

A hybrid fuzzy scenario-based decision-making approach to reach sustainability, resilience, and responsiveness goals in the industrial tourism value chain

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Keywords

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Abstract

Industrial tourism leverages the strengths of both industry and tourism to foster the development of each society. The value chain emphasizes the creation of perceived value for the customers and increasing the competitive advantage in the industry. Moreover, it can be stated that the value chain is actually formed within the core and function of the supply chain and is the result of the effective interaction of its components. Therefore, we have considered the value chain in industrial tourism through examination of the Industrial Tourism Supply Chain (ITSC) comprising two important members, including Industrial Units (IUs) and Accommodation Centers (ACs). Then, the research considers Sustainability, Resilience, and Responsiveness (SRR) issues in the ITSC by emphasizing that members must be engaged in the chain that is at the highest possible SSR performance. To do our research, first, based on the literature and experts, key SRR criteria are identified. Then, a real case in Iran is considered, and feasible alternatives are selected and ranked through a hybrid scenario-based fuzzy decision-making framework. The findings highlight that criteria “Innovative products or services” and “Demand responding level” have the greatest impact, and criteria “Job opportunities and labor force” and “Availability and location” have the least impact, in achieving the highest level of SRR in the proposed chain. Moreover, among the ranked alternatives, “Mazinoor Lighting Industries Company” (top IU) and “Mizban Hotel” (top AC) emerged as the highest performers in terms of SRR level. Finally, the present work provides detailed implications and insights for beneficiaries of ITSC.

Highlights

- Considering the value chain concept in industrial tourism through examination of its supply chain.
- Considering Sustainability, Resilience, and Responsiveness (SSR) issues in the proposed chain.
- Introducing a new form of the DEMATEL method called Stochastic Fuzzy DEMATEL (SFD) method.
- Applying a hybrid fuzzy scenario-based decision-making approach to conduct the present work.
- Applying a case study in Mazandaran province, Iran.

1. Introduction

Every business that produces and sells a specific product or provides a specific service needs a system that can coordinate all these processes well and give them order and integrity. In the past, when businesses were different, competition was not as serious and tight, and the need to use up-to-date and appropriate technologies was not felt to this extent. But now, a simple negligence may destroy a business, and using proper strategies to lead to its success is necessary, where one of the strategies to guarantee success is Supply Chain Management (SCM)[1]. The supply chain includes all the processes through which a service or a product is produced and offered to the customer. There are various actors, each of whom has a specific role, including the manufacturer of goods or services, suppliers, logistics service providers, warehouses, retailers, and supply managers, who are present throughout the supply chain process. Every business must identify its SCM process well and be able to cooperate and interact with the various players in these processes. Otherwise, there is a possibility of process disruption and even business failure[2]. In the modern economy, the service sector accounts for the majority of the Gross Domestic Product (GDP) of many countries, and its supply chain plays a vital role in delivering value to customers, creating satisfaction, and maintaining competitive advantage. In other words, in contemporary economic landscapes, a pronounced shift toward service-based economies has become evident[3]. The tourism industry is one of the most important types of service sector and is recognized as the world's largest and most diverse industry, serving as a vital economic pillar for numerous countries, generating significant income and employment opportunities[4]. Today, the intense global competition in the tourism industry has focused on the Tourism Supply Chain (TSC) rather than on individual firms. Tourism products are generally considered by customers as a value-added chain consisting of various service components. For this reason, tourism firms are always looking for ways to efficiently manage the operations of related businesses to maintain their competitive advantage in today's competitive environment[5]. The TSC is mainly service-driven, delivering travel experiences through accommodations, transport, and tours[6]. While it utilizes physical goods like food and souvenirs, its core value lies in service provision, making it fundamentally a service industry, and management of the TSC enables tourism firms to identify and meet customer needs and achieve business goals[7]. Nowadays,

Industrial Tourism (IndT) is an emerging branch of tourism and is very popular among tourists. In industrial tourism, the destination of tourists is to visit old and new industrial places[8]. The concept of IndT in Europe is not new, and for years, tour organizers have created opportunities for enthusiasts to visit, for example, very old factories producing cocoa and cheese, or modern factories producing toys, shoes, and many other European products [9]. IndT involves traveling to destinations connected to industrial operations, such as factories, production plants, and similar facilities. It offers visitors a chance to explore how different industries function, while also discovering their historical, cultural, and innovative aspects [9]. Many communities are industrially well-positioned and have sufficient and suitable tourism potential, but they have not yet reaped the benefits of IndT to develop and improve their situations. Besides, the IndT sector has expanded rapidly in recent times, with its value projected to rise from 2.6 billion in 2024 to 2.6 billion in 2024 to 3.38 billion in 2025, reflecting a Compound Annual Growth Rate (CAGR) of 29.7%. These statistics point to the importance of IndT nowadays and in the future of developing the IndT in various societies[9]. Moreover, it is noteworthy that, given the importance and lots of benefits for the IndT, significant research has not yet been conducted in this field in recent years. All of these reasons lead to the fact that it has not reached its desired position. Therefore, to bridge the mentioned gap and problem, we have considered this branch of tourism through studying the Supply Chain (SC) to evaluate its advantages and capabilities for society development. Supply chain and value chain are considered two separate but complementary concepts. The supply chain focuses more on the coordinated flow of services, information, resources, and various actors from the design stage to the provision of services or products to the customers[10], while the value chain emphasizes the creation of perceived value for the customers and increasing the competitive advantage of the destination or industry[11]. From this perspective, it can be stated that the value chain is actually formed within the core and function of the supply chain and is the result of the effective interaction of its components. In the tourism industry, actors such as hotels, travel agencies, transportation, tourist attractions, creative industries, and local institutions form a network of supply and service delivery relationships that is the tourism supply chain[12]. However, when these interactions lead to the enhancement of the tourist experience, increased satisfaction, creation of differentiation, development of the destination brand, and the creation of economic and social benefits, the supply chain is elevated to the level of a value chain. Therefore, the value chain can be considered the result of the value creation and strategic function of the supply chain. Accordingly, in the present study, the concept of supply chain does not simply mean the transfer of services and operational coordination between actors, but is considered a value-creating network that, through synergy between stakeholders, leads to the creation of a desirable tourism experience and sustainable competitive advantage. Therefore, the value chain is considered an internal and evolved dimension of the supply chain and not an independent and separate concept from it. Also, in the tourism industry, the supply chain becomes strategic when the relationships between different actors go beyond the exchange of services and lead to the creation of shared value for tourists and other stakeholders; in such circumstances, the supply chain is explained in the form of a value chain. Additionally, based on the current studies in the SC field, Sustainability, Resilience, and Responsiveness (SRR) are three significant and crucial issues in SC studies [13, 14]. A sustainable SC includes economic, social, and environmental aspects and incorporates eco-friendly principles to reduce harm to the environment and society without compromising efficiency[15]. A resilient SC is defined by its capacity to be resistant and recover the chain against disruptions in such a way that it can further reduce SC disruptions and limit their impact on the SC configuration[16]. Moreover, a responsive SC is designed to adjust to fluctuations in demand or other influencing factors rapidly. It enables quick reactions to shifts in customer preferences, market dynamics, or any disruptions that may arise[13]. Therefore, in our work, we have considered these three substantial issues in ITSC for the first time. To reach this target, we emphasize that members must be involved and active in the proposed chain that ensures the highest possible level of SRR aspects of the chain. Despite the diversity of industries and a strong background of Iran in fields such as oil, mining, steel, and handicrafts, and its sufficient tourism activity potential. However, IndT in Iran is still in the early stages of development and requires a lot of attention. In this regard, we have adopted a real case in Iran as one of the best potential locations for IndT activity to evaluate and validate our work's findings. In general, the significant points of the current research compared to other studies are as follows:

- Studying the SC network of IndT for the first time.
- Considering three important issues, including sustainability, resilience, and responsiveness simultaneously in the tourism industry, especially in ITSC, for the first time.
- Introducing a new hybrid fuzzy scenario-based decision-making approach.
- Presenting a new version of the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method called the Stochastic Fuzzy DEMATEL (SFD) method.
- Using a real case study to evaluate and validate the research findings.

