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Developing a new framework for conceptualizing the emerging sustainable community-based tourism using an extended interval-valued Pythagorean fuzzy SWARA-MULTIMOORA

Jun He [a], Zilong Huang [a], Arunodaya Raj Mishra [b,*], Melfi Alrasheedi [c]

[a] School of Economics, Liaoning University, Shenyang, Liaoning 110036, China
[b] Department of Mathematics, Govt. College Jaitwara, Satna, MP-485221, India
[c] Department of Quantitative Methods, School of Business, King Faisal University, Saudi Arabia

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ABSTRACT

During these years, the sustainable Community-Based Tourism (CBT) notion has received more attention in the context of the tourism industry. Sustainable CBT mainly emphasizes social, environmental, and cultural sustainability and gives power to local communities in any aspect of tourism management. This manuscript aims to propose a novel approach to examine the current status of sustainable CBT in the Indian Himalayan region context. In this regard, a comprehensive framework was developed using experts' opinions, and the relevant literature in tourism studies was reviewed based on sustainable CBT. To this end, this study proposed an integrated decision-making method using Step-wise Weight Assessment Ratio Analysis (SWARA) and MULTIMOORA (Multiple Objective Optimization based on the Ratio Analysis plus Full Multiplicative Form) under Interval-Valued Pythagorean Fuzzy Sets (IVPFSs). Additionally, some comparisons were discussed with the outcomes obtained from the developed approach and those of extant ones to evaluate the efficiency of the proposed model. To confirm the applicability of the proposed IVPF-SWARA-MULTIMOORA approach to real-world decision-making problems, a sustainable CBT problem was considered as a case study. The final results confirmed the efficiency of the proposed approach as well as its consistency with the existing ones.

1. Introduction

A community's economy can be invigorated, and also the relationship between the environment and society can be balanced by implementing sustainability in the development of Community-Based Tourism (CBT) (Cheng et al, 2019). According to Wang and Pfister (2008), in the past 30 years, scholars studying Sustainable Tourism Development (STD) have focused on the interaction between STD and community residents. According to Asker et al (2010), the term CBT appeared in the mid-1990s. Since the century started, CBT has been prominently discussed; what CBT entails has been diversely understood (Mayaka et al, 2012), and how much it is community-oriented has been critically evaluated (Mayaka et al, 2018a). CBT involves several stakeholders Dangi and Jamal (2016b), resulting in several direct and indirect close relationships. CBT stakeholders generally include local and national governments, the community, Non-governmental Organizations (NGOs), and the private sector Simpson (2008). Researchers consider the tourism field based on different meanings of CBT, but the CBT's real essence directly encompasses the Local Community (LC) in all projects of the tourism development in an area. Kontogeorgopoulos et al (2014) stated that tourism results from a tool of conservation and community development. CBT has often been quoted as an approach toward more sustainable tourism and an option to mass tourism. The well-developed CBT can make a poverty alleviation mechanism, provide access to the improved quality of life, and empower and bring more economic benefits to individuals in the local communities (Dodds et al, 2018). CBT is a proper substitute for mass tourism (Dodds et al, 2018). Commonly, small-scale CBT, which includes interactions between host community and visitor, is particularly suitable for regional and rural areas Peric and Djurkin (2014).

Several researchers have widely studied CBT in the field of tourism inside or outside countries (Dodds et al, 2018; Matilainen et al, 2018a; Mayaka et al, 2019; Park et al, 2018). Tourists in CBT programs stay with local families, usually in rural areas. CBT emphasizes that LCs must

* Corresponding author.
E-mail address: arunodaya87@outlook.com (A.R. Mishra).

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contribute to developing tourism and the management of tourism sustainability (Avila-Foucat and Rodríguez-Robayo, 2018; Mayaka et al, 2018a). In addition, the focus of CBT is on the fact that the active participation of local people in the process of tourism development is so fundamental that local benefits could be maximized by minimizing the negative cultural, social, environmental, and economic effects of local control and by implementing more tourism initiatives (Lee and Jan, 2019; Tolkach and King, 2015). According to Schott and Nhem (2018), CBT was regarded as another form of tourism, maximizing benefits to local people and achieving objectives of community development by empowerment and building community capacity.

On the other hand, CBT is regarded as a new paradigm in the tourism industry (Zielinski et al, 2018). It is a commonly accepted fact that CBT management is done by the community in a way to be fruitful for the same community. CBT mainly emphasizes social, environmental, and cultural sustainability and empowers the local communities in any aspect of tourism management in their communities (Mayaka et al, 2018a; Ngo et al, 2018b). CBT, closely associated with ecotourism, is a process for community development and cultural and natural resource conservation. Cultural and natural conservation are contributed to and motivated by community-based practices, providing opportunities to improve community livelihood.

Despite the original implementation of the practice and concept of CBT in developed countries, the developing countries, with publishing most of the literature in recent times, have found it more popular Vajirakachorn (2011). Rogerson (2007) responds and recommends prioritizing the community capacity building to keep an accountable and transparent benefit-sharing mechanism. Environmental, socio-cultural, and economic aspects are included in CBT, similar to sustainable tourism Dangi and Jamal (2016a). Despite the criticality of the business-focused dimension and economic sustainability for CBT Spenceley and Meyer (2012), this research field has been neglected. A growing literature has emerged on CBT in the past three decades in tourism studies. This work commences a comprehensive analysis of sustainable CBT to find the main criteria for analysis. Therefore, this study attempts to evaluate the concept of sustainable CBT in a way that provides a comprehensive framework based on the current literature review. In this regard, a survey study using literature review and interviews is conducted to examine CBT from three main perspectives that are environmental, socio-cultural, and economic.

In the context of sustainable tourism, the decision-making problems frequently demand that many answers and alternatives be evaluated with multiple viewpoints and criteria available at present due to their complexity (Bidstrup, 2015; Silva et al, 2014). In this way, the involvement of several stakeholders in the tourism industry has made the decision-making processes even more complex (González-Ramiro et al, 2016). Decision-making is facilitated by Multi-Criteria Decision--Making (MCDM) methods in many situations where there are various contradictory criteria for making decisions (Gutiérrez Gallego et al, 2015). Moreover, there have been more significant uncertainties of demand and complex dynamics in the tourism industry due to intense competition between sustainable CBT, therefore, it is complex to evaluate the criteria that involving a transversal process to achieve strategic and logistical objectives Zhang and Murphy (2009). Despite recent debates on the significance of CBT, the concept is still vague and fuzzy, with little consensus on its compositional facets. Due to such vagueness, it seems complicated to define and recognize its determining criteria. It has been largely accepted to indulgence human judgments and priorities as vague phenomena that cannot be accurately articulated in precise numbers Li and Tong (2018). An effective way to address properly its complex nature is the use of the fuzzy sets theory that has been pioneered as a remedy to handle the uncertainty. Therefore, the CBT criteria in this study are evaluated by developing a new fuzzy decision-making framework.

In the structure of MCDM, the criteria weights are important aspects for Decision Experts (DEs). Kersuliene et al. (2010) introduced the Stepwise Weight Assessment Ratio Analysis (SWARA) approach to compute the subjective weights. The assessment procedure of the SWARA model is simple as compared to diverse extant procedure namely Analytic Hierarchy Process (AHP). Mishra et al. (2020) proposed a methodology combining the SWARA and Complex Proportional Assessment (COPRAS) models to assess bioenergy production methods with Intuitionistic Fuzzy Sets (IFSs). Rani et al. (2020a) gave an integrated MCDM model for evaluating healthcare waste method problem. Rani et al. (2020b) also combined the SWARA and COPRAS approaches to evaluate the sustainable supplier for Hesitant Fuzzy Sets (HFSs). Mardani et al. (2020) combined the decision-making structure with SWARA, Weighted Aggregated Sum Product Assessment (WASPAS), and HFSs to assess the digital technologies intervention to control the COVID-19 outbreak. Rani and Mishra (2020) combined SWARA with VIKOR to evaluate the eco-industrial thermal power plants on Single-Valued Neutrosophic Sets (SVNSs). Since SWARA model appearance, various integrating theories for handling different realistic problems have been proposed (Alrasheedi, et al, 2021; Saraji et al, 2021)

To handle uncertain or imprecise information in MCDM problems, Yager (2013) introduced the Pythagorean Fuzzy Sets (PFSs) theory to handle the concern mentioned above. Yager (2013) illustrated the case in which DEs assign the degree to which an option R_i satisfies the criteria C_j is $\frac{\sqrt{3}}{2}$, and the degree to which an option R_i invalidate the criteria C_j is $\frac{1}{2}$. In this concern, it can be observed that $\frac{\sqrt{3}}{2}+\frac{1}{2}>1$, consequently, IFSs failed to tackle the issue. As $\left(\frac{\sqrt{3}}{2}\right)^2+\left(\frac{1}{2}\right)^2\leq 1$, thus, this situation can be systematically tackled by PFSs. As can be concluded from the above discussion, PFSs could model various MCDM situations that cannot be handled by IFSs. Thus, PFSs are assumed as a more reliable model to solve complex MCDM problems (Rani et al., 2020c). To choose a suitable conversion technology and upgrade the agriculture residues-to-energy industries, Rani et al (2021) integrated an approach to PFSs and WDBA. Liu et al (2021) assessed and obtained a suitable medical waste treatment technology using the CoCoSo model for PFSs. PFS has been addressed from various perspectives, including decision-making technologies (Rani et al., 2019; Rani et al., 2020d; Liu et al., 2021). Zhang (2016) and Peng and Yang (2016) generalized PFSs to Interval-Valued Pythagorean Fuzzy Sets (IVPFSs). As an extension of PFSs and Interval-Valued Intuitionistic Fuzzy Sets (IVIFSs), the IVPFSs have wider applications in the field of MCDM, e.g., in sustainable supplier selection, goods evaluation, etc. Garg (2018) proposed various scores and accuracy functions of IVPFSs for handling some comparative concerns. Chen (2018) extended complex MCDM approaches for IVPFS. Peng and Li (2019) proposed a Weighted Discrimination-Based Approximation (WDBA) and similarity measure-based approach by applying a risk assignment procedure under IPFSs context to tackle the financial decision-making problems.

