sustainability strategies must be applied across all sectors [27].

With the awareness that living in a sustainable world is the most important responsibility that can be passed on to future generations, the efforts of today's industry stakeholders regarding this issue encourage humanity to protect the environment, emphasize locality, raise awareness about the scarcity of resources, and establish production systems and businesses focused on economic gains created within this framework. The continuity of tourism and accommodation businesses also largely

depends on the preservation and development of the resources being used [28]. Sustainable tourism aims to minimize negative environmental, socio-cultural, and economic impacts while creating positive effects such as environmental protection, improving social structures and facilities, contributing to the local economy, creating new jobs, and strengthening communication between people and communities [29]. In other words, sustainable tourism and sustainability strategies have the potential to create value for all stakeholders in the sector [30].

In the scope of this study, emphasis is placed on the importance of sustainability strategies and practices in hotel businesses within the tourism sector, and various evaluations are presented in order to leave a livable environment for future generations. Factors affecting sustainable practices in hotel businesses are assessed, and the most ideal sustainable marketing strategy is selected. Although research on sustainability practices in hotel businesses is quite current, it is scattered across a wide and interdisciplinary field. This study is also significant in terms of evaluating planned environmental practices in the tourism sector through sustainable transformation, making critical decisions, and forming strategies, along with the wide range of studies spread across the field. Table 3 below provides information about the experts who participated in the study.

**Table 3**  
 Characteristics of the experts participating in the study

Expert	Gender	Position	Experience (years)	Level of education
1	Male	Hotel operations manager	17	Bachelor's degree
2	Male	Customer relations officer	8	High school
3	Male	Housekeeping manager	18	High school
4	Female	General manager	27	Bachelor's degree
5	Male	Customer relations officer	9	Bachelor's degree
6	Male	Sales and organization manager	15	Bachelor's degree
7	Male	Front office manager	17	Associate degree
8	Female	Food and beverage manager	24	High school
9	Female	Food and beverage manager	18	Master's degree
10	Female	General manager	33	Bachelor's degree
11	Male	Housekeeping manager	15	Bachelor's degree
12	Male	Front office manager	15	Master's degree
13	Female	General manager	23	Bachelor's degree
14	Male	Front office manager	15	Bachelor's degree
15	Male	General manager	27	Bachelor's degree

The criteria used in the solution of the problem are presented in Table 4.

**Table 4**  
 Criteria used in the study

Codes	Criteria	Explanation	Source(s)
C <sub>1</sub>	Saving, recycling, and reusing solid and liquid waste	It refers to the saving, recycling, and reuse of solid and liquid waste.	[31]
C <sub>2</sub>	Sustainability awareness level of businesses	The level of sustainability awareness and practices existing in businesses.	[32]
C <sub>3</sub>	Prioritization of local products	It is the added value of prioritizing local products.	[33]
C <sub>4</sub>	Support local employment and the local economy	Supporting local employment and the local economy in businesses.	[34]
C <sub>5</sub>	Use of renewable energy	It refers to increasing the use of renewable energy.	[35]
C <sub>6</sub>	Prioritizing the protection of natural resources	Prioritizing the protection of natural resources in businesses.	[36]

**Table 4**  
Continued

Codes	Criteria	Explanation	Source(s)
C <sub>7</sub>	Environmental quality awareness and quality certificates	Environmental quality awareness and quality certificates.	[37]
C <sub>8</sub>	Encouraging new entrepreneurship projects for environmental protection	It refers to the promotion of new entrepreneurship projects for environmental protection in enterprises.	[38]
C <sub>9</sub>	Integrate staff training into sustainable tourism business practices	The level of integration of staff training into sustainable tourism business practices.	[39]
C <sub>10</sub>	Reducing overconsumption in hotel businesses	Reducing excessive consumption in hotel businesses are practices aimed at eliminating waste.	[39]
C <sub>11</sub>	Use of environmentally friendly materials	Materials that do not contain toxic chemicals and have environmental labels.	[40]
C <sub>12</sub>	Raising awareness among hotel guests about environmental issues	Practices related to raising awareness of hotel guests about environmental problems.	[41]
C <sub>13</sub>	Selection of suppliers who are aware of their environmental responsibilities	Selection of suppliers that are aware of their environmental responsibilities.	[42]
C <sub>14</sub>	Cleaner production and eco labels	It refers to having clean production and eco-labels in businesses.	[40]
C <sub>15</sub>	Level of compliance with all requirements set by environmental legislation	The level of compliance with all requirements set by environmental legislation.	[35]
C <sub>16</sub>	Ensuring that the architectural project is compatible with cultural, urban, and rural identities	Ensuring that the architectural project is compatible with cultural, urban, and rural identities.	[43]
C <sub>17</sub>	Ensuring the demonstrability of the principles guiding corporate sustainability	Ensuring the demonstrability and implementation of the principles guiding corporate sustainability in businesses.	[7]
C <sub>18</sub>	Regular sustainability performance reporting and communication	Regular reporting and communication of sustainability performance in businesses.	[7]
C <sub>19</sub>	Guidance on risk assessment and crisis management procedure	Guiding risk assessment and crisis management procedures.	[32]
C <sub>20</sub>	Sustainability communication studies	Expresses sustainability communication studies in businesses.	[35]

The alternatives are presented in Table 5.