Other parts of the current work are as follows: In the second section, the LR related to the research field has been studied. In the third section, the problem is clearly explained. In the fourth section, the applied methodology is presented. The fifth section presents the implementation results. The sixth section discusses the obtained results and provides useful management suggestions for the stakeholders of the chain. Finally, in the last section, conclusions and suggestions for future research are presented. In Figure 1, the proposed research framework is presented.

2. Literature review: SSR issues in tourism

Calgaro et al.[17] studied tourism resiliency and vulnerability by providing a framework called the Destination-Sustainability Framework (DSF). This framework contains six aspects, and the important one is the social-ecological change timeframes. They also claimed that their proposed framework is innovative and the first one that considers tourism sustainability, resiliency, and vulnerability. Amir et al. [18] studied rural tourism resiliency and its relations with sustainability planning and local governments

'role in Malaysia. They provided some sustainable strategies that consider tourism resiliency in the destination. Lew et al. [19] explained resiliency and sustainability in the tourism industry and the importance of these topics. They deeply studied community resiliency and sustainability by presenting their differences, similarities, and indicators. Holladay [20] examined the community resilience impacts on tourism sustainability in Dong Van Karst Plateau Geopark in northern Vietnam. They claimed that the well-being status of rural communities deeply affects the resiliency level. They applied household survey techniques to examine residents' attitudes toward community resilience and mixed sustainable resilience aspects, including environmental, social, and economic resilience. In this section, articles that studied all three issues of sustainability, resilience, and responsiveness, or at least two of them simultaneously in the tourism industry, are examined. Powell et al. [21] studied the relationship between destination resilience and its impact on the sustainability of tourism in a region. They paid attention to the system's capacity as an indicator of resiliency and its relationship with sustainability aspects, including economic, social, and cultural aspects, in their work. Also, a heuristic model has been applied to investigate this relationship. In the tourism industry, to increase tourism and develop the tourism industry, resiliency and sustainability should be paid attention to. In this regard, Cheung and Li [22] considered visitor–resident relations as a communicator of resiliency and sustainability in the tourism industry. They also introduced a new concept, “over-tourism,” that considers the potential hazard in tourism destinations. Sgroi [23] studied forest resources' impacts on tourism sustainability and their relation with tourism resiliency. He claimed that correct resource management is the core factor in achieving the sustainability and resiliency goals in the tourism industry. Also, He examined the different sustainable tourism models and their relations with the management of natural resources. Sobaih et al. [24] focused on topics such as pandemic recovery, sustainable tourism, and climate resilience in the tourism industry. She studied the effects of these three topics on tourism reconstruction in the Caribbean, USA, by considering mobility justice. Sheller [25] studied how to reach sustainable development in the tourism industry through resiliency in small hospitality enterprises in the Covid-19 era in Egypt. To do their research, they presented a conceptual framework and applied Structural Equation Modeling (SEM) and AMOS software. Della Corte et al. [26] studied the impacts of destination resilience and open innovation on the sustainability goals of the tourism industry through a bibliometric analysis. Moreover, they provided some unsolved questions in this era and believed answering these questions could significantly improve the resiliency and sustainability relationship in the tourism industry. Shi et al. [27] studied the sustainability and resiliency in rural land and examined its relations with tourism development in Zhengzhou, Henan Province, China. They presented a sustainable resilience model that contains the physical-mechanical theory. The model includes four aspects: industry, population, infrastructure, and location role. Traskevich and Fontanari [28] studied the impacts of COVID-19 on destination resilience by providing a resilience-oriented market framework. They also presented a conceptual integrative model for their investigation. They claimed that destination resilience and innovative business plans have a significant role in tourist attraction and business competitiveness in the tourism industry. Yang and Kim [29] studied resilience and sustainable tourism development in a host community in Florida, USA. They conducted their work by proposing an integrated framework that considers tourism sustainability, community resilience, and quality of life. Novelli [30] worked on obtaining sustainability and resiliency goals in tourism ecosystems in Africa. In his study, he applied two concepts: open innovation and peer-to-peer collaboration. Summarized information on the reviewed articles in Section 2 is provided in Table 1.

2.1. Research gaps

According to the reviewed papers in LR, it can be seen that no research has studied the ITSC so far. Moreover, we also know that the three issues of sustainability, resiliency, and responsiveness are important, up-to-date, and efficient topics in SC studies. Also, no study has considered these three issues simultaneously, not only in the field of industrial tourism, but also in the tourism industry, and our work is the first research that has studied these three important issues simultaneously in the tourism industry, especially in IndT. In IndT, simultaneous attention to sustainability, resilience, and responsiveness is of fundamental importance because this type of tourism is directly related to industrial environments, local communities, economic infrastructure, and human resources. Sustainability allows tourism activities to create economic benefits while causing minimal damage to the environment, industrial heritage, and the interests of future generations. Resilience also increases the ability of the tourism system to face crises, economic fluctuations, technological changes, industrial accidents, and environmental shocks, and helps to continue operations and maintain a competitive advantage. On the other hand, responsiveness enables actors in the ITSC to act responsibly towards the needs, expectations, and concerns of tourists, the local community, and other stakeholders, and to improve the quality of services and public trust. Therefore, the integration of these three components can pave the way for balanced development, sustainable competitiveness, and long-term value creation in InT. Therefore, due to the nature of the tourism industry and its characteristics, considering these three issues is essential. Considering the explanations provided and the importance of these three issues in the tourism field and InT. Also, in most of the research related to Decision-Making (DM), researchers used hybrid approaches as a solution methodology because taking advantage of several MCDM methods ensures the accuracy and quality of the results, and our work is not exempt from this point of view [31]. Also, we developed a new version of the DEMATEL method based on scenarios and in a stochastic form, named the SFD method in the hybrid approach, which can consider different scenarios and examine the internal relationships of the criteria in each scenario.

3. Problem Statement

The development of each industry requires a detailed study of its SC and an examination of all members involved in the chain and their roles in the chain. Despite the great importance and potential of the IndT industry, as explained earlier, no research has yet studied and examined the supply chain of this industry. Therefore, in this research, for the first time, we study and design ITSC in detail. In this regard, with the help of relevant experts, the ITSC is examined, and it is concluded that it includes three main levels, which include the customer level, the intermediary level, and the service level (Figure 2). The level of intermediaries

or facilitators means governmental or private centers (non-governmental) that operate especially in the field of IndT and provide specialized IndT services to the applicants of this industry in cooperation with service level members. The service level members include all types of Industrial Units (IUs) and Accommodation Centers (ACs) such as hotels, hotel apartments, and ecotourism centers. As we know, in recent years, the SRR issues have been very important to consider in all SC studies, especially in tourism content. But no research has studied these three issues simultaneously, not only in tourism but also in industrial tourism. Therefore, to fill this gap, we study all three SRR issues simultaneously in ITSC. In other words, our main intention is that in ITSC, members should be involved and active to ensure the SSR issues in the chain.

3.1. Case Study

Gano-Gardesh tourism service center is one of the centers that operates especially in the field of IndT in Mazandaran province, Iran. This unit, as a member of the chain, acts as a facilitator at the intermediary level, providing IndT services to the applicants of this industry in cooperation with IUs and ACs. The services provided by this unit include industrial visit tours, city sightseeing tours, accommodation, food (main meals), and transportation. This unit cooperates with industrial centers to provide industrial tour services and with ACs to provide food and accommodation services. This center aims to cooperate with centers that are at an acceptable and higher level with respect to SRR issues among the various IUs and ACs existing in the province. In other words, this unit intends to ensure and increase the SRR aspects of the proposed ITSC by allocating the applicants of this industry to the centers that have a more suitable status than others in terms of these three aspects. In Table 2, specifications of the IUs and ACs that cooperate with the Gano Gardesh tourism unit are prepared. Figure 3 shows the geographical location of each IU and AC considered in the case study.