Due to widespread changes and the development of the socio-economic environment, the practical MCDM problems are becoming progressively more complex. Brauers and Zavadskas (2010) pioneered the Multi-Objective Optimization based on Ratio Analysis plus the full multiplicative form (MULTIMOORA) procedure, which integrates three aggregation models, namely ratio system (RS), reference point (RP), and the Full Multiplicative Form (FMF). In comparison with numerous extant models, the MULTIMOORA method has some advantages such as easier mathematical terminologies, less complexity and higher robustness (Brauers and Zavadskas, 2011, 2012). Due to its unique advantages over other MCDM methods, the classical MULTIMOORA method has been employed to solve different realistic problems (Stankevičienė et al., 2019). Furthermore, to tackle with uncertain information that occurs in MCDM problems, the MULTIMOORA model has been extended over diverse fuzzy environments. Chen et al. (2018) developed the MULTIMOORA framework with linguistic assessments. Hafezalkotob et al. (2019) offered a widespread review of the MULTIMOORA model with the theoretical and practical perspectives. Apart from these studies, several other extensions of the MULTIMOORA method have been discussed in the literature (Xian et al., 2020). Rani and Mishra (2021) gave an integrated tool using MULTIMOORA approach for solving electric vehicle charging location selection problem on under Fermatean Fuzzy Sets (FFSs). However, there is no research regarding examining the current status of sustainable CBT in the Indian Himalayan region context by utilizing the MULTIMOORA approach under IVPFSs settings.

1.1. Motivation and novelty of the paper

The literature consists of different definitions, interpretations, and practices, with some criticisms. Several indicators, definitions, stakeholders, and principles are involved in the path toward sustainability (Asmelash and Kumar, 2019; Blancas et al, 2018; Font et al, 2019; Hall, 2019; Lee and Jan, 2019; Nepal et al, 2019; Paiano et al, 2020). Consequently, this article aims to present an innovative method to investigate the current status of sustainable CBT in the Indian context. In this regard, the related literature in tourism studies was comprehensively analyzed to collect the related criteria of sustainable CBT. The results of this analysis revealed that there have been evolving rich knowledge domains of CBT and sustainable tourism, primarily along with tourism pathways. Therefore, the current paper's aim is to present empirical findings and theoretical insights to contribute to the literature. To identify and structure a set of criteria, in this study, a hierarchical model for decision-makers is provided, and the framework of sustainable CBT is extended, and a comprehensive structure is presented to be applicable by the tourism industry and the related stakeholders. Thus, this methodology develops an IVPF-SWARA-MULTIMOORA framework by integrating the SWARA and MULTIMOORA models on IVPFS settings. As mentioned earlier, the MULTIMOORA method is based on three structures: RS, RP, and FMF, and the final rank of each option are determined using the dominance doctrine. Therefore, the contributions of the paper are presented as follow:

- A comprehensive framework using experts' interviews and the current literature is developed based on the various criteria of sustainable CBT.
- To evaluate the sustainable CBT framework, a novel decision-making approach using SWARA and MULTIMOORA on IVPF environment is introduced.
- To obtain the significance or criteria weights, the SWARA method under IVPFSs is used to examine the current status of sustainable CBT in the Indian Himalayan region context.
- To evaluate and rank the sustainable CBT options, MULTIMOORA is applied under IVPFSs.
- The proposed IVPF-SWARA-MULTIMOORA approach is validated through comparing its performance with that of other existing decision-making approaches.

2. Literature review

2.1. Stakeholder doctrine and CBT

The development of CBT needs the involvement of the stakeholders in all phases (Curcija et al, 2019; Woldu, 2018), from the earlier phase until the phase to sustain the program. The objectives of the CBT program are to help the economy of the rural community and benefit all stakeholders Mahaarachchie and Ranasinghe (2019). Each stakeholder in the homestay program has its own roles and contributions. According to Swarbrooke (1999), the stakeholders in tourism should work together if they wish to develop a more sustainable form of tourism. Thus, there is an emerging consensus that tourism can be better managed through stakeholders' collaboration.

The assessment and investigation on the understanding and perception of stakeholders about sustainability will significantly contribute to an improved understanding of sustainable development of CBT through homestay programs. There is research about the residents' perceptions about sustainable CBT, resulting in the fact that the residents' perception could significantly support the development of CBT with an acceptable level of sustainability concept.

Several previous studies have examined the stakeholder's roles and contributions (Christou et al, 2018; Herrera et al, 2018; Todd et al, 2017), but none has looked from the multi-stakeholders perspectives and attempted to understand the criteria of sustainable development of homestay program. There is a study focusing on criteria for homestay development, where the criteria have been grouped into product, participant, and principal to ensure the homestay program to be successfully implemented (Razzaq et al, 2016). However, the literature lacks research on the sustainable criteria for homestay development from the viewpoint of multi-stakeholders.

Literature of tourism indicates that different types of stakeholder exist (Heslinga et al, 2019; Pulido-Fernández and Merinero-Rodríguez, 2018; Tham, 2018), which can be categorized into six groups: local community, tourists, government, industry, educational institutions, and special interest groups (Waligo et al, 2013). These groups of stakeholders can impact sustainable CBT in several ways: tourist management, regulation, and legal perspective. On the other hand, tourism impacts management, which can be addressed from different perspectives: economic, socio-cultural, environmental, talent development, and product development. While the details of stakeholder structure differ through diverse tourism contexts, stakeholders can significantly influence the sustainable CBT initiatives.

Three aspects of the stakeholder theory (i.e., instrumental, empirical/descriptive, and normative) were proposed by Donaldson and Preston (1995). The characteristic or behavior of a development or an organization can be described using the empirical/descriptive aspect of the stakeholder theory. In addition, the present, past, and future state of affairs of an association and its stakeholders are examined and explained using this aspect Donaldson and Preston (1995). From an empirical or descriptive perspective, the stakeholder doctrine can describe many elements of tourism in a community, including the history of tourism development, the policies made by policymakers to manage and develop tourism, the size of the tourism sector, the attractions types, the general economic impact of tourism, and the relationships between various companies, organizations, and agencies generally involved in the tourism industry (Byrd Erick, 2007; Gursoy et al, 2019).

Furthermore, the stakeholder theory has been widely applied to tourism when dealing with the interdependency of stakeholders and impact of their ability on the tourism destination development processes Jamal and Getz (1995). Robson and Robson (1996) presented that one of the main principles of the stakeholder doctrines is that an organization can function based on its social contract with stakeholders. Stakeholders' participation in the tourism development and planning processes, experience and knowledge of tourism management, and long-term community involvement has been found to affect the tourism destination management Hardy and Beeton (2001). However, more importantly, some stakeholders determine the success of activities more than others, while each group of stakeholders shows a significant part in developing the tourism industry. Therefore, this study used the stakeholder theory to build the proposed sustainable CBT framework and criteria by expanding knowledge about the stakeholder's role in STD and sustainable CBT.

2.2. An overview of sustainable CBT

There has been an emergence of sustainable tourism to manage the increasingly adverse effects of this industry on the destination regions (Dorin-Paul, 2013). Therefore, sustainable tourism has emerged as a reactive idea, attempting to avoid the negative social, environmental, cultural, and economic impacts that outshine the benefits of tourism to host communities Lee and Jan (2019). Tourism sustainability should be urgently assessed for some crucial reasons. There should be consistent

Table 1
Selected criteria for sustainable CBT.