**Table 5**  
Alternatives used in the study

Codes	Alternatives	Explanation	Source(s)
A <sub>1</sub>	Auxiliary sustainable marketing strategy	It aims to integrate sustainability into all aspects of marketing strategies and focus on the environmental, social, and economic dimensions.	[44]
A <sub>2</sub>	Transformative sustainability marketing strategy	It is a perspective in which businesses focus on sustainability goals by changing not only their products but also their business model and corporate culture.	[45]
A <sub>3</sub>	Improving sustainability marketing strategy	It aims to promote sustainable lifestyles and change existing business and marketing models by being seen as responsible for marketing certain harmful or undesirable products/services.	[46]
A <sub>4</sub>	Segmentation and positioning strategy	In this strategy, segmentation provides an advantage for segmenting the consumer group that is sincere about environmental awareness and the less interested groups. Another element, positioning, is related to how the target market perceives the products or the brand.	[47]
A <sub>5</sub>	Competitive advantage strategy	Businesses should now perceive sustainability as a necessity, and it is both a necessity for competitive advantage and a means of creating value based on sustainability.	[48]

#### 4.1 Results of the Proposed *r,s,t*-Spherical Fuzzy–SWARA–REF Methodology

In this study, the evaluations of the experts were of a high level of importance. Thus, the expert weight values  $\lambda_k = 0.0667$  were obtained. Experts assessed the importance of the criteria (Table A.1) and rating of the alternatives (Table A.2). These evaluations are given in the Appendix.

Table A.3 provides the integrated *r,s,t*-SF importance values of criteria. Then, the results in Table 6 were obtained by applying the *r,s,t*-SF-SWARA. The results in Table 6 show that the most important criterion is "saving, recycling and reuse of solid and liquid waste" ( $C_1$ ). The second most important criterion is "reducing overconsumption in hotel businesses" ( $C_{10}$ ), while "prioritizing the protection of natural resources" ( $C_6$ ) is the third most important criterion.

Thus, in the context of the analysis conducted within the scope of the study, it was determined that the most important sustainability practice in sustainable hotel operations is the "saving, recycling and reuse of solid and liquid waste". The findings highlight that waste management is a crucial perspective for hotel operations, not only in terms of the hotel's financial activities (such as minimizing solid waste, recycling, and recovery), but also in terms of reducing environmental pollution, ensuring the sustainability of tourism, and safeguarding the health of the surrounding community [49]. Another important sustainability criterion identified in hotel operations is "reducing overconsumption in hotel businesses". Reducing excessive consumption can be achieved through a delicate balance between cost and customer satisfaction. Efforts to reduce consumption should not result in a lack of meeting customers' needs or create a false perception among customers [50]. An important criterion in sustainability practices is "prioritizing the protection of natural resources". This is because, without acting in accordance with environmental awareness, the future of tourism is less likely to be bright. A tourism approach that neglects environmental factors and does not aim to conserve natural resources will lead to negative consequences in the distribution of tourist demand in the coming years. Therefore, environmental factors must be protected, developed, planned, and coordinated in a way that does not harm the environmental structure [38].

**Table 6**  
 Results obtained via *r,s,t*-SF-SWARA

Criteria	$S(\xi_j)$	$C_j$	$\kappa_j$	$q_j$	$w_j$	Rank
$C_1$	0.85463		1.0	1.0	0.0598	1
$C_{10}$	0.80795	0.0467	1.0467	0.9554	0.0572	2
$C_6$	0.75270	0.0552	1.0552	0.9054	0.0542	3
$C_{11}$	0.72904	0.0237	1.0237	0.8845	0.0529	4
$C_{14}$	0.71834	0.0107	1.0107	0.8751	0.0524	5
$C_7$	0.71036	0.0080	1.0080	0.8682	0.0519	6
$C_2$	0.69272	0.0176	1.0176	0.8531	0.0510	7
$C_8$	0.67183	0.0209	1.0209	0.8357	0.0500	8
$C_5$	0.66635	0.0055	1.0055	0.8311	0.0497	9
$C_9$	0.66408	0.0023	1.0023	0.8292	0.0496	10
$C_{12}$	0.66033	0.0038	1.0038	0.8261	0.0494	11
$C_{13}$	0.65372	0.0066	1.0066	0.8207	0.0491	12
$C_4$	0.63365	0.0201	1.0201	0.8045	0.0481	13
$C_3$	0.62437	0.0093	1.0093	0.7972	0.0477	14
$C_{20}$	0.61588	0.0085	1.0085	0.7904	0.0473	15
$C_{18}$	0.61490	0.0010	1.0010	0.7897	0.0472	16
$C_{15}$	0.61200	0.0029	1.0029	0.7874	0.0471	17
$C_{17}$	0.57826	0.0337	1.0337	0.7617	0.0456	18
$C_{19}$	0.57615	0.0021	1.0021	0.7601	0.0455	19
$C_{16}$	0.54612	0.0300	1.0300	0.7379	0.0442	20

Table A.4 displays the integrated r,s,t-SF decision matrix. Also, it was decided that the ideal solution for each criterion would be "VVG" in the context of the linguistic terms given in Table 2. Accordingly, the reference value of each criterion is  $x_{gj} = (0.95, 0.15, 0.15)$ . Table A.5 presents the results obtained with r,s,t-SF-REF.

When the results in Table 7 are examined, it is seen that "auxiliary sustainable marketing strategy" (A<sub>1</sub>) is in the first place and "transformative sustainability marketing strategy" (A<sub>2</sub>) is in the second place. The ideal sustainable marketing strategy has been selected by using the weights of sustainability factors in hotel operations. It has been found that the most important strategy is the "auxiliary sustainable marketing strategy". This is because the relevant result indicates that sustainability practices in hotel operations can lead to cost savings, operational efficiency, and environmental compliance. This approach also helps businesses employ skilled workers and differentiate themselves from competitors by emphasizing their environmental and social responsibilities [51]. Another important strategy identified is the "transformative sustainability marketing strategy". This focuses on understanding the barriers consumers face regarding sustainable consumption, such as persuasive consumption ideologies, institutional barriers, and social norms [46].