3.2. Determination of the decision framework

As we know, the goal of the present study is to achieve a sustainable, resilient, and responsive supply chain for IdT. To achieve the desired goal, members who should be involved and play a role in the ITSC should be in a suitable condition in terms of the SRR criteria. Therefore, as is obvious in Table 3, 19 criteria related to three dimensions (Sustainability, Resiliency, and Responsiveness) are identified based on the LR and expert team opinions. Finally, the proposed hierarchical diagram for sustainable-resilient-responsive IndT in Figure 4.

4. Methodology: A novel hybrid fuzzy stochastic decision-making approach

The proposed approach consists of the SFD, the Fuzzy Analytic Network Process (FANP), and the Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (FTOPSIS) methods. Through the SFD and FANP methods, the weights of the extracted criteria are calculated. Then, ranking of the potential alternatives (including IUs and ACs) is done through adopting the FTOPSIS method.

4.1. The SFD method

The DEMATEL method, as an MCDM method, does not give us a ranking of alternatives, but it is used to determine the effectiveness of the criteria in a system. The method has an advantage over techniques like AHP because it considers the interdependence among a system's criteria using a causal diagram, an aspect often overlooked by traditional methods[48]. While traditional quantitative methods offer precise solutions, they are less effective for addressing people-centered issues due to the complexities introduced by human factors. To handle such real-world problems involving environmental uncertainty and ambiguity, fuzzy set theory was introduced and is now widely applied. Moreover, the DM process takes place in the light of culture, perceptions, values, beliefs, attitudes, personality, knowledge, and insight, and these factors interact with each other. DM has always been a difficult task, and it requires more accuracy. Therefore, to deal with this problem, in addition to fuzzy logic, stochastic models are needed. Thus, our proposed method is a fuzzy stochastic version of the DEMATEL method, considering different scenarios to deeply analyze the interrelationship between indicators or criteria. The steps of the proposed SFD method are provided in detail and are shown in Figure 5.

Step 1: Collecting the evaluation information through linguistic variables.

After the criteria or factors that are considered for evaluation have been extracted and selected. The required data from the expert team are collected using the fuzzy linguistic variables presented in Table 4.

Step 2: Making the Stochastic Fuzzy Initial Direct Influence (SFIDI) matrix.

Assume that K scenarios are considered, C criteria are selected for being evaluated, and D is the SFIDI matrix; then the dimension of the SFIDI matrix is equal to $C^*(C*K)$, $D = [d_{ij}]_{C \times (C \times k)}$

Step 3: Computing the Stochastic Fuzzy Normalized Direct Influence (SFNDI) matrix

It is assumed that S is the SFNDI matrix, so to reach this matrix, we must first get the value of α from Eq. (1), and then the SFNDI matrix is equal to: $S = [s_{ij}]_{C \times (C \times k)} = D \times \alpha$

$$\alpha = \frac{1}{\max(1 \leq i \leq c) \sum_{j=1}^{c \times k} d_{ij}} \quad (1)$$

Step 4: Splitting the SFNDI matrix into the Fuzzy Normalized Direct Influence (FNDI) matrix for each Scenario.

If we have k scenarios, we will have k FNDI matrices. Suppose that N_k is defined as the FNDI in Scenario k .

Step 5: Calculating the inverse matrix of the FNDI matrix for each scenario.

If we suppose that N^{-1}_k is the inverse matrix in scenario k and I is the identity matrix, then we will have, $N^{-1}_k = (I - N)^{-1}$.

Step 6: Obtaining the Total-Influence (TI) matrix for each scenario.

If we show the TI matrix with T , then T_k indicates the TI matrix in scenario k and will be obtained as Eq. (2).

$$T_k = N_k \times N_k^{-1} \quad (2)$$

Step 7: Defuzzifying the TI matrix in each scenario.

There are different approaches to defuzzifying the TI matrix, but we suggest the Graded Mean Integration Representation (GMIR) technique to defuzzify this matrix. The formulation of the GMIR technique is shown in Eq. (3)[36].

Assume that $\tilde{E} = (E^l, E^m, E^u)$ is a fuzzy number and the $\tilde{E}^{def}$ is the defuzzification value of $\tilde{E}$.

$$\tilde{E}^{def} = \frac{E^l + 4 \times E^m + E^u}{6} \quad (3)$$

Step 8: Calculating the influencing degree D_i and R_j for each of the TI in each scenario

After defuzzifying the TI matrix ($T_k = [t_{ijk}]_{c \times c}$), we should obtain the influencing degree D_{ik} and R_{jk} from the T^{def} in each scenario k , and R_{jk} are calculated as Eq. (4) and Eq. (5).

$$D_{ik} = \sum_{j=1}^c h_{ijk}, \forall i, k \quad (4)$$

$$R_{jk} = \sum_{i=1}^c h_{ijk}, \forall j, k \quad (5)$$

Step 9: Integrating the scenarios (Calculating final influencing degree D_i^* and R_j^*)

We suppose that p_k is equal to the probability or importance degree of scenario k . Therefore, the influencing degree D_i^* and R_j^* will be obtained through Eq. (6) and Eq. (7).

$$D_i^* = \sum_{k=1}^K D_{ik} \times p_{ik} \quad \forall i \quad (6)$$

$$R_j^* = \sum_{k=1}^K R_{jk} \times p_{jk} \quad \forall j \quad (7)$$

Step 10: Establishing the interrelationship map

4.2. FANP method

The ANP method is an MCDM method used to determine the weights of criteria and select the optimal option based on pairwise comparisons. The ANP method represents the complex relationships among decision levels in a network structure, accounting for interactions and feedback between criteria. The weights derived from these causal relationships, along with the internal weights of each cluster, create an initial super matrix. The super matrix is weighted linearly, and the final weights of the elements are determined by applying the limit form of this weighted super matrix. Super Decision software is usually used to perform the calculations of this method[49].

4.3. FTOPSIS method

FTOPSIS is an MCDM method for choosing the best alternative based on the distance to positive and negative ideal solutions. In general, the purpose of the TOPSIS method is to prioritize the alternatives based on decision criteria. In this method, first of all, the decision matrix is formed, and a score is assigned to each alternative based on each criterion. Then, the steps of the TOPSIS method are implemented on the decision matrix to calculate the final score of each alternative and rank them based on the score. More details, as well as its steps, are provided in[50] 'work.

5. Implementations and findings

5.1. Expert team

In order to collect the required data to conduct the current research, face-to-face and virtual (online) meetings with five different groups of experts related to the field of tourism and industry were held. These experts include: **E1**: Academic experts who include university professors, students, and graduates related to the tourism field and industrial fields; **E2**: Tourism experts and

governmental officials; **E3**: Industrial experts and governmental officials; **E4**: Industrial units active or inclined to do activity in the field of industrial tourism; and **E5**: Tourism activists. More detailed information about the expert team is provided in Table 5.

5.2. Weight calculations for dimensions and criteria

5.2.1. The SFD implementation

The proposed SFD method is used to examine the interrelationship between dimensions and the criteria in each dimension, and to construct the model in the FANP method.

S1: Non-ideal status: a status where the appropriate economic conditions and necessary infrastructure for the development of IndT are not available, and critical conditions such as a pandemic, war, and/or drought exist in the region.

S2: Current status: This condition exactly corresponds to the current conditions of the region.

S3: Ideal status: a status exactly opposite of non-ideal conditions, no pandemic, no war, and/or no drought.