Aspects	Dimensions	Sources
Environmental	Environment and the purity of nature	Stănciulescu and Ţîrca (2010); McLoughlin and Hanrahan (2016); Pralong (2006); Kask et al (2016)
	Physical Integrity	Tseng et al (2018); Tshipala et al (2019); Parga Dans and Alonso González (2019); Koren-Lawrence et al (2020); Gössling (2017); Dłużewska (2019); Okonkwo and Odey (2018)
	Natural Resources	Boley and Green (2016); Heyne et al (2018); Sgroi (2020); Cetin et al (2018); Drius et al (2019); He et al (2018); Boley et al (2017); Zhu et al (2017)
	Protection of The Natural Ecosystems	Blancas et al (2016); Gan et al (2019); Fraguell et al (2016); Lozano-Oyola et al (2019)
	Environment Legislation	Verma and Chandra (2018); Aqueveque and Bianchi (2017); Perez Alonso et al (2018); Higgins-Desbiolles (2018)
	Environment Policy	Kitheka and Backman (2016); Buijtendijk and Eijgelaar (2020); Brendehaug et al (2017); Mihalic (2016); Danish and Wang (2018)
Economic	Employment Quality	Thongdejsri and Nitivattananon (2019); Pfueller et al (2011); Tseng et al (2018); Urtasun and Gutiérrez (2006); Gössling (2017); de Grosbois (2016)
	Economical Capacity	Tseng et al (2018); Janusz and Bajdor (2013); Pomering et al (2011); Torres-Delgado and Palomeque (2014); Sgroi (2020); Fletcher et al (2016)
	Economic Feasibility	Roda et al (2017); Kurniawan et al (2019); James et al (2020); Kurniawan et al (2019); McCool (2016)
	Financial Leakage	Alzboun et al (2016); Ambelu et al (2018); Seok et al (2020)
	Economic Opportunities	Lee and Jan (2019); Fang (2020); López et al (2018); Loperena (2017); Hsu et al (2020); Weber (2019)
Socio-Cultural	Socio-Cultural Policy	Lee & Jan (2019); Kangas et al (2017); Higham and Miller (2018); Hanrahan and Maguire (2016)
	Leadership	Andersen et al (2018); Zhu et al (2017); Thomas (2020); Mihalič et al (2016)
	Infrastructure development	Irazábal (2018); Andrades and Dimanche (2017); Koster and Main (2019); Pawson et al (2018)
	Quality of Life	Dangi and Jamal (2016c); Lee & Jan (2019); Dodds et al (2018); Burgos and Mertens (2017); Álvarez-García et al (2018)
	Training and Education	Wearing et al (2017); Novelli et al (2017); Whitney-Gould et al (2018)
	Stakeholder's involvement	Dangi and Jamal (2016c); Ngo et al (2018a); Domínguez-Gómez and González-Gómez (2017); Matilainen et al (2018b)
	Local Control	Dangi and Jamal (2016c); Mtapuri and Giampiccoli (2019); Ruiz-Ballesteros and del Campo Tejedor (2020); Juma and Khademi-Vidra (2019)
	Community Well-Being	Park et al (2017); Lee and Jan (2019); Mtapuri and Giampiccoli (2019); Dangi and Jamal (2016c)
	Socio Equity	Mtapuri and Giampiccoli (2019); (Phelan et al, 2020); Redmore et al (2017); Strydom et al (2019); Sawatsuk et al (2018)
	Community Participation	Mayaka et al (2018b); Jaafar et al (2020); Dangi and Jamal (2016c); Lapeyre (2010); Sebele (2010); Kayat (2002)

evaluation and monitoring of tourism impacts for the cultural sensitiveness of attraction sites and the fragile ecological settings. Tourism projects that were supposed to be beneficial turned out to be neither socially nor economically beneficial often due to problems with the supposed economic benefits and the methods of development employed Eadington and Smith (1992). The fact is that those who make policies regarding tourism (which includes the industry sector, tourism researchers, and destination marketing organizations) mainly focus on sustainable development Hall (2019). Consequently, many tourism researchers and policymakers are seeking ways to remedy the situation or mitigate the negative impacts of mass tourism (Qiu et al, 2019).

To summarize the main benefits of CBT, Tolkach and King (2015) suggested the active participation of the community in tourism management, tourism planning, and profit distribution. There are ambitious goals of the CBT development due to their embracing the broad issues of socio-cultural, political, economic, and environmental dimensions Kontogeorgopoulos (2005). Economically, CBT should improve local living standards by creating local jobs Manyara and Jones (2007). Likewise, Lapeyre (2010) maintains that rural livelihoods can be enhanced by CBT, offering better local economic connections while economic leakages are minimized. CBT can also encourage decision-making, local participation, and empowerment regarding a community's direction in the future and improve the democratic procedures over consensus agreement. From a socio-cultural perspective, CBT can revitalize local tradition Tolkach and King (2015) and help enhance the local self-esteem and pride. Environmentally, CBT can effectively raise cultural and environmental awareness and conservation Hall (2010). Although there is no consensus, definitions of CBT have several commonalities, including locals' meaningful and strong participation in all decision-making stages, development projects, local ownership, meaningful host-guest interaction, and transparent benefit-sharing procedures among community members. Environmental, economic, and socio-cultural dimensions are included in CBT, similar to sustainable tourism Dangi and Jamal (2016a). Despite the criticality of the business-focused dimension and economic sustainability for CBT Spenceley and Meyer (2012), this research field has been neglected; though, in very recent years, more efforts have been made in this regard.

2.3. Sustainable CBT criteria

Sustainability encompasses all aspects as a complete experience of tourism. Most of the scientists (Higgins-Desbiolles, 2018) have stated that STD is related to the economic, environmental, and socio-cultural aspects of tourism development, focusing on the continual improvement of tourists' experiences. Sustainable tourism mainly aims to build a balance and stability among caring and protecting the environment, meeting the needs of the host community based on the upgraded standards of living in the short and long run, keeping cultural assets, and encouraging economic benefits (Liu et al, 2013) in both developing and developed nations Horner and Swarbrooke (2004).

It should be appreciated that these three pillars including economic, socio-cultural and environmental are interdependent in several ways, which can be both competing and mutually reinforcing. A balance between them is due to the delivery of sustainable development. Environmentally, there is a natural, farmed, and built environment in a community Swarbrooke (1999). New monetary supports are given to a local community to support it from the economic perspective, and the local businesses obtain profits from tourism activities. The synchronization between economic growth and the limits of nature (especially between the regeneration time and quantity of natural sources, the neutralization capabilities of nature, and human-made emissions) will lead to sustainable development Pozeb and Krope (2007).

According to several researchers, the main factors affecting sustainability are the changes to social, economic, and environmental dimensions, which influence each other. Therefore, sustainable

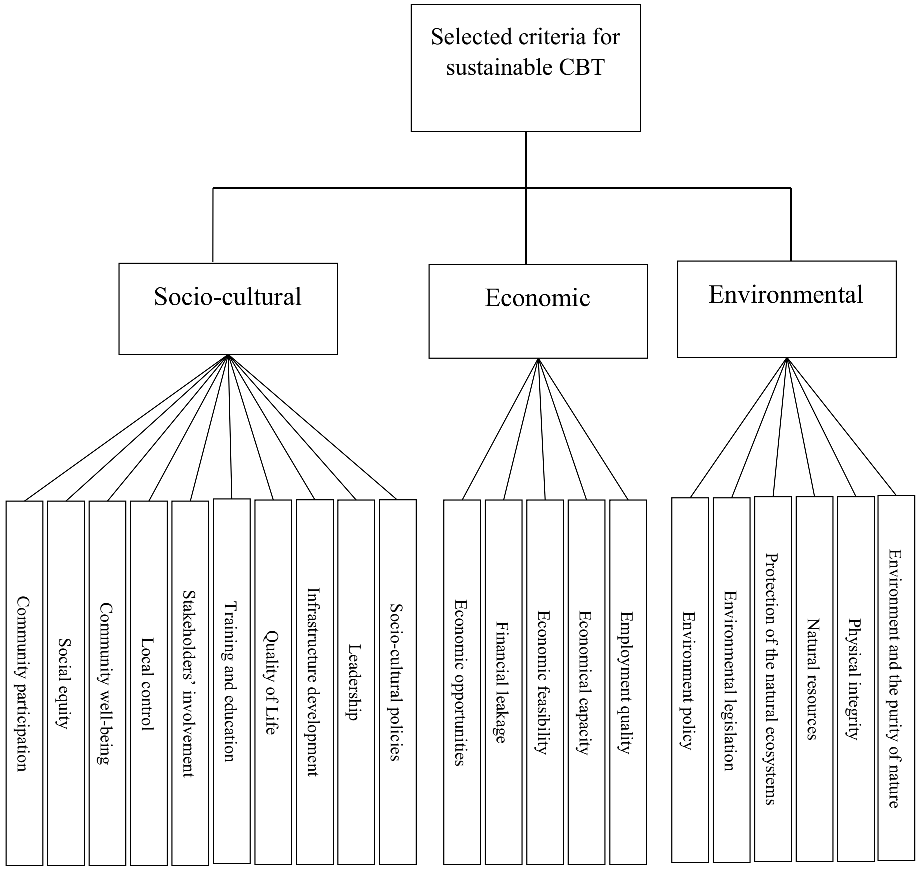

Fig. 1. Hierarchical framework for selected criteria of sustainable CBT.

development means making a better life for all people to be as feasible for the people in the future as they are at present. In other words, sustainable development is based on the equity of using these resources and distributing the benefits obtained from them and the principles of sound husbandry of the world's resources. Due to different socio-economic and environmental problems caused by tourism activities, the tourism principles that consider sustainability are progressively embedded into strategic destination planning (Muresan et al, 2016).