**Table 7**  
 Ranking results obtained via r,s,t-SF-REF

	Distance from the references										Rank
	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	C <sub>8</sub>	C <sub>9</sub>	C <sub>10</sub>	
A <sub>1</sub>	0.0847	0.0249	0.0648	0.0166	0.0704	0.0335	0.0888	0.0863	0.0264	0.0309	0.0642
A <sub>2</sub>	0.0118	0.0862	0.0628	0.2006	0.0112	0.0161	0.1000	0.0695	0.1072	0.0928	0.0549
A <sub>3</sub>	0.1147	0.0281	0.1556	0.0308	0.0223	0.0526	0.2168	0.0765	0.0922	0.0234	0.1201
A <sub>4</sub>	0.2224	0.0420	0.0566	0.1007	0.0481	0.0613	0.1423	0.1069	0.1061	0.2406	0.1384
A <sub>5</sub>	0.0787	0.0657	0.1721	0.1390	0.0404	0.2288	0.0110	0.0433	0.0405	0.0682	0.1011

	Distance from the references										$\varphi_i$	Rank
	C <sub>12</sub>	C <sub>13</sub>	C <sub>14</sub>	C <sub>15</sub>	C <sub>16</sub>	C <sub>17</sub>	C <sub>18</sub>	C <sub>19</sub>	C <sub>20</sub>			
A <sub>1</sub>	0.0482	0.0778	0.0872	0.1229	0.1479	0.1234	0.0423	0.1199	0.0161	0.0679	1	
A <sub>2</sub>	0.1101	0.1388	0.0516	0.0765	0.0716	0.1138	0.2043	0.2426	0.0661	0.0921	2	
A <sub>3</sub>	0.1088	0.2485	0.0977	0.0803	0.1147	0.1123	0.0568	0.0829	0.0143	0.0923	3	
A <sub>4</sub>	0.2253	0.0862	0.0734	0.1190	0.1831	0.1295	0.1414	0.0779	0.0229	0.1179	5	
A <sub>5</sub>	0.2433	0.1050	0.0261	0.1279	0.2618	0.1092	0.0639	0.0485	0.0090	0.0981	4	

#### 4.2 Validation of the Results

The first part contains a rank reversal examination. In this context, one alternative will be removed from the problem each time, based on the ranking results shown in Table 7. Table 8 shows the obtained ranking results. The results in Table 8 show that when alternatives are removed from the problem, the ranking order of those remaining is preserved.

**Table 8**  
 Results of the rank reversal examinations

Alternatives	Initial results	Excluded options		
		A <sub>4</sub>	A <sub>4</sub> , A <sub>5</sub>	A <sub>4</sub> , A <sub>5</sub> , A <sub>3</sub>
A <sub>1</sub>	1	1	1	1
A <sub>2</sub>	2	2	2	2
A <sub>3</sub>	3	3	3	-
A <sub>4</sub>	5	-	-	-
A <sub>5</sub>	4	4	-	-

The second analysis includes the results of solving the same problem using different methods from those produced by the proposed methodology. Table 9 summarizes the findings from the *r,s,t-SF-SAW*, *r,s,t-SF-TOPSIS*, *r,s,t-SF-WASPAS*, and *r,s,t-SF-CoCoSo* methods. The results in Table 9 show a high level of agreement among the ranks generated using various methods. Thus, based on the results in Table 8 and Table 9, it is concluded that the proposed methodology generated reliable and valid results.

**Table 9**  
 Ranking results of the comparison analyses

	<i>r,s,t-SF-SWARA-REF</i>	<i>r,s,t-SF-SAW</i>	<i>r,s,t-SF-TOPSIS</i>	<i>r,s,t-SF-WASPAS</i>	<i>r,s,t-SF-CoCoSo</i>
A <sub>1</sub>	1	1	1	1	1
A <sub>2</sub>	2	3	3	3	4
A <sub>3</sub>	3	4	2	4	3
A <sub>4</sub>	5	5	5	5	5
A <sub>5</sub>	4	2	4	2	2

## 5. Discussion

Today, the definitions in the literature and the focus of the activities to be carried out indicate that environmental management for sustainability is of high importance for hotel businesses. Areas of environmental concern in the hospitality industry include waste management, resource conservation, environmental health, legal procedures, procurement policy, and environmental education, particularly in relation to the natural environment [52]. Hotel operations must pay attention not only to economic capital but also to natural and social capital to sustain their operations in the long term. This is because hotels operate within physical and social environments. Any degradation occurring in these environments naturally affects the businesses directly. For example, if the carrying capacity of a destination is consistently exceeded, the area's natural resources and cultural values are eroded. The damage caused by businesses outweighs the benefits they provide to the region. Furthermore, tourism resources are depleted, and the sustainability of the tourism product is lost. Therefore, for corporate sustainability, industry representatives, public officials, non-governmental organizations, and tourists must all adopt responsible behaviors [24].

Sustainability practices in hotel operations not only help preserve natural heritage and biodiversity without damaging the ecological balance but also provide socio-economic benefits to all stakeholders through stable employment and income-generating opportunities. At the same time, they contribute to the optimal use of environmental resources, which is a key element for the existence and future of the sector. Sustainability practices and related strategies in hotel operations are becoming increasingly crucial, evolving into critical components that need to be addressed. In hotel operations that are guided by the principle of leaving a more livable nature for future generations, one way to protect natural resources and the environment is undoubtedly through the transformation of sustainable practices and strategies within the tourism industry. In this context, it is essential to evaluate the research findings and compare them with the literature to highlight similarities and differences. In this framework, Table 6 shows the final weights of the criteria and strategies used in sustainability practices in hotel businesses.