Table 7 provides the calculation for the final influencing degree of each dimension. Based on Table 6, the responsiveness dimension has the most impact, and the sustainability dimension has the least impact on others. Moreover, Table 7 provides the calculation for the final influencing degree for the criteria.

Figure 6 shows the cause-and-effect relationship map according to the results of implementing the SFD method for the dimensions and the criteria related to each dimension. Figure 6 is used in the first step of the FANP method to construct the model.

5.2.2. FANP implementations

In this section, the results of implementing the FANP method are presented. Table 8 provides the final weight for each criterion belonging to each dimension and the rank of each criterion in general and in each dimension. According to the results, C18 (Innovative products or services), C19 (Demand responding level), and C4 (Staff behavior) are introduced as the most important criteria and have the highest impacts, and C11 (Availability and location), C7 (Job opportunities and labor force), and C12 (Criticality plan) are introduced as the least important criteria and have the lowest impacts on achieving the sustainable-resilient-responsiveness ITSC.

5.2.3. FTOPSIS implementations

In this section, the results of implementing the FTOPSIS method and the rank of each alternative in each dimension and its overall rank are provided in Table 9.

5.3. Comparison of Traditional DEMATEL and the proposed SFD methods

To check the efficiency of the proposed SFD method, we have compared the traditional DEMATEL with our proposed method, and the results are shown in Figure 7. We have implemented each scenario separately in the traditional DEMATEL method and evaluated which criterion has the most and least impact on others. As it is clear from Figure 7, in the dimension of sustainability, when scenario 1 is implemented alone in the DEMATEL method, the criteria C1 and C4 have the most and least impact on others, respectively, whereas, in scenario 2, criteria C2 and C7 have the most and least impact, respectively. And for scenario 3, C4 and C1 criteria are recognized as the most and least influential criteria, respectively. But our proposed method shows that if different scenarios are considered together, which is closer to the real world, C7 and C4 criteria are known as the most and least influential criteria, respectively. Also, for the responsiveness criteria, when scenario 2 is implemented alone with the traditional DEMATEL method, the criteria C10 and C12 are known as the most and least influential criteria, respectively. The third scenario shows the ideal conditions and states that when the economic conditions in the society are suitable and critical conditions such as a pandemic, war, or drought do not exist, in this case, the result of this scenario shows that criterion C12 is the least influential. By considering all the scenarios together and implementing the proposed SFD method, it can be seen that criterion C10, which expresses the capacity, is the most influential criterion, and criterion C11, which is Availability and location, is the least influential criterion. Through evaluating the results of our proposed SFD method in comparison with the traditional DEMATEL method, we find that our proposed method provides more accurate and consistent results in the real world. In the proposed method, different scenarios can be considered, and the degree of influence of each factor on other factors can be checked in each scenario.

5.4. Discussion

In this research, to achieve SSR goals in the ITSC, 19 criteria in three dimensions are identified through studying the LR, with the help of relevant experts. Then, 16 alternatives in two categories of IUs and ACs are selected as a case study and prioritized based on criteria and using a hybrid approach of the SFD, FANP, and the FTOPSIS methods. According to the results, C18 (Innovative products or services), C19 (Demand responding level), and C4 (Staff behavior) are introduced as the most important criteria, and C11 (Availability and location), C7 (Job opportunities and labor force), and C12 (Criticality plan) are introduced as the least important criteria to achieve the research goal. Also, by examining the results, it can be seen that to achieve the sustainability of the ITSC, the criteria of employee behavior (C4) and the safety of the employees' working environment (C3) are the most important and have the most impact, and the criteria of the final price of products or services (C1) and job opportunities (C7) are the least important and have the least impact. It is quite obvious that human resources are the most important part of a production or service unit, and their satisfaction has a significant role and impact on the success of that unit, and the results of our research also show this issue. The noteworthy point is that criterion C3 is in second place in terms of importance in the sustainability dimension, but in general, it is in fourth place among 19 criteria. Capacity (C10) and security (C8) play an important role in achieving resilience in the ITSC. The results of our research also show that security in achieving

resilience goals in the chain has a significant role. Also, among the criteria of resilience dimension, criticality plan (C12) and Availability and location (C11) have the least importance and impact. Moreover, according to the results related to the prioritization of potential alternatives, it can be seen that IU9 (Mazinoor Lighting Industries Company) and IU7 (Nami Gostar Chemical Mamtir) obtain the first and last ranks among industrial units, respectively, based on the three different types of criteria. Moreover, it can also be seen that AC3 (Mizban Hotel) and AC4 (Shomal Olympic Hotel) obtain the first and last ranks among ACs, respectively. The results show that an alternative may have a better rank in each of the dimensions (sustainability, resilience, and responsiveness) separately, but in general, it has a lower final rank. This point shows that the Gano Gardesh unit should choose industrial and ACs for cooperation that have a more suitable overall rank.

6. Conclusions

IdT is one of the branches of the tourism industry that has not received special attention, but has a lot of development potential for a region. Therefore, in this research, we have studied IndT through the study of its SC for the first time. First, with the help of experts, the ITSC is proposed, and its different levels and members involved in the chain are identified. For the proposed chain, three levels of customers, intermediaries, and service levels are considered. Moreover, the three most up-to-date and important issues in SC studies, SRR issues, are considered simultaneously for the first time, not only in the field of IndT but also in the field of tourism. To achieve this goal, first, by studying the LR and with the help of a team of experts, 19 effective criteria based on the SRR aspects are identified. Then, a case study in Mazandaran province, Iran, is adopted to evaluate the authenticity of our present work. To conduct the work, we have applied a novel hybrid MCDM approach that includes the SFD, FANP, and FTOPSIS methods. First of all, by using the SFD and FANP methods, the importance degree (weight) of each criterion is determined. Then, the potential alternatives from the real case study are ranked using the FTOPSIS method. The results show that the criteria, including C18 (Innovative products or services), C19 (Demand responding level), and C4 (Staff behavior) are introduced as the most important criteria, and C11 (Availability and location), C7 (Job opportunities and labor force), and C12 (Criticality plan) are introduced as the least important criteria to achieve SSR goals in the ITSC. Also, the results reveal that IU9 (Mazinoor Lighting Industries Company) and IU7 (Nami Gostar Chemical Mamtir) obtain the first and the last rank among IUs, respectively, and AC3 (Mizban Hotel) and AC4 (Shomal Olympic Hotel) obtain the first and the last rank among ACs, respectively. Also, for future studies, researchers are advised to carefully study the ITSC by considering the mathematical model and operational research capabilities. They can also consider subjects such as blockchain, IoT-based chain, discounting, advertising, and similar subjects in the ITSC studies.

Authors' Credit

Seyyed Mehdi Hosseini: Conceptualization; Data curation; Formula analysis; Investigation; Methodology; Writing- original draft; editing.

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Conflicts of interest

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

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Figure Captions

1. The proposed research framework.
2. The proposed ITSC network design.
3. The geographical location of each IU and AC considered in the case study.
4. The proposed hierarchical diagram for sustainable-resilient-responsive IndT.
5. The steps of the SFD method.
6. The cause-and-effect relationship diagram.
7. Comparison of results of DEMATEL and proposed SFD methods.