There are significantly high challenges to sustainability since the development of each indicator has represented large gaps of competitiveness for the destination's success, requiring strategies in the medium and long term to convert them into positioning attributes (Herrera et al, 2018). The project development strategies should be positioned favoring the settings for comfortable collaboration, inter-role congruence, managing of perception on cultural distance, intercultural communication competence, and also the systematization and study of the previous experiences and satisfaction of the visitors by maximizing the benefits obtained from using the cultural-natural heritage and minimizing the negative effects. Remember that hosts generally get more satisfied when they have clear access to information plus improvements in the indicators or criteria, which the destination management locals perceive as unfavorable.

Swarbrooke (1999) divided STD into three environmental, social, and economic dimensions. The three sustainability dimensions are now underlined and recognized as follow:

- Economic sustainability: It refers to producing prosperity at society's different levels with focusing on the cost-effectiveness of all economic activities. The enterprises and activities need to be viable, and also, they should be kept in the long term.
- Social sustainability: It concerns equal opportunities and human rights for all people in a society and equitable distribution of benefits with a focus on alleviating poverty. The emphasis is placed on LCs, strengthening and maintaining their life support schemes, respecting and recognizing various cultures, and preventing any exploitation.
- Environmental sustainability: It refers to managing and conserving resources, particularly those precious or not renewable. This requires minimizing land, water, and air pollution and protecting natural heritage and biological diversity.

According to the current literature on sustainable tourism, several criteria are important for evaluating sustainable CBT; the list of selected criteria and related sources is provided in Table 1 and Fig. 1.

3. Research method

3.1. Basic Concept

Some essential notions of PFSs and IVPFSs are discussed in Appendix 1.

3.2. An extended IVPF-SWARA-MULTIMOORA method

To obtain the weight values or individual measure of the significance of DEs, a novel procedure based on score function is obtained under IVPFSs. The weights are then utilized to aggregate individual decisions and criteria weights given by DEs to create aggregated decision matrix and composite criteria weights based on the perspectives or expertise of all DEs. On the other hand, the SWARA model is an extensively applied approach in various disciplines and a significant approach to computing the subjective criteria weights or significance degrees of criteria. Though, there are very few studies that used the SWARA model under IVPFSs. It is shown from the literature that there has been no study that integrated the SWARA and MULTIMOORA approaches under the IVPF environment to analyze and assess the current status of sustainable CBT in the Indian Himalayan region context. Corresponding to the advantages of these approaches, this study develops a new approach called IVPF-SWARA-MULTIMOORA by integrating the SWARA and MULTIMOORA techniques within the IVPFSs context. The steps for the IVPF-SWARA-MULTIMOORA approach are discussed by

Step 1: Construct the IVPF-decision matrix (IVPF-DM)

For the MCDM procedure, assume a set of options $R = \{R_1, R_2, ..., R_m\}$ and classify the set of attributes $C = \{C_1, C_2, ..., C_n\}$ The DE gives his/her valuations λ_{ij} of the options$R_i\,(i = 1(1)m)$ over attribute $C_j\,(j = 1(1)n)$ in term of Linguistic Variables (LVs).

Step 2: Calculate the DEs' weights

Assume ℓ DEs $E = \{E_1, E_2, ..., E_\ell\}$ with important weight $\psi_k = (\psi_1, \psi_2, ..., \psi_\ell)^T$. These weights' are described as LVs and articulated in IVPFNs. Let $E_k = ([\mu_k^-,\ \mu_k^+], [\nu_k^-,\ \nu_k^+])$ be the rating of k^{th}expert. Then, the weight of the k^{th}DE is defined by

$$\psi_k = \frac{\left((\mu_k^-)^2 + (\mu_k^+)^2\right)\left(2 + (\pi_k^-)^2 + (\pi_k^+)^2\right)}{\sum_{k=1}^{\ell}\left(\left((\mu_k^-)^2 + (\mu_k^+)^2\right)\left(2 + (\pi_k^-)^2 + (\pi_k^+)^2\right)\right)}, \quad k = 1(1)\ell. \tag{6}$$

Also, $\psi_k \geq 0$ and $\sum_{k=1}^{\ell}\psi_k = 1$.

Step 3: Aggregated IVPF-DM (AIVPF-DM)

Let $Z = (z_{ij}^{(k)})$ be the IVPF-DM of k^{th} expert such that $z_{ij}^{(k)} = ([\mu_{ijk}^-, \mu_{ijk}^+], [\nu_{ijk}^-, \nu_{ijk}^+])$, is an IVPFN. To aggregate all the individual IVPF-DMs, we have to construct AIVPF-DM. Let $\mathbb{Z} = [z_{ij}]_{m\times n}$ where $z_{ij} = ([\mu_{ij}^-,\ \mu_{ij}^+], [\nu_{ij}^-,\ \nu_{ij}^+]), i = 1(1)m, j = 1(1)n$ be the AIVPF-DM, where $\mathbb{Z} = \sum_{k=1}^{\ell}\psi_k z_{ij}^{(k)}$ and

$$z_{ij} = \left(\left[\sqrt{1 - \prod_{k=1}^{\ell}\left(1 - \left(\mu_{ijk}^-\right)^2\right)^{\psi_k}},\ \sqrt{1 - \prod_{k=1}^{\ell}\left(1 - \left(\mu_{ijk}^+\right)^2\right)^{\psi_k}}\right],\ \left[\prod_{k=1}^{\ell}\left(\nu_{ijk}^-\right)^{\psi_k},\ \prod_{k=1}^{\ell}\left(\nu_{ijk}^+\right)^{\psi_k}\right]\right). \tag{7}$$

Step 4: Computation of attribute weights

Let $w = (w_1, w_2, ..., w_n)^T$ such that $\sum_{j=1}^{n} w_j = 1,\ w_j \in [0,\ 1]$ be the weight for the attribute set. Consecutively to obtain w, we utilize the SWARA approach following procedure:

Step 4.1: Calculate the crisp values. Score values $\mathbb{S}^*(z_{kj})$ of IVPFNs using Eq. (4), are computed.

Step 4.2: Prioritize the attribute. The selected attribute are prioritized using the DE's preferences from the most significant attribute to the least significant attribute.

Step 4.3: Identify the comparative significance of score value. The relative significance is measured using the attribute ranked in the second place, and subsequent comparative significance is obtained by comparing criterion j and criterion $j-1$.

Step 4.4: Assess the comparative coefficient. The coefficient k_j is obtained as follows:

$$k_j = \begin{cases} 1, & j = 1 \\ s_j + 1, & j > 1, \end{cases} \tag{8}$$

where s_j refers to the relative significance of score value.

Step 4.5: Calculate the attribute weights. The recalculated degree p_j is given by:

$$p_j = \begin{cases} 1, & j = 1 \\ \dfrac{k_{j-1}}{k_j}, & j > 1 \end{cases} \tag{9}$$

Step 4.6: Compute the attribute weights using the expression:

$$w_j = \frac{p_j}{\sum_{j=1}^{n} p_j}. \tag{10}$$

Step 5: Generate normalized AIVPF-DM.

Dimensionless and comparable values are called normalized values, and it is obtained by normalizing the decision matrix. Typically, normalization means comparing an alternative rating of a certain attribute which is a numerator, with a denominator representing all ratings of alternative on that attribute.

The following normalization ratio was recommended by Brauers and Zavadskas (2011) for the MULTIMOORA approach. In the MCDM process, the AIVPF-DM $\mathbb{Z} = (z_{ij})_{m\times n}$ is converted into normalized AIVPF-DM $\mathbb{N} = (\widetilde{z}_{ij})_{m\times n}$, where:

$$\widetilde{z}_{ij} = \left(\left[\widetilde{\mu}_{ij}^-,\ \widetilde{\mu}_{ij}^+\right], \left[\widetilde{\nu}_{ij}^-,\ \widetilde{\nu}_{ij}^+\right]\right) = \begin{cases} z_{ij} = \left(\left[\mu_{ij}^-,\ \mu_{ij}^+\right], \left[\nu_{ij}^-,\ \nu_{ij}^+\right]\right), & j \in C_b \\ (z_{ij})^c = \left(\left[\nu_{ij}^-,\ \nu_{ij}^+\right], \left[\mu_{ij}^-,\ \mu_{ij}^+\right]\right), & j \in C_n \end{cases}, \tag{11}$$

where C_b and C_n stand for the benefit & non-benefit attributes, respectively.