It was determined that the most important criterion affecting sustainability practices in hotel businesses is "saving, recycling and reuse of solid and liquid waste". The result supports the studies of [53] and [54]. Hotel operations consume large amounts of energy and water while also leaving gas, liquid, and solid waste, resulting in negative environmental sustainability outcomes such as increased ecological footprint and greenhouse gas emissions [55]. However, the foundation of sustainable tourism is based on the idea of reducing environmental problems caused by tourism businesses'

activities related to transportation, energy and water consumption, purchasing, waste management, and the environmental impact of tourist density. In this context, various hotels around the world produce all of their electricity in-house with zero carbon emissions, use induction cooktops for green energy in the kitchen, recycle all waste, use environmentally friendly cleaning products, and purchase kitchen materials from local producers or suppliers as part of their sustainable practices. This is because sustainable hotels are businesses that consider future generations, implementing strategies that conserve water and energy, reduce solid and liquid waste, and apply recycling and reuse programs, while also developing environmental regulations and economic solutions.

Another criterion that affects sustainability practices in hotel businesses is determined to be "reducing overconsumption in hotel businesses". The result is in line with the studies of [56] and [57]. Especially in recent times, the tourism phenomenon has led to conspicuous consumption and the emergence of artificial needs each year, resulting in waste, overconsumption, environmental and nature issues, depletion of existing resources, and, most importantly, endangering human life. Hotels, particularly those outside urban areas, and the generated tourist flows can negatively affect the region's flora and fauna, degrade the ecological environment, and harm the natural environment by deteriorating air and water quality. Additionally, they can adversely impact the social environment by causing the overconsumption of resources and creating dissatisfaction among local populations. Hotels that wish to preserve and sustain their existence must maintain a balance between protection and use of surrounding resources and fulfill their responsibilities [56].

It was determined that another important result reached within the scope of sustainability practices in hotel businesses is "prioritizing the protection of natural resources". This result is in line with the studies of [38] and [58]. Tourism businesses are in intense interaction with the ecological environment. From the planning process to the establishment phase, hotel operations have numerous positive and negative impacts on the environment. While tourism creates positive effects economically and socially, it also negatively affects natural resources and the environment. In this context, prioritizing the protection of natural resources is not only crucial for a sustainable future but also an important factor in achieving the goals of environmentally conscious hotel businesses [59].

In the context of the study, the most ideal strategy for sustainability practices in hotel operations was selected. It has been found that the most important strategy is the "auxiliary sustainable marketing strategy". The relevant result supports the studies by [51] and [60]. The perspective of the supporting sustainability marketing strategy aims to integrate sustainability into all aspects of marketing strategies and focus on the environmental, social, and economic dimensions of production and consumption. This strategy focuses on changes in regulations such as existing structures, free markets, government intervention, and business models, encompassing sustainable marketing views on a broad scale. The main principle of the supporting sustainability strategy is expressed as adopting a vision of combining the ecological and social impacts of producing and consuming better [46]. Through the integration of supporting sustainability strategies into production and service processes in hotel operations, costs may decrease and contribute to gaining a competitive advantage.

## **6. Conclusions**

This study analyzed the economic, social, and environmental dimensions of sustainability practices preferred in the management of hotel businesses. It proposed an integrated decision-making procedure consisting of the  $r,s,t$ -SF-SWARA and the  $r,s,t$ -SF-REF methods. The study drew on the insights of managers from five-star hotel businesses operating in Istanbul that adopted the principle of sustainable management. Within this framework, the study was designed to address the decision-making problem related to the integration of sustainability criteria considered in hotel management with the selection of the most appropriate sustainable marketing strategy. The

evaluation of the study using the introduced  $r,s,t$ -SF–SWARA–REF methodology comparatively analyzed hotel businesses based on sustainability and filled critical research gaps in the relevant literature.

While conducting a multidimensional evaluation covering sustainability criteria and sustainable marketing strategies used in the management of five-star hotel businesses, the study reveals that the "auxiliary sustainability marketing strategy" is the alternative with the highest sustainability performance. In terms of managerial implications, the study suggests that this strategy should be structured within hotel businesses and that other sustainability alternatives should be integrated into this approach. Furthermore, the study emphasizes the critical importance of selecting the appropriate sustainability criteria and the most suitable sustainable marketing strategies in the management of five-star hotels, not only in contributing to environmental outcomes but also in achieving fundamental sustainability goals such as leaving a livable environment for future generations.

The validity and consistency of the proposed  $r,s,t$ -SF–SWARA–REF model were confirmed through comprehensive comparisons and reverse ranking tests. Accordingly, the proposed decision-making framework provides a reliable and practical computational tool for five-star hotel managers to make environmentally and managerially sound plans in line with their preferred sustainability criteria and the selection of the most ideal sustainable marketing strategy.

Although this study offers valuable insights and significant managerial and environmental implications, it also has certain limitations. Firstly, although the study adopts a general perspective, it was conducted with sustainable hotel managers, experts, and professionals working in five-star hotels located in Istanbul. This may have resulted in the reflection of certain demographic factors and characteristics specific to sustainable hotel managers in Istanbul. Consequently, the findings of the study may present a limited capacity for generalization to sustainability practices and sustainable marketing strategy-related issues in hotel businesses in other cities. For example, the sustainability practices and sustainable marketing strategies implemented in Istanbul's hotel businesses, due to their unique structure, may not be representative of those in other regions. In addition, although the weighting model proposed in the survey is highly robust, the fact that the evaluation process primarily relies on expert opinions implies that subjective judgments and potential biases of experts, albeit limited, cannot be eliminated. Moreover, while the methods used in the study are highly effective in addressing and managing uncertainties, a more extended period may be required to comprehensively assess all processes involved.