Table Captions

1. The summary of papers reviewed in LR.
2. Information on the potential IUs and ACs.

3. The criteria related to each dimension.
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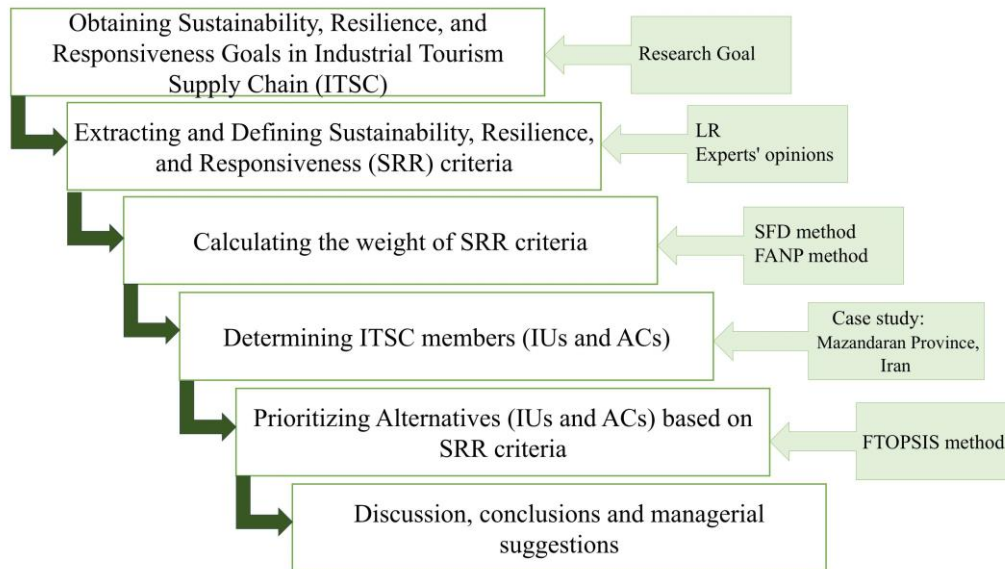


Figure1. The proposed research framework.

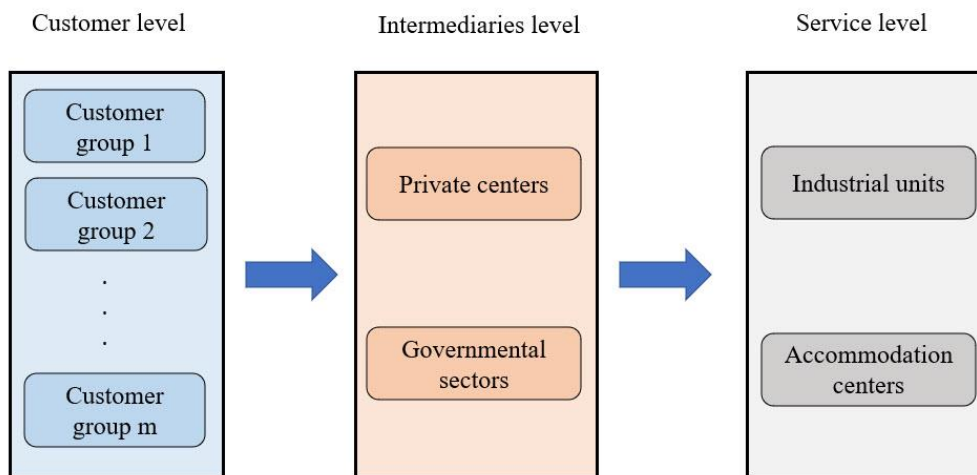


Figure2. The proposed ITSC network design.

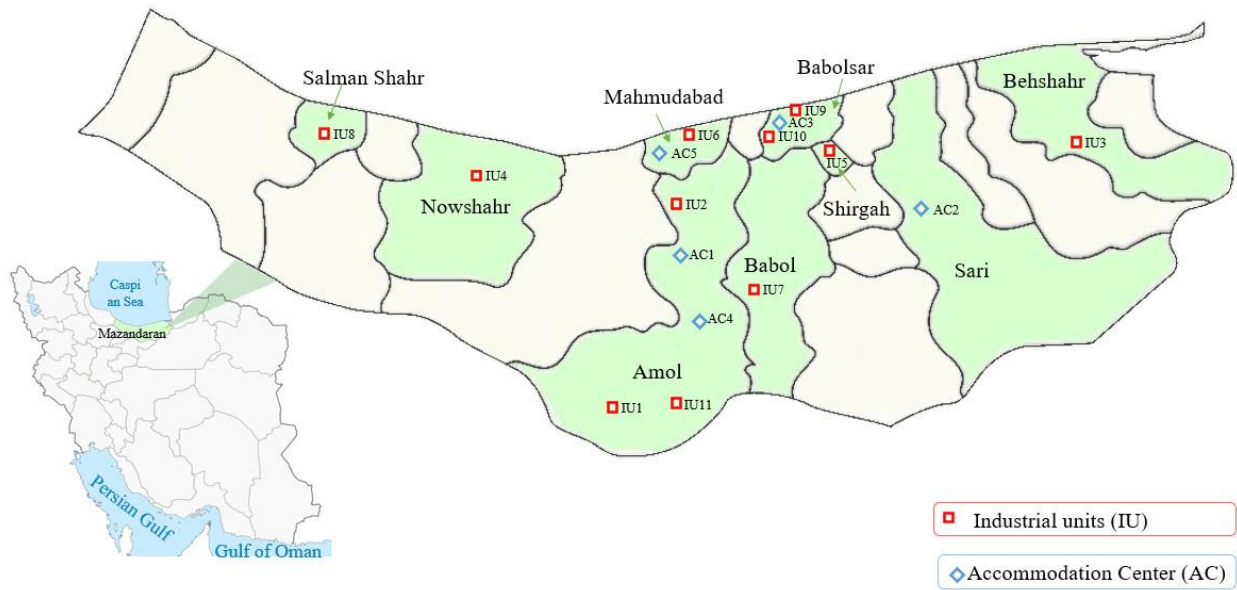


Figure3. The geographical location of each IU and AC considered in the case study.