Step 6: Assess the preferences of alternatives using the RS model.

The following sub-steps show the evaluation of an optimal option using the RS model:

Step 6.1: Compute Y_i^+ and $Y_i^-$by the IVPFWAO as follows:

$$Y_i^+ = \left(\left[\sqrt{1 - \prod_{j\in C_b}\left(1 - \left(\mu_{ij}^-\right)^2\right)^{w_j}},\ \sqrt{1 - \prod_{j\in C_b}\left(1 - \left(\mu_{ij}^+\right)^2\right)^{w_j}}\right],\ \left[\prod_{j\in C_b}\left(\nu_{ij}^-\right)^{w_j},\ \prod_{j\in C_b}\left(\nu_{ij}^+\right)^{w_j}\right]\right), \tag{12}$$

Table 2
Performance grades of options in terms of LVs.

LVs	IVPFNs
Perfectly Good (PG/PH)	([0.90, 0.95], [0.10, 0.15])
Very Good (VG/VH)	([0.80, 0.90], [0.20, 0.35])
Good (G/H)	([0.65, 0.80], [0.40, 0.50])
Moderate Good (MG/MH)	([0.50, 0.65], [0.50, 0.60])
Fair (F/H)	([0.40, 0.50], [0.60, 0.70])
Moderate Low (ML)	([0.30, 0.40], [0.70, 0.80])
Low (L)	([0.20, 0.30], [0.80, 0.85])
Very low (VL)	([0.10, 0.20], [0.85, 0.90])
Very very low (VVL)	([0.05, 0.10], [0.90, 0.95])

Table 3
Decision expert weight evaluation.

DEs	E_1	E_2	E_3
LTs	Good	Moderate Good	Fair
IVPFNs	([0.65, 0.80], [0.40, 0.50])	([0.50, 0.65], [0.50, 0.60])	([0.40, 0.50], [0.60, 0.70])
Weights	0.4765	0.3242	0.1993

Table 4
LVs of specifications of alternatives with respect to DEs.

	R_1	R_2	R_3	R_4
C_1	(F, MG, MG)	(G, G, G)	(MG, MG, F)	(G, MG, F)
C_2	(ML, L, F)	(VL, VL, VL)	(MG, F, MG)	(VG, MG, VG)
C_3	(G, VG, G)	(VG, VG, VG)	(F, MG, F)	(MG, G, F)
C_4	(L, VL, VL)	(L, ML, VL)	(L, ML, VL)	(MG, ML, F)
C_5	(MG, G, F)	(VG, G, VG)	(G, VG, F)	(VL, ML, L)
C_6	(VG, VG, MG)	(G, VG, VG)	(F, MG, VL)	(MG, ML, F)
C_7	(MG, L, F)	(PG, H, H)	(MG, F, VG)	(PG, G, F)
C_8	(L, L, VL)	(L, VL, VL)	(ML, ML, F)	(L, MG, F)
C_9	(F, G, MG)	(VL, L, VL)	(MG, G, F)	(VL, ML, VL)
C_{10}	(L, L, F)	(VL, ML, VL)	(ML, ML, F)	(VVL, ML, L)
C_{11}	(F, G, MG)	(G, G, PG)	(VG, MG, F)	(VVL, VL, L)
C_{12}	(PG, G, F)	(MG, G, VG)	(VG, F, ML)	(ML, MG, VG)
C_{13}	(VG, G, VG)	(G, PG, VG)	(MG, ML, F)	(MG, VG, L)
C_{14}	(L, ML, VL)	(L, L, ML)	(G, F, L)	(ML, L, F)
C_{15}	(G, MG, F)	(VG, G, MG)	(ML, G, F)	(VL, VVL, L)
C_{16}	(L, VL, L)	(L, VL, VL)	(G, VG, F)	(ML, MG, F)
C_{17}	(ML, F, F)	(ML, ML, VL)	(ML, F, MG)	(VG, MG, VL)
C_{18}	(VG, G, PG)	(VG, G, VG)	(F, L, F)	(VG, L, F)
C_{19}	(F, G, MG)	(G, PG, G)	(ML, G, F)	(L, ML, ML)
C_{20}	(F, G, F)	(VG, F, VG)	(ML, VVL, F)	(ML, VL, L)
C_{21}	(L, F, VL)	(L, ML, ML)	(G, G, L)	(ML, MG, L)

$$Y_i^- = \left(\left[\sqrt{1 - \prod_{j\in C_n} \left(1 - \left(\mu_{ij}^-\right)^2\right)^{w_j}}, \sqrt{1 - \prod_{j\in C_n} \left(1 - \left(\mu_{ij}^+\right)^2\right)^{w_j}} \right], \left[\prod_{j\in C_n} \left(\nu_{ij}^-\right)^{w_j}, \prod_{j\in C_n} \left(\nu_{ij}^+\right)^{w_j} \right] \right), \tag{13}$$

where Y_i^+ and Y_i^- signify the significance values of the option with the benefit and cost attributes.

Step 6.2: Compute the y_i^+ and y_i^- by the score degrees as follows:

$$y_i^+ = \mathbb{S}^*\left(Y_i^+\right) \text{ and } y_i^- = \mathbb{S}^*\left(Y_i^-\right) \tag{14}$$

Step 6.3: Estimate the final utility degree for each alternative as

$$y_i = y_i^+ - y_i^-. \tag{15}$$

Step 7: Assess the preference of alternative using the RP model.

The following steps include the ranking of the options to find the optimal one using the RP procedure:

Step 7.1: Compute the reference point. The coordinate value of the RP $r_j^* = \{r_1^*, r_2^*, ..., r_n^*\}$ is an IVPFN r_j^* and is computed by using:

$$r_j^* = \begin{cases} \left(\left[\max_i \mu_{ij}^-, \max_i \mu_{ij}^+ \right], \left[\min_i \nu_{ij}^-, \min_i \nu_{ij}^+ \right] \right) & \text{for } \textit{benefit criterion } C_b \\ \left(\left[\min_i \mu_{ij}^-, \min_i \mu_{ij}^+ \right], \left[\max_i \nu_{ij}^-, \max_i \nu_{ij}^+ \right] \right), & \text{for } \textit{cost criterion } C_n \end{cases} \tag{16}$$

Step 7.2: Estimate the distances from the alternatives to all the coordinates of the RP as

$$D_{ij} = w_j \left(D\left(z_{ij}, r_j^*\right) \right) \tag{17}$$

where D signifies the distance of the option obtained by Eq. (3).

Step 7.3: Evaluate the highest distance of each alternative as follows:

$$d_i = \max_j D_{ij}, i = 1(1)m. \tag{18}$$

Step 8: Choose the preference of alternatives based on FMF model.

The following steps include the ranking of the options and assess the optimal one using the FMF procedure:

Step 8.1: Compute A_i and B_i by IVPFWGO as

$$A_i = \left(\left[\prod_{j\in C_b} \left(\mu_{ij}^-\right)^{w_j}, \prod_{j\in C_b} \left(\mu_{ij}^+\right)^{w_j} \right], \left[\sqrt{1 - \prod_{j\in C_b} \left(1 - \left(\nu_{ij}^-\right)^2\right)^{w_j}}, \sqrt{1 - \prod_{j\in C_b} \left(1 - \left(\nu_{ij}^+\right)^2\right)^{w_j}} \right] \right), \tag{19}$$

$$B_i = \left(\left[\prod_{j\in C_n} \left(\mu_{ij}^-\right)^{w_j}, \prod_{j\in C_n} \left(\mu_{ij}^+\right)^{w_j} \right], \left[\sqrt{1 - \prod_{j\in C_n} \left(1 - \left(\nu_{ij}^-\right)^2\right)^{w_j}}, \sqrt{1 - \prod_{j\in C_n} \left(1 - \left(\nu_{ij}^+\right)^2\right)^{w_j}} \right] \right), \tag{20}$$

Table 5
The AIVPF-DM of alternatives with respect to criteria.