Future studies and research could apply the proposed  $r,s,t$ -SF–SWARA–REF model in different countries and cities. The proposed model holds exciting potential for the future with the possibility of integration with artificial intelligence, deep learning, and other advanced technologies. This integration could lead to the development of practical and highly sophisticated decision support systems, enabling researchers to successfully address dynamic sustainability issues during the evaluation process. Moreover, future studies could provide deeper insights into the social and environmental dimensions of sustainability in hotel businesses and, more broadly, in the tourism industry. The more rational and effective adaptation of concepts and factors such as circular economy principles, waste management, and renewable energy usage to hotel businesses could make critical contributions to achieving sustainability goals. Finally, the creation of broad perspective platforms involving the participation of various stakeholders, including individuals and managers of sustainable hotels, and integrating them into decision-making processes, could significantly contribute to the more effective and efficient structuring of environmental, social, and economic factors.

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This study did not receive any external financial support.

### Conflicts of Interest

The authors declare no conflicts of interest.

### Appendix

**Table A.1**  
 Importance evaluations of the criteria provided by the experts

	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	C <sub>8</sub>	C <sub>9</sub>	C <sub>10</sub>
E <sub>1</sub>	G	MG	VG	VG	M	M	MG	MG	VG	M
E <sub>2</sub>	VVG	G	VVG	VG	VG	VVG	MG	VVG	M	VVG
E <sub>3</sub>	VVG	G	B	VVG	VVG	VG	VG	VG	VG	M
E <sub>4</sub>	VG	VVG	M	M	M	VG	M	M	M	VVG
E <sub>5</sub>	VG	VVG	M	MB	VVG	VVG	VG	VG	VG	M
E <sub>6</sub>	G	M	G	G	VVB	VB	M	M	M	G
E <sub>7</sub>	VVG	M	M	MB	M	VG	VVG	MB	MB	VVG
E <sub>8</sub>	VVG	MB	M	VB	G	G	G	MB	M	VVG
E <sub>9</sub>	G	G	G	VVB	B	B	MG	M	M	M
E <sub>10</sub>	VVG	M	MB	MB	VG	VVG	VVG	G	VVG	VVG
E <sub>11</sub>	VG	VVG	VVG	VG	VG	VVG	VG	VG	VG	VG
E <sub>12</sub>	M	G	M	M	M	M	M	MB	G	G
E <sub>13</sub>	MG	M	M	M	VB	M	M	M	B	VVG
E <sub>14</sub>	VVG	MG	MG	G	VB	VB	MG	MG	M	MG
E <sub>15</sub>	VVG	M	M	G	G	G	G	VVG	VG	VG
	C <sub>11</sub>	C <sub>12</sub>	C <sub>13</sub>	C <sub>14</sub>	C <sub>15</sub>	C <sub>16</sub>	C <sub>17</sub>	C <sub>18</sub>	C <sub>19</sub>	C <sub>20</sub>
E <sub>1</sub>	M	M	M	MB	M	M	MB	M	M	M
E <sub>2</sub>	M	VG	G	G	MB	MG	M	VG	VVG	G
E <sub>3</sub>	VVG	VG	MG	M	G	MG	MG	MG	MG	G
E <sub>4</sub>	VVG	M	M	MG	M	VB	M	M	M	M
E <sub>5</sub>	M	VG	VG	VVG	MB	MB	MB	MB	MB	MB
E <sub>6</sub>	M	B	VB	M	M	M	M	M	M	M
E <sub>7</sub>	VVG	B	G	VVG	VG	VVG	M	M	M	M
E <sub>8</sub>	M	M	VVG	VVG	M	M	VVB	B	B	M
E <sub>9</sub>	M	M	M	M	MG	M	M	M	M	M
E <sub>10</sub>	VG	VVB	M	VVG	VVG	VVB	VVG	VVG	G	VVG
E <sub>11</sub>	VG	VVG	VVG	VG	VG	VG	VVG	VVG	VG	VVG
E <sub>12</sub>	M	M	M	M	M	M	M	M	M	M
E <sub>13</sub>	VG	VG	MG	M	MG	G	M	M	MB	M
E <sub>14</sub>	MB	MB	MB	MB	M	M	M	M	M	M
E <sub>15</sub>	VVG	VVG	G	G	G	B	VG	VG	VG	VG