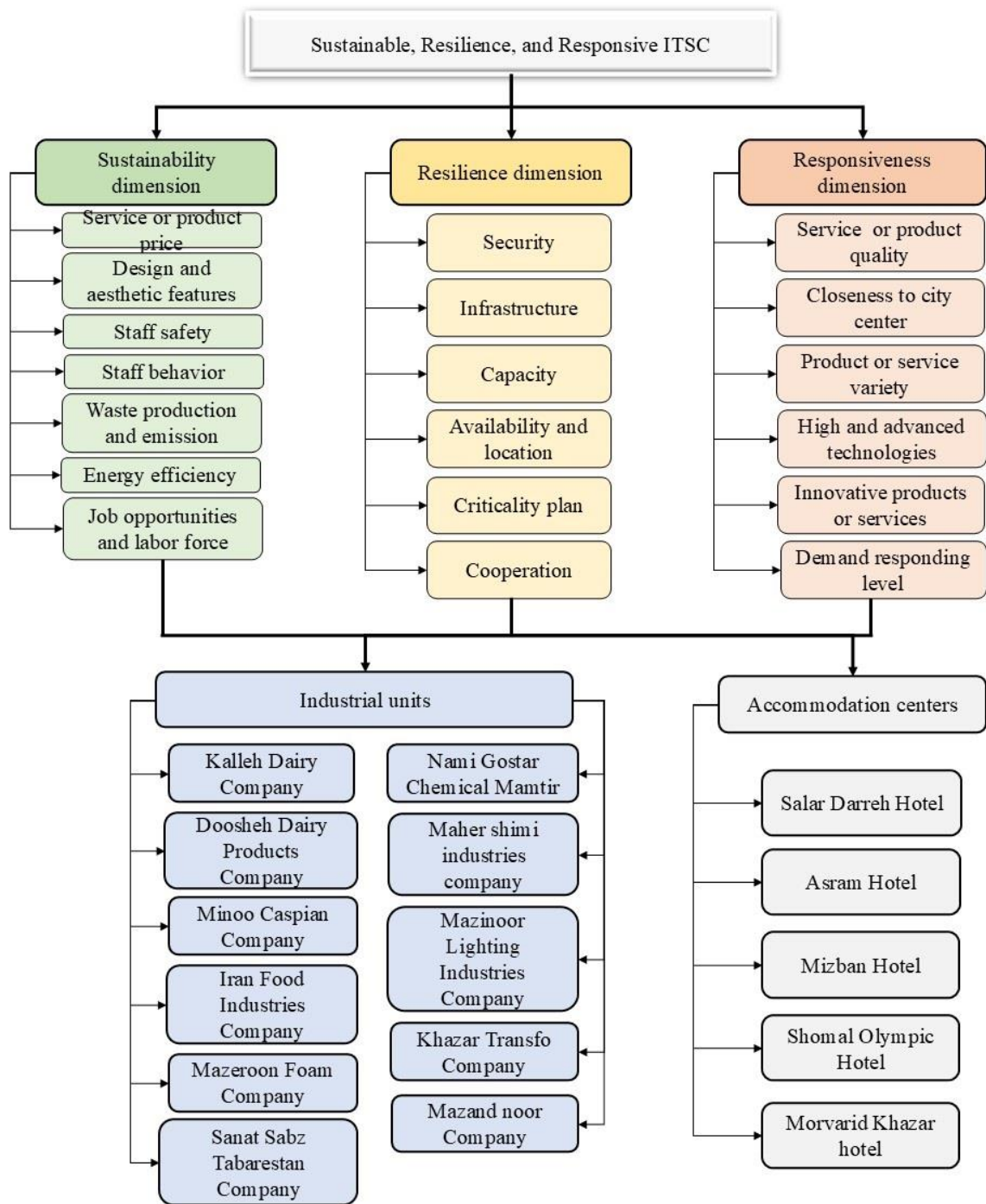


Figure4. The proposed hierarchical diagram for sustainable-resilient-responsive IndT.

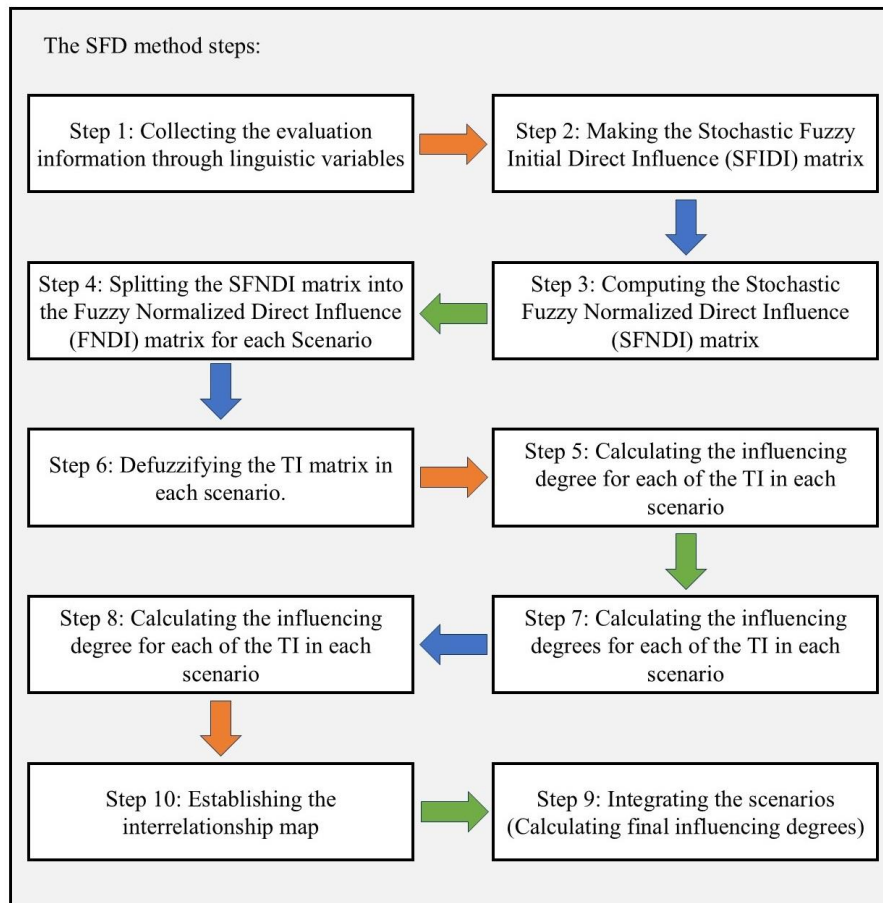


Figure5. The steps of the SFD method.

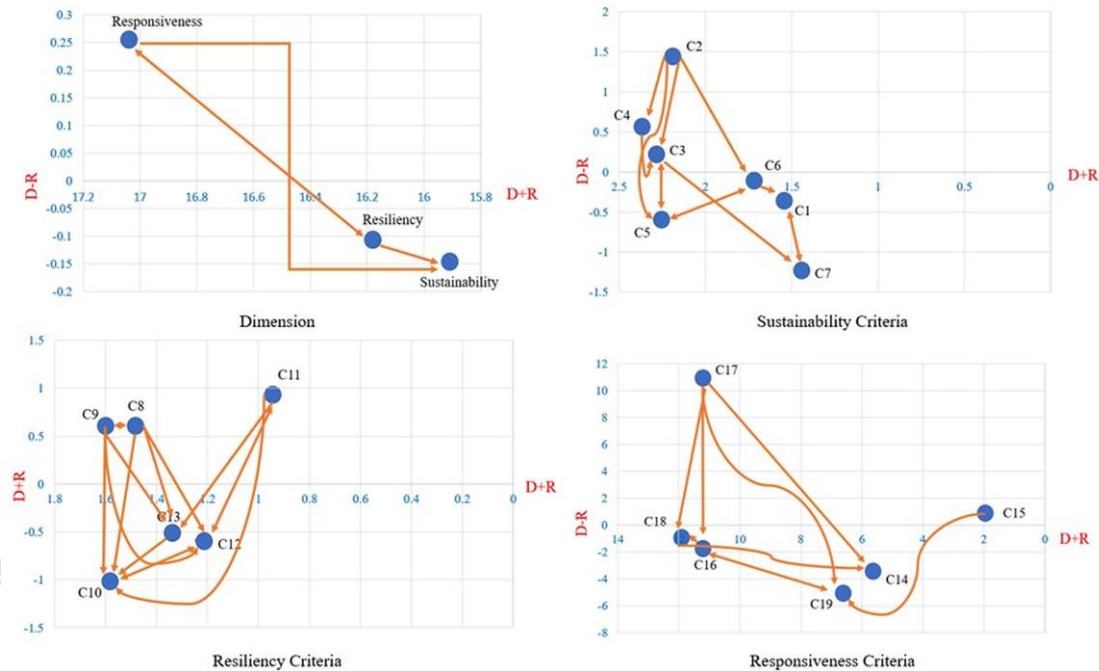


Figure6. The cause-and-effect relationship diagram.