	R_1	R_2	R_3	R_4
C_1	([0.456, 0.588], [0.545, 0.646])	([0.650, 0.800], [0.400, 0.500])	([0.483, 0.626], [0.519, 0.619])	([0.568, 0.717], [0.466, 0.567])
C_2	([0.298, 0.396], [0.709, 0.794])	([0.100, 0.200], [0.850, 0.900])	([0.471, 0.609], [0.530, 0.631])	([0.737, 0.853], [0.269, 0.417])
C_3	([0.710, 0.841], [0.319, 0.445])	([0.800, 0.900], [0.200, 0.350])	([0.436, 0.558], [0.566, 0.666])	([0.543, 0.691], [0.482, 0.583])
C_4	([0.156, 0.253], [0.826, 0.876])	([0.225, 0.322], [0.775, 0.843])	([0.225, 0.322], [0.775, 0.843])	([0.428, 0.560], [0.578, 0.679])
C_5	([0.543, 0.691], [0.482, 0.583])	([0.762, 0.875], [0.250, 0.393])	([0.683, 0.813], [0.346, 0.476])	([0.206, 0.301], [0.789, 0.856])
C_6	([0.764, 0.873], [0.240, 0.390])	([0.741, 0.862], [0.278, 0.415])	([0.404, 0.526], [0.606, 0.700])	([0.428, 0.560], [0.578, 0.679])
C_7	([0.411, 0.543], [0.604, 0.693])	([0.812, 0.898], [0.207, 0.282])	([0.573, 0.705], [0.442, 0.567])	([0.796, 0.881], [0.224, 0.301])
C_8	([0.185, 0.283], [0.810, 0.860])	([0.156, 0.253], [0.826, 0.876])	([0.323, 0.423], [0.679, 0.779])	([0.370, 0.494], [0.649, 0.730])
C_9	([0.522, 0.662], [0.507, 0.609])	([0.141, 0.238], [0.833, 0.883])	([0.543, 0.691], [0.482, 0.583])	([0.192, 0.284], [0.798, 0.866])
C_{10}	([0.255, 0.353], [0.755, 0.818])	([0.192, 0.284], [0.798, 0.866])	([0.323, 0.423], [0.679, 0.779])	([0.198, 0.277], [0.810, 0.879])
C_{11}	([0.522, 0.662], [0.507, 0.609])	([0.733, 0.850], [0.303, 0.393])	([0.678, 0.801], [0.335, 0.479])	([0.112, 0.190], [0.863, 0.913])
C_{12}	([0.796, 0.881], [0.224, 0.301])	([0.636, 0.777], [0.387, 0.508])	([0.656, 0.775], [0.367, 0.517])	([0.538, 0.668], [0.489, 0.618])
C_{13}	([0.762, 0.875], [0.250, 0.393])	([0.796, 0.890], [0.222, 0.315])	([0.428, 0.560], [0.578, 0.679])	([0.616, 0.748], [0.408, 0.540])
C_{14}	([0.225, 0.322], [0.775, 0.843])	([0.224, 0.323], [0.779, 0.840])	([0.528, 0.671], [0.524, 0.620])	([0.298, 0.396], [0.709, 0.794])
C_{15}	([0.436, 0.558], [0.566, 0.666])	([0.717, 0.842], [0.301, 0.437])	([0.477, 0.613], [0.566, 0.669])	([0.117, 0.202], [0.855, 0.906])
C_{16}	([0.174, 0.272], [0.816, 0.866])	([0.156, 0.253], [0.826, 0.876])	([0.683, 0.813], [0.346, 0.476])	([0.399, 0.522], [0.609, 0.710])
C_{17}	([0.357, 0.456], [0.646, 0.746])	([0.273, 0.371], [0.728, 0.819])	([0.383, 0.499], [0.623, 0.723])	([0.664, 0.790], [0.359, 0.503])
C_{18}	([0.794, 0.892], [0.218, 0.308])	([0.762, 0.875], [0.250, 0.365])	([0.350, 0.449], [0.659, 0.745])	([0.644, 0.765], [0.390, 0.536])
C_{19}	([0.522, 0.662], [0.507, 0.466])	([0.773, 0.874], [0.255, 0.338])	([0.477, 0.613], [0.566, 0.669])	([0.258, 0.357], [0.746, 0.823])
C_{20}	([0.506, 0.639], [0.526, 0.628])	([0.725, 0.839], [0.286, 0.438])	([0.278, 0.366], [0.736, 0.824])	([0.234, 0.330], [0.766, 0.841])
C_{21}	([0.274, 0.369], [0.738, 0.807])	([0.258, 0.357], [0.746, 0.823])	([0.601, 0.753], [0.459, 0.556])	([0.369, 0.494], [0.645, 0.738])

where A_i and B_i are IVPFNs.

Step 8.2: Estimate α_i and β_i by score function as

$$\alpha_i = \mathbb{S}^*(A_i) \text{ and } \beta_i = \mathbb{S}^*(B_i) \tag{21}$$

Step 8.3: Assess the overall utility for each alternative as

$$u_i = \frac{\alpha_i}{\beta_i} \tag{22}$$

Step 9: Decide the final preference order of alternatives.

First, let y_i^*, d_i^*, and u_i^*, be the normalized values of RS, RP and FMF, respectively, using the vector normalization. Then the overall evaluation degree of alternative by Improved Borda Rule is given by

$$I_B(R_i) = y_i^* \cdot \frac{m - \rho(y_i^*) + 1}{(m(m+1)/2)} - d_i^* \cdot \frac{\rho(d_i^*)}{(m(m+1)/2)} + u_i^* \cdot \frac{m - \rho(u_i^*) + 1}{(m(m+1)/2)}, \; i = 1(1)m, \tag{23}$$

where $y_i^* = \frac{y_i}{\sqrt{\sum_{i=1}^{m} (y_i)^2}}$, and $\rho(y_i^*)$, $\rho(d_i^*)$, and $\rho(u_i^*)$, are priority order of RS, RP and FMF approaches, respectively. The optimal option has the highest value of $I_B(R_i)$.

Table 6
Score values in terms of LVs for SWARA method.

Criteria	E_1	E_2	E_3	AIVPF-DM	Crisp degrees $\mathbb{S}^*(\tilde{\xi}_{kj})$
C_1	G	G	MG	([0.626, 0.777], [0.418, 0.519])	0.638
C_2	G	MG	MG	([0.581, 0.734], [0.450, 0.550])	0.593
C_3	F	G	MG	([0.522, 0.662], [0.507, 0.609])	0.521
C_4	F	ML	MG	([0.396, 0.511], [0.608, 0.709])	0.387
C_5	MG	F	G	([0.511, 0.654], [0.507, 0.608])	0.515
C_6	VG	F	MG	([0.672, 0.794], [0.343, 0.488])	0.681
C_7	VL	ML	L	([0.206, 0.301], [0.789, 0.856])	0.194
C_8	MG	F	ML	([0.437, 0.568], [0.567, 0.668])	0.437
C_9	ML	L	VL	([0.242, 0.339], [0.760, 0.835])	0.225
C_{10}	F	ML	ML	([0.352, 0.452], [0.650, 0.751])	0.335
C_{11}	VG	G	G	([0.734, 0.857], [0.287, 0.422])	0.753
C_{12}	ML	F	MG	([0.383, 0.499], [0.623, 0.723])	0.371
C_{13}	ML	F	F	([0.357, 0.456], [0.646, 0.746])	0.341
C_{14}	MG	ML	MG	([0.449, 0.590], [0.558, 0.659])	0.451
C_{15}	L	ML	VL	([0.225, 0.322], [0.775, 0.843])	0.211
C_{16}	VG	MG	L	([0.667, 0.792], [0.355, 0.497])	0.675
C_{17}	VL	ML	F	([0.260, 0.353], [0.745, 0.824])	0.240
C_{18}	ML	L	ML	([0.272, 0.371], [0.731, 0.816])	0.253
C_{19}	G	F	L	([0.528, 0.671], [0.524, 0.620])	0.518
C_{20}	ML	MG	F	([0.399, 0.522], [0.609, 0.710])	0.389
C_{21}	F	MG	G	([0.499, 0.636], [0.522, 0.623])	0.498

Table 7
Implementation of SWARA method for evaluating the criteria weights.

Criteria	Crisp values	Relative significance of criteria value (s_j)	Coefficient (k_j)	Recalculated weight (p_j)	Final weight (w_j)
C_{11}	0.753	-	1.000	1.000	0.0638
C_6	0.681	0.072	1.072	0.933	0.0595
C_{16}	0.675	0.006	1.006	0.927	0.0591
C_1	0.638	0.037	1.037	0.894	0.0570
C_2	0.593	0.045	1.045	0.855	0.0545
C_3	0.521	0.072	1.072	0.798	0.0509
C_{19}	0.518	0.003	1.003	0.796	0.0508
C_{15}	0.515	0.003	1.003	0.794	0.0507
C_{21}	0.498	0.017	1.017	0.781	0.0498
C_{14}	0.451	0.047	1.047	0.746	0.0476
C_8	0.437	0.014	1.014	0.736	0.0470
C_{20}	0.389	0.048	1.048	0.702	0.0448
C_4	0.387	0.002	1.002	0.700	0.0447
C_{12}	0.371	0.016	1.016	0.689	0.0440
C_{13}	0.341	0.030	1.030	0.669	0.0427
C_{10}	0.335	0.006	1.006	0.665	0.0424
C_{18}	0.253	0.082	1.082	0.615	0.0392
C_{17}	0.240	0.013	1.013	0.607	0.0387
C_9	0.225	0.015	1.015	0.598	0.0381
C_{15}	0.211	0.014	1.014	0.590	0.0376
C_7	0.194	0.017	1.017	0.580	0.0371

Table 8
Normalized AIVPF-DM of alternatives with respect to criteria.