**Table A.2**  
 Performance evaluations of the options provided by the experts

		C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	C <sub>8</sub>	C <sub>9</sub>	C <sub>10</sub>	C <sub>11</sub>	C <sub>12</sub>	C <sub>13</sub>	C <sub>14</sub>	C <sub>15</sub>	C <sub>16</sub>	C <sub>17</sub>	C <sub>18</sub>	C <sub>19</sub>	C <sub>20</sub>
E <sub>1</sub>	A <sub>1</sub>	M	G	VVG	VVG	MG	G	VVG	G	VVG	G	MG	G	M	MG	M	MB	MB	G	G	VG
	A <sub>2</sub>	VVG	M	G	M	VVG	VVG	M	VG	M	G	VVG	M	MG	VVG	G	G	G	M	M	M
	A <sub>3</sub>	M	VVG	M	VVG	G	VVG	MB	VVG	M	VVG	M	G	B	G	VVG	G	VVG	G	M	VVG
	A <sub>4</sub>	B	VVG	VVG	M	VVG	G	G	MG	MG	M	M	MG	VVG	VG	G	VVG	G	M	G	VG
	A <sub>5</sub>	G	M	M	M	VVG	M	VVG	VG	MG	G	VVG	MB	MG	G	M	M	B	MG	G	VG
E <sub>2</sub>	A <sub>1</sub>	MB	VG	G	VG	M	M	VG	VG	VVG	VG	G	M	B	MB	MG	M	B	VG	M	G
	A <sub>2</sub>	G	M	MG	MG	G	G	M	MG	M	M	G	B	MB	G	VVG	M	G	B	MG	MG
	A <sub>3</sub>	MG	VG	MG	VG	VG	G	B	G	MB	VG	MB	G	VB	M	G	VG	G	G	G	G
	A <sub>4</sub>	M	VG	G	MG	VVG	VG	MG	VG	M	M	MG	M	G	MG	VG	VG	VG	MB	MG	G
	A <sub>5</sub>	MG	MG	MB	B	G	MG	G	MG	G	MG	MG	M	G	VG	G	B	M	MG	VG	G
E <sub>3</sub>	A <sub>1</sub>	MG	G	M	VVG	G	VG	MG	MG	VVG	G	VG	G	MG	M	VG	M	VB	MG	MG	VVG
	A <sub>2</sub>	VG	G	VG	M	VG	MG	G	MB	M	MB	MB	M	VB	M	G	M	M	M	MG	M
	A <sub>3</sub>	M	MG	G	MG	VVG	M	VB	VG	MB	VG	B	M	MB	B	MG	M	MG	MG	MG	VG
	A <sub>4</sub>	G	G	M	MB	G	M	MB	G	M	MG	M	B	VG	M	MG	M	MG	M	MG	G
	A <sub>5</sub>	M	MB	MG	VB	M	B	VVG	M	G	G	MG	MB	M	MG	MG	MB	MG	G	M	VG
E <sub>4</sub>	A <sub>1</sub>	G	MG	MG	G	M	M	G	M	G	M	VG	VVG	MG	G	B	VB	M	MG	G	VVG
	A <sub>2</sub>	G	G	MG	MB	G	VG	MG	MG	MB	M	G	MB	MG	G	M	VG	MG	MG	MB	VVG
	A <sub>3</sub>	MG	G	MB	G	MG	G	MG	MG	MB	G	MG	VG	MB	G	G	MG	MG	VG	VG	VVG
	A <sub>4</sub>	MG	G	MG	M	G	VG	MG	MG	G	G	MG	G	MG	VG	G	MG	M	B	VG	VVG
	A <sub>5</sub>	VG	G	M	G	G	G	G	G	M	G	VB	VG	VVG	MG	B	G	M	VG	VG	VG
E <sub>5</sub>	A <sub>1</sub>	G	VG	MG	VG	MG	G	G	G	G	VG	G	MG	VG	MB	G	G	M	VG	M	VG
	A <sub>2</sub>	G	MG	G	G	MG	G	MG	MG	G	MG	M	G	M	M	VG	G	G	G	M	VG
	A <sub>3</sub>	MG	M	G	M	G	G	B	MG	M	MG	M	MG	MG	M	MG	MB	VG	M	MB	VVG
	A <sub>4</sub>	MG	G	G	B	MG	MG	B	M	M	M	M	MB	MG	M	M	MG	VG	G	G	VG
	A <sub>5</sub>	MG	M	M	MB	MG	MB	G	MG	VG	MG	M	M	MG	M	G	MB	G	VVG	G	G
E <sub>6</sub>	A <sub>1</sub>	G	G	MG	VVG	VG	VG	M	MG	G	VG	VG	G	G	G	G	G	VG	VG	G	VVG
	A <sub>2</sub>	VG	MG	M	M	G	G	MB	M	M	MG	MG	MG	M	MG	M	G	MG	M	M	M
	A <sub>3</sub>	MB	G	MG	VG	MG	VG	G	G	G	G	G	M	G	VG	VVG	G	M	VG	G	G
	A <sub>4</sub>	B	MG	G	G	G	VVG	VG	G	VG	M	MG	M	M	G	G	M	G	G	VG	VVG
	A <sub>5</sub>	VG	MG	G	MG	VG	MG	VVG	VVG	MG	VVG	MG	M	G	VG	MG	G	MG	MG	M	VG
E <sub>7</sub>	A <sub>1</sub>	MG	G	MG	G	G	VG	G	VG	VG	G	G	G	VG	VG	G	MG	MG	G	MG	G
	A <sub>2</sub>	G	VG	VG	M	VG	VVG	VG	VVG	G	VVG	VVG	VVG	VVG	VVG	VG	MG	M	MG	MG	G
	A <sub>3</sub>	MG	VG	M	MG	G	MG	M	VVG	MG	MB	MB	MB	MB	MB	MB	MB	M	VVG	G	G
	A <sub>4</sub>	G	VVG	G	VG	G	VG	VG	VVG	M	MG	MG	M	MG	G	M	G	VG	G	VG	VG
	A <sub>5</sub>	G	VVG	VG	VG	VG	G	G	G	VVG	G	MG	MG	MG	MG	G	M	VVG	VVG	VVG	VVG
E <sub>8</sub>	A <sub>1</sub>	G	VVG	G	VG	MG	VG	MG	MG	MG	MG	VG	VG	MG	G	M	MB	G	VG	M	G
	A <sub>2</sub>	VG	G	MG	MB	VVG	VG	VVG	G	VG	VG	VVG	G	VG	MG	G	M	M	G	M	G
	A <sub>3</sub>	VG	G	B	VG	VG	MB	B	MB	VG	VB	VB	VB	VB	B	M	MB	G	VVG	G	G
	A <sub>4</sub>	MG	G	M	G	MG	G	MG	VG	VVG	MG	VG	G	MG	G	MG	M	M	VVG	VG	G
	A <sub>5</sub>	MG	VG	MG	G	VG	MG	VG	MG	G	MG	G	VG	M	VG	G	MG	G	G	VG	G
E <sub>9</sub>	A <sub>1</sub>	VG	G	MG	M	G	G	M	MB	G	VG	G	G	G	VG	MB	G	MG	G	MG	VG
	A <sub>2</sub>	MG	M	G	M	G	G	G	MG	G	MG	G	G	G	VG	M	MG	G	M	MG	G
	A <sub>3</sub>	M	MB	MB	MG	MG	M	MG	G	MG	MG	B	M	M	MG	M	G	M	MG	G	VVG
	A <sub>4</sub>	M	MG	MB	MG	G	MB	M	G	VG	MB	MG	G	M	VG	G	M	B	G	VVG	VG
	A <sub>5</sub>	G	G	M	MG	MG	M	G	MG	MG	M	M	MG	M	VVG	M	M	VG	M	VVG	VVG
E <sub>10</sub>	A <sub>1</sub>	MG	VG	VG	G	VG	VG	G	VG	G	VG	G	VG	MG	M	M	MG	MG	M	M	G
	A <sub>2</sub>	G	VG	VG	G	MG	VG	G	VVG	MG	VG	G	MB	MB	G	M	G	G	M	M	G
	A <sub>3</sub>	G	G	VG	G	VG	VG	M	G	MG	G	MG	VG	M	M	G	G	G	VG	G	VG
	A <sub>4</sub>	MG	MG	VG	MG	MG	M	M	MB	MG	MG	MG	MB	G	VVG	M	MG	M	MB	MG	VVG
	A <sub>5</sub>	VG	MB	G	M	G	MB	G	G	MG	G	G	B	VG	M	MB	G	M	VG	VG	VVG
E <sub>11</sub>	A <sub>1</sub>	M	G	M	MG	MG	G	B	B	M	MG	M	MG	M	VG	M	G	VG	VG	MG	G
	A <sub>2</sub>	VG	MB	MG	M	VVG	VVG	MB	B	VB	MB	M	VB	B	B	G	MB	B	MB	VG	VG
	A <sub>3</sub>	MB	MG	M	VG	G	MG	MG	M	G	VG	G	G	G	MG	MG	G	MB	MB	B	G
	A <sub>4</sub>	MB	M	MB	MB	VVG	M	G	M	B	B	B	B	VVG	MG	B	MB	MG	MB	VB	VVG
	A <sub>5</sub>	M	VG	G	VVG	VVG	MB	VG	VG	VG	MB	M	M	G	VG	MB	M	MG	MG	MG	G
E <sub>12</sub>	A <sub>1</sub>	G	MG	G	VVG	VVG	VG	MG	MB	VG	VG	M	VG	VVG	MG	VG	G	MG	G	MG	G
	A <sub>2</sub>	VVG	M	B	MB	VVG	MG	VB	M	MB	M	MB	MB	M	VG	M	G	M	MB	M	MG
	A <sub>3</sub>	MG	VVG	B	VVG	VVG	VG	B	G	MB	VVG	VG	G	MG	VVG	G	MG	M	B	M	MG
	A <sub>4</sub>	MB	VVG	VVG	VG	M	MG	MB	MB	VB	MB	B	MB	MG	M	VB	B	M	MG	M	MB
	A <sub>5</sub>	G	VVG	MB	MB	MG	MB	VVG	VG	VG	G	G	M	M	VG	MG	M	M	G	M	VVG
E <sub>13</sub>	A <sub>1</sub>	VG	VVG	MG	M	MG	G	MB	MG	MG	G	M	M	MB	M	MG	MB	M	M	MB	MG
	A <sub>2</sub>	VG	M	VG	G	MG	G	B	M	MG	M	MG	MB	VB	M	B	MG	MB	MB	M	MB
	A <sub>3</sub>	VG	VG	MG	G	VVG	G	MB	M	MG	VG	MG	B	MG	M	M	B	M	B	M	M
	A <sub>4</sub>	VB	VG	VG	VG	G	G	MG	MG	B	MG	VG	VB	MG	VG	M	MB	MG	M	B	G
	A <sub>5</sub>	MB	M	B	M	MG	M	VVG	VVG	G	G	G	G	MG	G	VVG	MG	MB	MG	MG	MG
E <sub>14</sub>	A <sub>1</sub>	B	M	G	G	VB	M	M	MG	B	VG	MB	MG	G	G	M	MB	M	MG	MG	G
	A <sub>2</sub>	VVG	G	MG	VB	VVG	M	MB	G	VG	MB	M	G	B	M	M	MG	M	VB	MB	MG
	A <sub>3</sub>	G	G	MB	MG	G	G	MG	MG	MG	VG	VVG	MB	B	VG	M	M	M	MG	MG	G
	A <sub>4</sub>	VB	B	VG	VG	B	VVG	B	M	VB	B	G	MB	VB	M	MG	B	M	MB	B	MB
	A <sub>5</sub>	G	VVG	M	MG	VG	M	VVG	G	VG	VVG	M	M	MG	VVG	G	M	M	G	G	VVG
E <sub>15</sub>	A <sub>1</sub>	M	G	MG	VG	M	VG	M	MG	G	MB	MB	MB	MB	MB	M	B	G	G	G	MG
	A <sub>2</sub>	G	VG	M	M	VG	VVG	G	G	G	VG	VG	VG	G	VG	VVG	G	VG	MG	M	MG
	A <sub>3</sub>	M	VG	MG	MG	M	M	MG	M	VG	M	MB	MB	MB	M	M	MB	G	G	M	VG
	A <sub>4</sub>	G	G	MG	G	G	G	G	MG	MG	G	G	G	G	G	MG	VG	MG	MG	M	G
	A <sub>5</sub>	G	VVG	G	G	G	VVG	G	G	VVG	M	M	M	M	M	G	M	VG	VVG	VVG	VVG