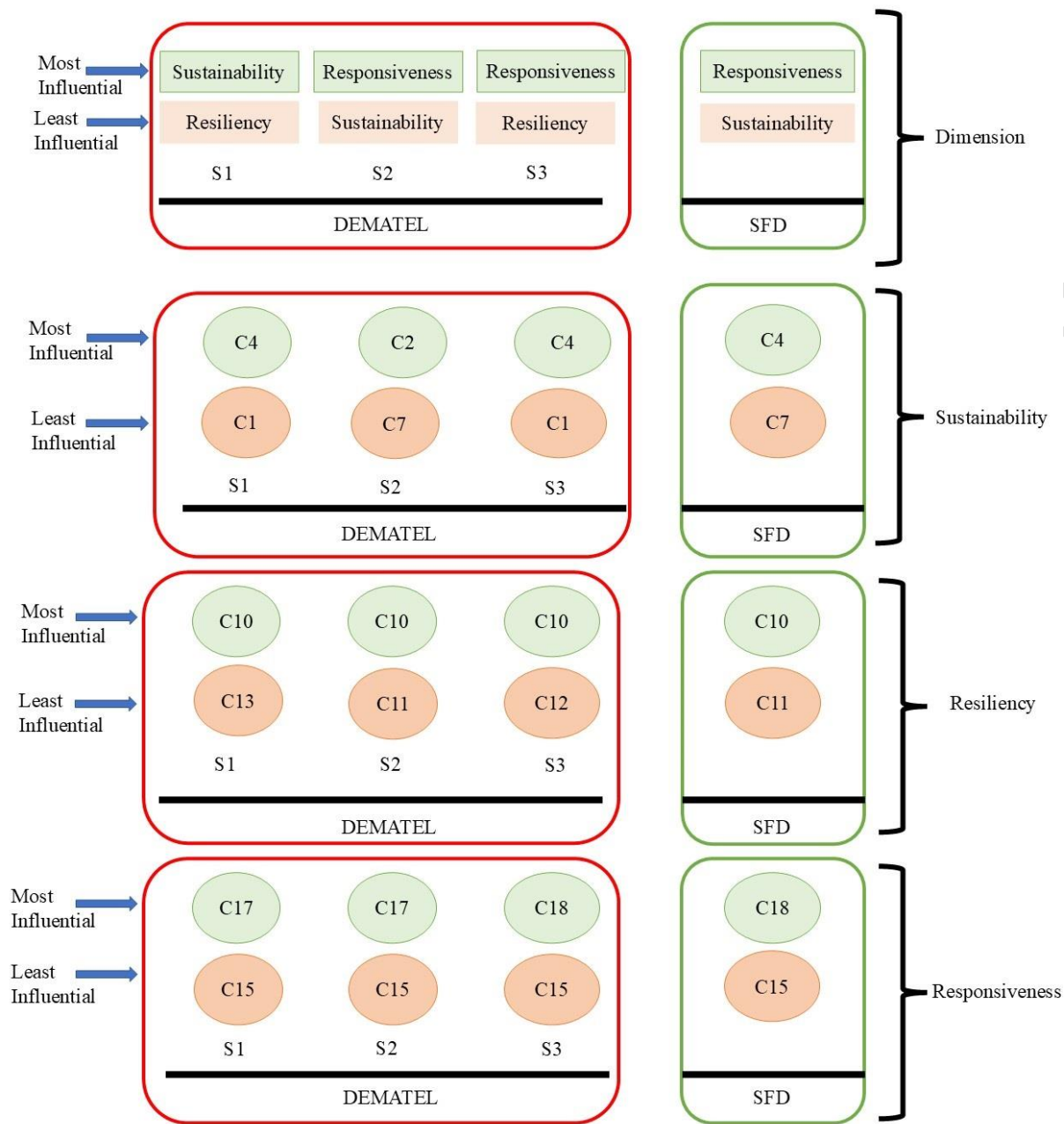


Figure7. Comparison of results of DEMATEL and proposed SFD methods.

Tables

Table 1. The summary of papers reviewed in LR.

Author(s)	Year	InT?	Research type		subjects			Tools or methods	Case study
			Qualitative	Quantitative	Sus*	Res**	Resp***		
Calgaro et al.	2014	×	✓	×	✓	✓	×	DSF	-
Amir et al.	2015	×	✓	×	✓	✓	×	-	Malaysia
Lew et al.	2016	×	✓	×	✓	✓	×	-	-
Holladay	2018	×	×	✓	✓	✓	×	Heuristic model	-
Powell et al.	2018	×	✓	×	✓	✓	×	Household survey techniques	Dong Van Karst Plateau Geopark, Vietnam
Cheung and Li	2019	×	✓	×	✓	✓	×	Conceptual model	-
Sgroi	2020	×	✓	×	✓	✓	×	-	-
Sobaih et al.	2021	×	×	✓	✓	✓	×	SEM and AMOS software	Egypt
Sheller	2021	×	✓	×	✓	✓	×	-	The Caribbean, USA
Della Corte et al.	2021	×	✓	×	✓	✓	×	-	-
Shi et al.	2022	×	✓	×	✓	✓	×	Physical-mechanical theory	Zhengzhou, Henan Province, China
Traskevich and Fontanari	2023	×	✓	×	✓	✓	×	A conceptual integrative model	-
Yang and Kim	2023	×	✓	×	✓	✓	×	-	Florida, USA
Novelli	2024	×	✓	×	✓	✓	×	-	Africa
Current study	2025	✓	×	✓	✓	✓	✓	A hybrid method	Mazandaran Province, Iran

*Sus: sustainability, **Res: resiliency, ***Resp: Responsiveness.

Table 2. Information on the potential IUs and ACs.

	Name	Number	Industry type
Industrial units (IU)	Kalleh Dairy Company	IU1	Food and beverage industry
	Doosheh Dairy Products Company	IU2	
	Minoo Caspian Company	IU3	
	Iran Food Industries Company	IU4	
	Mazeroon Foam Company	IU5	Chemical industry
	Sanat Sabz Tabarestan Company	IU6	
	Nami Gostar Chemical Mamtir Company	IU7	
	Maher Shimi Industries Company	IU8	
	Mazinoor Lighting Industries Company	IU9	Lighting and the Electronic Industry
	Khazar Transfo Company	IU10	
	Mazandaran Wire and Cable Company	IU11	
Accommodation Center (AC)	Oxin Hotel	AC1	Four stars
	Salar Darreh Hotel	AC2	Four stars
	Mizban Hotel	AC3	Five stars
	Shomal Olympic Hotel	AC4	Three stars
	Morvarid Khazar Hotel	AC5	Five stars

Table 3. The criteria related to each dimension.

Dimension	Criterion	Criterion number	Definition	References
Sustainability	Service or product price	C1	It is the final price of products or services paid by customers.	[32] +Expert
	Design and aesthetic features	C2	What is the status of the internal and external architecture and design of the relevant unit in terms of beauty and compliance with national and local symbols and standards?	[33]+Expert
	Staff health and safety	C3	The status of the relevant unit in terms of health, sanitary, and environmental safety of its employees.	[34]+Expert
	Staff behavior	C4	The behavior of the employees of the relevant unit with each other, and especially with the customers.	[35]+Expert
	Waste generation and emission	C5	The status of the relevant unit in terms of the number of environmental pollutants.	[36]
	Energy efficiency	C6	The status of the relevant unit in terms of energy consumption.	[36]
	Job opportunities and the labor force	C7	The number of job opportunities created by the relevant unit, the number of active workforces, and the job stability status of its employees.	[36, 37]+Expert
Resilience	Security	C8	The security status of the deployment area of the relevant unit.	[38]+Expert
	Infrastructure	C9	The condition of the necessary infrastructure for the activity of the relevant unit, such as equipment, devices, and information technology.	[39]+Expert
	Capacity	C10	The status of the capacity of the relevant unit responds to the customer's demand	[40]+Expert
	Availability and location	C11	Access status to the relevant unit (road and transportation status).	[41]+Expert
	Criticality plan	C12	Does the relevant unit have a road map or specific plan for critical times such as inflation, recession, war, or pandemic conditions?	[36]+Expert
	Cooperation	C13	The level of interest and willingness of the relevant unit to cooperate with other related units.	[42]+Expert
Responsiveness	Service or product quality	C14	Quality status of products and services provided by the relevant unit	[43]+Expert
	Closeness to the city center	C15	The status of the relevant unit in terms of distance to the city center	[44]+Expert
	Product or service variety	C16	A variety of products and services are provided by the unit	[45]+Expert
	High and advanced technologies	C17	Are there advanced and up-to-date technologies for operation in the relevant unit?	[36]+Expert
	Innovative products or services	C18	The status of the relevant unit in terms of producing or offering innovative products or services	[46]+Expert
	Demand responding level	C19	The time from receiving the order to delivering it to the customer	[47]+Expert

Table 4. The fuzzy linguistic variables in the SFD method.