	R_1	R_2	R_3	R_4
C_1	([0.545, 0.646], [0.456, 0.588])	([0.400, 0.500], [0.650, 0.800])	([0.519, 0.619], [0.483, 0.626])	([0.466, 0.567], [0.568, 0.717])
C_2	([0.298, 0.396], [0.709, 0.794])	([0.100, 0.200], [0.850, 0.900])	([0.471, 0.609], [0.530, 0.631])	([0.737, 0.853], [0.269, 0.417])
C_3	([0.710, 0.841], [0.319, 0.445])	([0.800, 0.900], [0.200, 0.350])	([0.436, 0.558], [0.566, 0.666])	([0.543, 0.691], [0.482, 0.583])
C_4	([0.826, 0.876], [0.156, 0.253])	([0.775, 0.843], [0.225, 0.322])	([0.775, 0.843], [0.225, 0.322])	([0.578, 0.679], [0.428, 0.560])
C_5	([0.543, 0.691], [0.482, 0.583])	([0.762, 0.875], [0.250, 0.393])	([0.683, 0.813], [0.346, 0.476])	([0.206, 0.301], [0.789, 0.856])
C_6	([0.764, 0.873], [0.240, 0.390])	([0.741, 0.862], [0.278, 0.415])	([0.404, 0.526], [0.606, 0.700])	([0.428, 0.560], [0.578, 0.679])
C_7	([0.411, 0.543], [0.604, 0.693])	([0.812, 0.898], [0.207, 0.282])	([0.573, 0.705], [0.442, 0.567])	([0.796, 0.881], [0.224, 0.301])
C_8	([0.810, 0.860], [0.185, 0.283])	([0.826, 0.876], [0.156, 0.253])	([0.679, 0.779], [0.323, 0.423])	([0.649, 0.730], [0.370, 0.494])
C_9	([0.507, 0.609], [0.522, 0.662])	([0.833, 0.883], [0.141, 0.238])	([0.482, 0.583], [0.543, 0.691])	([0.798, 0.866], [0.192, 0.284])
C_{10}	([0.755, 0.818], [0.255, 0.353])	([0.798, 0.866], [0.192, 0.284])	([0.679, 0.779], [0.323, 0.423])	([0.810, 0.879], [0.198, 0.277])
C_{11}	([0.522, 0.662], [0.507, 0.609])	([0.733, 0.850], [0.303, 0.393])	([0.678, 0.801], [0.335, 0.479])	([0.112, 0.190], [0.863, 0.913])
C_{12}	([0.796, 0.881], [0.224, 0.301])	([0.636, 0.777], [0.387, 0.508])	([0.656, 0.775], [0.367, 0.517])	([0.538, 0.668], [0.489, 0.618])
C_{13}	([0.762, 0.875], [0.250, 0.393])	([0.796, 0.890], [0.222, 0.315])	([0.428, 0.560], [0.578, 0.679])	([0.616, 0.748], [0.408, 0.540])
C_{14}	([0.775, 0.843], [0.225, 0.322])	([0.779, 0.840], [0.224, 0.323])	([0.524, 0.620], [0.528, 0.671])	([0.709, 0.794], [0.298, 0.396])
C_{15}	([0.436, 0.558], [0.566, 0.666])	([0.717, 0.842], [0.301, 0.437])	([0.477, 0.613], [0.566, 0.669])	([0.117, 0.202], [0.855, 0.906])
C_{16}	([0.816, 0.866], [0.174, 0.272])	([0.826, 0.876], [0.156, 0.253])	([0.346, 0.476], [0.683, 0.813])	([0.609, 0.710], [0.399, 0.522])
C_{17}	([0.357, 0.456], [0.646, 0.746])	([0.273, 0.371], [0.728, 0.819])	([0.383, 0.499], [0.623, 0.723])	([0.664, 0.790], [0.359, 0.503])
C_{18}	([0.794, 0.892], [0.218, 0.308])	([0.762, 0.875], [0.250, 0.365])	([0.350, 0.449], [0.659, 0.745])	([0.644, 0.765], [0.390, 0.536])
C_{19}	([0.522, 0.662], [0.507, 0.466])	([0.773, 0.874], [0.255, 0.338])	([0.477, 0.613], [0.566, 0.669])	([0.258, 0.357], [0.746, 0.823])
C_{20}	([0.506, 0.639], [0.526, 0.628])	([0.725, 0.839], [0.286, 0.438])	([0.278, 0.366], [0.736, 0.824])	([0.234, 0.330], [0.766, 0.841])
C_{21}	([0.274, 0.369], [0.738, 0.807])	([0.258, 0.357], [0.746, 0.823])	([0.601, 0.753], [0.459, 0.556])	([0.369, 0.494], [0.645, 0.738])

Table 9
Prioritization of options using the RS approach.

	Y_i^+	Y_i^-	y_i^+	y_i^-	y_i	Ranking
R_1	([0.527, 0.648], [0.545, 0.639])	([0.476, 0.533], [0.657, 0.732])	0.498	0.385	0.113	3
R_2	([0.605, 0.727], [0.470, 0.584])	([0.506, 0.565], [0.619, 0.699])	0.583	0.426	0.157	2
R_3	([0.455, 0.576], [0.610, 0.710])	([0.348, 0.419], [0.784, 0.841])	0.416	0.244	0.172	1
R_4	([0.444, 0.557], [0.637, 0.733])	([0.414, 0.485], [0.720, 0.784])	0.391	0.318	0.073	4

Table 10
Prioritization of options using the RP approach.

RPs	R_1	R_2	R_3	R_4
r_1^*	0.000	0.012	0.002	0.007
r_2^*	0.026	0.034	0.015	0.000
r_3^*	0.005	0.000	0.020	0.014
r_4^*	0.012	0.010	0.010	0.000
r_5^*	0.012	0.000	0.004	0.030
r_6^*	0.000	0.001	0.023	0.021
r_7^*	0.016	0.000	0.010	0.001
r_8^*	0.008	0.009	0.002	0.000
r_9^*	0.001	0.015	0.000	0.014
r_{10}^*	0.003	0.005	0.000	0.006
r_{11}^*	0.015	0.000	0.004	0.041
r_{12}^*	0.000	0.007	0.007	0.013
r_{13}^*	0.002	0.000	0.017	0.009
r_{14}^*	0.015	0.015	0.000	0.011
r_{15}^*	0.011	0.000	0.010	0.023
r_{16}^*	0.031	0.032	0.000	0.018
r_{17}^*	0.013	0.016	0.012	0.000
r_{18}^*	0.000	0.001	0.019	0.007
r_{19}^*	0.012	0.000	0.017	0.028
r_{20}^*	0.011	0.000	0.022	0.023
r_{21}^*	0.017	0.018	0.000	0.012
d_i	0.031	0.034	0.023	0.041
Ranking	2	3	1	4

Table 11
Prioritization of alternatives using FMF approach.

Option	A_i	B_i	α_i	β_i	u_i	Ranking
R_1	([0.625, 0.727], [0.445, 0.531])	([0.923, 0.945], [0.148, 0.208])	0.610	0.920	0.663	2
R_2	([0.640, 0.745], [0.437, 0.534])	([0.942, 0.960], [0.098, 0.151])	0.622	0.944	0.659	3
R_3	([0.594, 0.700], [0.469, 0.570])	([0.846, 0.889], [0.274, 0.361])	0.575	0.825	0.696	1
R_4	([0.489, 0.599], [0.569, 0.660])	([0.898, 0.928], [0.182, 0.248])	0.460	0.893	0.515	4

4. Results

4.1. Case study: sustainable community-based tourism selection

CBT in developing nations “tends to inevitably be located in rural areas” Equations and India (2008). India has discovered and opened increasing destinations in small and remote areas and provided the opportunity for tourism a little late in comparison with the global trends. An activity taking place in the countryside is rural tourism. It has multiple activities, including cultural tourism, agricultural/farm tourism, adventure tourism, nature tourism, eco-tourism, and CBT. A popular destination for trekkers, climbers, and cultural tourists has been the Himalayan region for several years, in which tourism is an important income source for the impoverished region.

Sikkim, one of the Indian Himalayan states that has the highest biodiversity and the highest eco-tourism attraction with access to Bagdogra Airport, the Indian railway system at Siliguri, and desirable roads inside the state. For example, in Sikkim, Trekkers need to walk only for some days from Yuksom village to have a close-up view of Kanchendzonga, the third-highest peak globally; it is a long way, hard and expensive for the Nepalese to reach the same mountain. Sikkim, the twenty-second state of India, emerged on 26 April 1975 with geographical and cultural differences from other nation-states. Once, it was a part of the fabled Sikkim Route China and the Himalayan monarchy. Sikkim has several names, which three main inhabitants of Sikkim gave, i.e., Limbu, Bhutia, and Lepcha. Original inhabitants of Lepcha called it Nye-mee-el “paradise,” inhabitants of Bhutan called it Beymul Demazong, meaning “the hidden valley of rice,” and the Limbus inhabitants named Sukhim or “new house”. It is extended to Mt. Khanchendzonga, measuring 8534 m, which is the third highest mountain in the world. The Sikkimese regarded it as their protective deity measuring

Table 12
The final prioritization of alternatives using Borda rule.