**Table A.3**  
 Integrated r,s,t-SF importance values of the criteria

C <sub>1</sub>			C <sub>2</sub>			C <sub>3</sub>			C <sub>4</sub>			C <sub>5</sub>		
$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$
0.8892	0.2018	0.2018	0.7606	0.3042	0.3170	0.7060	0.3326	0.3729	0.6969	0.2704	0.3811	0.7312	0.2521	0.3720
C <sub>6</sub>			C <sub>7</sub>			C <sub>8</sub>			C <sub>9</sub>			C <sub>10</sub>		
$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$
0.8073	0.2326	0.3036	0.7704	0.2939	0.2939	0.7414	0.3006	0.3402	0.7314	0.3027	0.3394	0.8570	0.2434	0.2434
C <sub>11</sub>			C <sub>12</sub>			C <sub>13</sub>			C <sub>14</sub>			C <sub>15</sub>		
$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$
0.7997	0.2949	0.3073	0.7318	0.2740	0.3739	0.7237	0.3055	0.3506	0.7871	0.2897	0.3146	0.6883	0.3385	0.3677
C <sub>16</sub>			C <sub>17</sub>			C <sub>18</sub>			C <sub>19</sub>			C <sub>20</sub>		
$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$
0.6279	0.3199	0.4468	0.6737	0.3443	0.4228	0.7040	0.3431	0.3848	0.6608	0.3467	0.4051	0.7051	0.3567	0.3717