Linguistic term	Influence score	Triangular fuzzy numbers
No Influence (No)	0	(0,0,0.25)
Very Low Influence (VL)	1	(0,0.25,0.50)
Low Influence (L)	2	(0.25,0.50,0.75)
High Influence (H)	3	(0.50,0.75,1)
Very High Influence (H)	4	(0.75,1,1)

Table 5: Detailed information of the Expert team.

	Expert group	Organization	Position	Gender	Working year	Degree	Filed
1	Academic experts (E1)	Mazandaran University	University professor	Female	10	PhD	Tourism
2		Tehran University	University professor	Male	15	PhD	Tourism
3		Tehran University	Graduated	Female	-	MSc	Tourism
4		Babol Noshirvani University of Technology	University professor	Male	17	PhD	Industrial engineering
5		Babol Noshirvani University of Technology	University professor	Male	16	PhD	Industrial engineering
6		Iran University of Science and Technology	PhD candidate	Male	-	PhD	Industrial engineering
7	Tourism experts of governmental officials (E2)	Mazandaran Cultural Heritage, Tourism and Handicrafts Office	Expert	Male	13	BSc	Tourism
8			Expert	Female	11	BSc	Tourism
9			Expert	Male	14	MSc	Tourism
10	Industrial experts or governmental officials (E3)	Mazandaran Industry, Mine and Trade Office	Expert	Male	23	MSc	International Business Management
11			Expert	Female	26	BSc	Industrial management
12		Mazandaran Chamber of Commerce, Industries, Mines, and Agriculture	Expert	Male	21	MSc	Industrial management
13	Industrial units (E4)	Mazinoor	Sales Engineering Support Expert	Male	7	MSc	Industrial engineering
14		Kalleh Dairy	Research and Development Expert	Male	8	MSc	Industrial engineering
15		Mazeroon Foam Industrial Group	Future studies expert	Female	8	PhD	Chemical engineering
16	Tourism activists (E5)	Funweekend tour	Tour leader	Female	7	MSc	Tourism
17		Tika Parvaz Travel Agency	Management	Male	14	MSc	Tourism
18		Sepantarojan Academy	Management	Female	11	MSc	Tourism

Table 6. Calculation for the final influencing degree of dimensions.

	D			R			D*	R*	D*+R*	D*-R*
	S1	S2	S3	S1	S2	S3				
Sustainability	7.7414	9.6032	4.6055	7.9529	9.8984	4.3781	7.8883	8.0320	15.9203	-0.1436
Resilience	8.2623	9.8792	4.1282	8.0170	10.0496	4.4584	8.0372	8.1436	16.1809	-0.1064
Responsiveness	8.3563	10.6494	4.9332	8.3901	10.1838	4.8304	8.6471	8.3970	17.0442	0.2500

Table 7. Calculation for the final influencing degree of sustainability criteria.

		D			R			D*	R*	D*+R*	D*-R*
		S1	S2	S3	S1	S2	S3				
Sustainability	C1	0.7696	0.5808	0.5118	1.1112	0.9293	0.7881	0.6108229	0.9395	1.5503	-0.3287
	C2	2.1598	1.7291	1.6142	0.5182	0.3452	0.2792	1.8080699	0.3720	2.1800	1.4360
	C3	1.5506	1.1841	1.1378	1.2816	0.8891	0.9971	1.2641861	1.0142	2.2784	0.2499
	C4	1.8051	1.3526	1.2930	1.0457	0.8434	0.905262	1.4508	0.9094	2.3603	0.5414
	C5	1.1965	0.6875	0.7126	1.6975	1.3378	1.271102	0.8210	1.4110	2.2321	-0.5900
	C6	0.9640	0.7538	0.7776	1.1447	0.8597	0.715334	0.8123	0.8948	1.7072	-0.0825
	C7	0.0929	0.1069	0.1318	1.7396	1.1903	1.222902	0.1096	1.3358	1.4455	-1.2261
Resilience	C8	1.2428	0.9980	0.9219	0.4907	0.4438	0.4450	1.0402	0.4558	1.4961	0.5844
	C9	1.2265	1.0204	1.0318	0.5428	0.4886	0.4934	1.0748	0.5034	1.5782	0.5714
	C10	0.3633	0.2782	0.2528	1.4530	1.2601	1.2042	0.2931	1.2943	1.5875	-1.0012
	C11	1.1404	0.9119	0.8369	0.0334	0.0158	0.0162	0.9503	0.0203	0.9707	0.9299
	C12	0.4302	0.2988	0.2609	1.1572	0.8876	0.7385	0.3222	0.9177	1.2399	-0.5955
	C13	0.4165	0.4074	0.4213	1.1427	0.8188	0.8284	0.4131	0.9022	1.3154	-0.4890
Responsiveness	C14	1.5891	0.7162	1.1510	4.9694	4.0427	5.7711	1.0431	4.7065	5.7496	-3.6633
	C15	0	1.8204	1.5881	1.1324	0.6077	0.5033	1.3072	0.7128	2.0200	0.59445
	C16	5.1017	4.5829	5.5731	5.4794	6.1719	7.7673	4.9601	6.3976	11.3578	-1.4374
	C17	11.0715	10.2080	12.8938	0.4001	0	0	11.0953	0.1000	11.1954	10.9953
	C18	5	4.8904	6.3531	5.7560	6.1367	8.1012	5.2835	6.5326	11.8162	-1.2491
	C19	0.7309	0.5651	0.6515	5.7560	5.8241	6.0676	0.6282	5.8679	6.4962	-5.2397

Table 8. The obtained weights in the FANP method.

Dimension/Criteria	Weight	Rank in dimension	General Rank
Sustainability	0.2824		
C1	0.0206	6	15
C2	0.0268	4	12
C3	0.0745	2	4
C4	0.0940	1	3
C5	0.0339	3	11
C6	0.0222	5	14
C7	0.0104	7	18
Resilience	0.1569		
C8	0.0378	2	10
C9	0.0240	3	13
C10	0.0640	1	6
C11	0.0072	6	19
C12	0.0117	5	17
C13	0.0122	4	16
Responsiveness	0.5607		
C14	0.0646	3	5
C15	0.0460	6	9
C16	0.0527	5	8
C17	0.0538	4	7
C18	0.2120	1	1
C19	0.1316	2	2

Table 9. Final rank of alternatives obtained from FTOPSIS.

Alternatives	Sustainability		Resiliency		Responsiveness		Overall	
	Weight	Rank	Weight	Rank	Weight	Rank	Weight	Rank
IU1	0.0964	4	0.1045	2	0.0973	3	0.0979	3
IU2	0.0824	8	0.0878	5	0.0896	6	0.0853	5
IU3	0.0796	9	0.0881	6	0.0912	4	0.0842	7
IU4	0.0827	7	0.0881	6	0.0864	9	0.0846	6
IU5	0.0999	3	0.1	3	0.0995	2	0.0998	2
IU6	0.0931	5	0.0847	7	0.0893	7	0.0907	4
IU7	0.0758	10	0.0826	8	0.0886	8	0.0805	10
IU8	0.0824	8	0.0821	9	0.0784	11	0.0812	9
IU9	0.1143	1	0.1094	1	0.11	1	0.1123	1
IU10	0.1051	2	0.0967	4	0.0909	5	0.0998	2
IU11	0.0883	6	0.076	10	0.0788	10	0.0837	8
AC1	0.204	3	0.1951	3	0.1848	3	0.1972	3
AC2	0.1541	4	0.1489	5	0.1397	4	0.1492	4
AC3	0.2485	1	0.2734	1	0.285	1	0.2627	1
AC4	0.1481	5	0.1508	4	0.13	5	0.1434	5
AC5	0.2453	2	0.2318	2	0.2605	2	0.2475	2

Biographies

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