**Table A.4**  
 The r,s,t-SF decision matrix

	C <sub>1</sub>			C <sub>2</sub>			C <sub>3</sub>			C <sub>4</sub>			C <sub>5</sub>		
	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$
A <sub>1</sub>	0.6824	0.3049	0.3419	0.8052	0.2446	0.2446	0.7282	0.3055	0.3055	0.8460	0.2306	0.2306	0.7214	0.2970	0.3270
A <sub>2</sub>	0.8464	0.2143	0.2143	0.6931	0.3222	0.3358	0.7207	0.2890	0.3110	0.5530	0.3723	0.4641	0.8626	0.2157	0.2157
A <sub>3</sub>	0.6541	0.3416	0.3710	0.8016	0.2465	0.2569	0.5936	0.3310	0.4338	0.7996	0.2578	0.2578	0.8221	0.2418	0.2418
A <sub>4</sub>	0.5278	0.3340	0.5093	0.7928	0.2692	0.2897	0.7649	0.2874	0.3121	0.6805	0.3170	0.3705	0.7780	0.2773	0.2984
A <sub>5</sub>	0.7056	0.3146	0.3279	0.7690	0.3020	0.3279	0.5975	0.3723	0.4351	0.6472	0.3306	0.4254	0.7911	0.2765	0.2765
	C <sub>6</sub>			C <sub>7</sub>			C <sub>8</sub>			C <sub>9</sub>			C <sub>10</sub>		
	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$
A <sub>1</sub>	0.7784	0.2588	0.2588	0.6953	0.3133	0.3513	0.6826	0.2996	0.3501	0.8092	0.2400	0.2582	0.7831	0.2486	0.2591
A <sub>2</sub>	0.8439	0.2285	0.2285	0.6741	0.2878	0.3860	0.7354	0.2957	0.3315	0.6554	0.3146	0.3763	0.7022	0.3180	0.3600
A <sub>3</sub>	0.7500	0.2839	0.2959	0.5190	0.3161	0.5067	0.7135	0.3133	0.3265	0.6936	0.3078	0.3631	0.8141	0.2429	0.2429
A <sub>4</sub>	0.7627	0.3010	0.3137	0.6234	0.3340	0.4200	0.6743	0.3370	0.3660	0.7028	0.2900	0.4071	0.5257	0.3953	0.4970
A <sub>5</sub>	0.5341	0.3860	0.4898	0.8726	0.2170	0.2170	0.7838	0.2806	0.2806	0.7753	0.2732	0.2732	0.7414	0.3073	0.3203
	C <sub>11</sub>			C <sub>12</sub>			C <sub>13</sub>			C <sub>14</sub>			C <sub>15</sub>		
	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$
A <sub>1</sub>	0.7194	0.2894	0.3143	0.7550	0.2773	0.2889	0.7088	0.2943	0.3439	0.6851	0.3072	0.3477	0.6448	0.3425	0.3840
A <sub>2</sub>	0.7706	0.2858	0.3104	0.6625	0.2878	0.4022	0.6335	0.2904	0.4428	0.7667	0.2810	0.3024	0.7329	0.2991	0.3463
A <sub>3</sub>	0.6578	0.2900	0.4184	0.6509	0.3072	0.3829	0.4903	0.3045	0.5426	0.6870	0.3041	0.3755	0.7199	0.3073	0.3446
A <sub>4</sub>	0.6329	0.3498	0.4050	0.5254	0.3390	0.5098	0.7262	0.3195	0.3519	0.7402	0.3213	0.3213	0.6439	0.3270	0.3875
A <sub>5</sub>	0.6928	0.3488	0.3488	0.5334	0.3929	0.5056	0.6776	0.3503	0.3503	0.8386	0.2548	0.2548	0.6341	0.3519	0.3822
	C <sub>16</sub>			C <sub>17</sub>			C <sub>18</sub>			C <sub>19</sub>			C <sub>20</sub>		
	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$	$\alpha$	$\beta$	$\gamma$
A <sub>1</sub>	0.5906	0.3091	0.4320	0.6368	0.3218	0.3973	0.7570	0.2723	0.2723	0.6393	0.3519	0.3667	0.8325	0.2258	0.2258
A <sub>2</sub>	0.7007	0.3095	0.3095	0.6493	0.3395	0.3687	0.5400	0.3472	0.4807	0.5274	0.4233	0.4791	0.7294	0.3014	0.3141
A <sub>3</sub>	0.6446	0.3315	0.3752	0.6704	0.3281	0.3834	0.7400	0.2773	0.3109	0.6967	0.2925	0.3529	0.8470	0.2235	0.2235
A <sub>4</sub>	0.6136	0.3680	0.4627	0.6488	0.3587	0.3860	0.6456	0.3355	0.4258	0.7155	0.2797	0.3567	0.8360	0.2358	0.2561
A <sub>5</sub>	0.5066	0.3958	0.5186	0.6850	0.3436	0.3697	0.7532	0.3097	0.3097	0.7827	0.2900	0.2900	0.8806	0.2106	0.2106

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