Option	RS model		RP model		FMF model		$I_B(P_i)$	Final Ranking
	y_i^*	$\rho(y_i^*)$	d_i^*	$\rho(d_i^*)$	u_i^*	$\rho(u_i^*)$		
R_1	0.4202	3	0.4713	2	0.5203	2	0.146	2
R_2	0.5838	2	0.5169	3	0.5172	3	0.124	3
R_3	0.6395	1	0.3497	1	0.5462	1	0.439	1
R_4	0.2714	4	0.6233	4	0.4042	4	-0.182	4

Table 13
Prioritization of IVPF-TOPSIS for sustainable CBT alternatives.

Options	$D(R_i, r^+)$	$D(R_i, r^-)$	$\mathbb{C}(R_i)$	Ranking
R_1	0.209	0.226	0.520	3
R_2	0.175	0.260	0.597	1
R_3	0.194	0.212	0.522	2
R_4	0.277	0.152	0.354	4

7,300 km^2 and measuring about 114 km^2 from the north to south and 64 km from the east to west. Sikkim is separated into 4 districts that each being divided into two parts.

A portion of the inner mountain ranges of the Himalayas, i.e., Sikkim state, is hilly with elevation varying from 300 to 8540 m, and the altitude of 2100 m can be only an inhabitable area. The state's altitude has risen steeply in the climate from tropical to temperate to alpine and in the shortest distance. Sikkim covers 0.2% of the geographical area of the nation with very high biodiversity, identified as one of the hotspots in the Eastern Himalayas. Sikkim is located in Central Himalaya (2c) biotic province and Himalayan (2) bio-geographic zone. A homogeneous blend is created by intermingling the cultures, communities, customs, and religions of different hues freely in Sikkim. Ethnically, there are three main groups of people, i.e., Lepchas, Bhutias, and Nepalese in Sikkim. There are wonderfully various tourism products in Sikkim. This is the first state with an ecotourism policy aiming to promote Sikkim as the destination that visitors preferred and allows the Community Based Ecotourism (CBET) to use the latest participatory management approaches for sustainable development to revenue, income, and employment for the state. The LCs' participation in tourism will directly support the conservation of local culture, environment, and ecology and fulfill their livelihood needs.

However, in the current paper, both primary and secondary data were employed to collect the related information. A group interview was conducted as a focused-group discussion among the local community, and finally, the community was observed by the researcher to view the situation academically. A total of 10 respondents participated in the current research.

In addition, the convenience sampling method was used to choose 4 out of 10 respondents. The purposive sampling method was used, depending on the study objectives, availability of time, resources, and the most important factor of data saturation, where more data cannot bring additional insight to the researcher any longer Hudson (2008). The researchers in this study first interviewed one of the homestay owners. Other respondents were chosen using the networks with local people due to the unfamiliarity of the researchers with the area, and then, the owner stated that the locals would answer more accurately if the homestay owner introduces the researcher to the respondents. There was an interview with a group of nomads from the Indian Himalayan region. This group mainly attracts tourism activity in the region, and

Table 14
Different criteria weight sets for ranking of sustainable CBT selection.

Criteria	Set-I	Set-II	Set-III	Set-IV	Set-V	Set-VI	Set-VII	Set-VIII	Set-IX	Set-X
C_1	0.0570	0.0498	0.0448	0.0508	0.0392	0.0387	0.0591	0.0376	0.0476	0.0427
C_2	0.0545	0.0570	0.0498	0.0448	0.0508	0.0392	0.0387	0.0591	0.0376	0.0476
C_3	0.0509	0.0545	0.0570	0.0498	0.0448	0.0508	0.0392	0.0387	0.0591	0.0376
C_4	0.0447	0.0509	0.0545	0.0570	0.0498	0.0448	0.0508	0.0392	0.0387	0.0591
C_5	0.0507	0.0447	0.0509	0.0545	0.0570	0.0498	0.0448	0.0508	0.0392	0.0387
C_6	0.0595	0.0507	0.0447	0.0509	0.0545	0.0570	0.0498	0.0448	0.0508	0.0392
C_7	0.0371	0.0595	0.0507	0.0447	0.0509	0.0545	0.0570	0.0498	0.0448	0.0508
C_8	0.0470	0.0371	0.0595	0.0507	0.0447	0.0509	0.0545	0.0570	0.0498	0.0448
C_9	0.0381	0.0470	0.0371	0.0595	0.0507	0.0447	0.0509	0.0545	0.0570	0.0498
C_{10}	0.0424	0.0381	0.0470	0.0371	0.0595	0.0507	0.0447	0.0509	0.0545	0.0570
C_{11}	0.0638	0.0424	0.0381	0.0470	0.0371	0.0595	0.0507	0.0447	0.0509	0.0545
C_{12}	0.0440	0.0638	0.0424	0.0381	0.0470	0.0371	0.0595	0.0507	0.0447	0.0509
C_{13}	0.0427	0.0440	0.0638	0.0424	0.0381	0.0470	0.0371	0.0595	0.0507	0.0447
C_{14}	0.0476	0.0427	0.0440	0.0638	0.0424	0.0381	0.0470	0.0371	0.0595	0.0507
C_{15}	0.0376	0.0476	0.0427	0.0440	0.0638	0.0424	0.0381	0.0470	0.0371	0.0595
C_{16}	0.0591	0.0376	0.0476	0.0427	0.0440	0.0638	0.0424	0.0381	0.0470	0.0371
C_{17}	0.0387	0.0591	0.0376	0.0476	0.0427	0.0440	0.0638	0.0424	0.0381	0.0470
C_{18}	0.0392	0.0387	0.0591	0.0376	0.0476	0.0427	0.0440	0.0638	0.0424	0.0381
C_{19}	0.0508	0.0392	0.0387	0.0591	0.0376	0.0476	0.0427	0.0440	0.0638	0.0424
C_{20}	0.0448	0.0508	0.0392	0.0387	0.0591	0.0376	0.0476	0.0427	0.0440	0.0638
C_{21}	0.0498	0.0448	0.0508	0.0392	0.0387	0.0591	0.0376	0.0476	0.0427	0.0440

Table 15
The Assessment degree of alternatives over different weight sets.

Alternatives	Set-I	Set-II	Set-III	Set-IV	Set-V	Set-VI	Set-VII	Set-VIII	Set-IX	Set-X
R_1	0.215	0.220	0.154	0.183	0.154	0.146	0.219	0.226	0.154	0.148
R_2	0.169	0.192	0.253	0.212	0.289	0.239	0.168	0.184	0.245	0.252
R_3	0.345	0.317	0.307	0.323	0.275	0.344	0.333	0.309	0.337	0.304
R_4	0.042	0.057	0.059	0.044	0.042	0.044	0.049	0.056	0.043	0.042

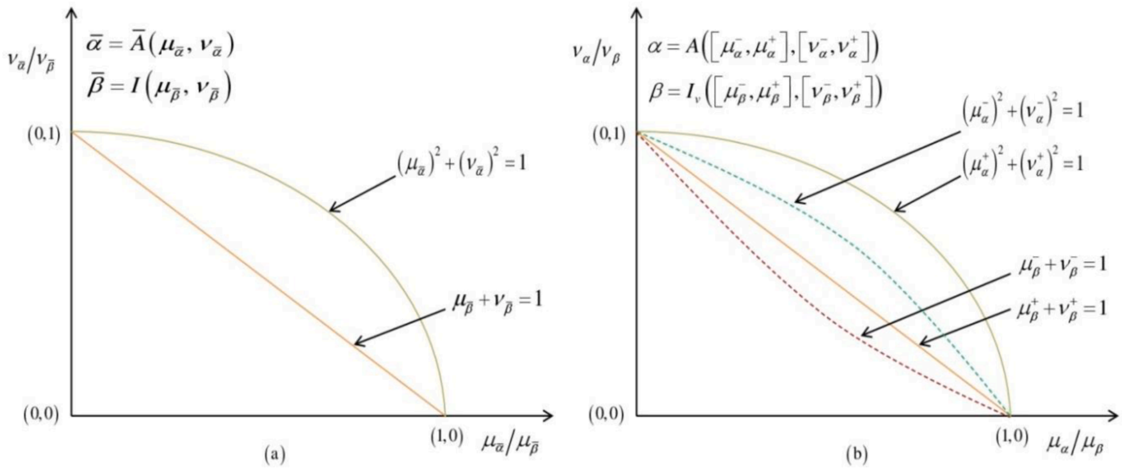

Fig. 2. Geometrical analyses of IF/IVIFNs and PF/IVPFNs, Comparison of spaces of (a) IFNs and PFNs, (b) IVIFNs and IVPFNs.

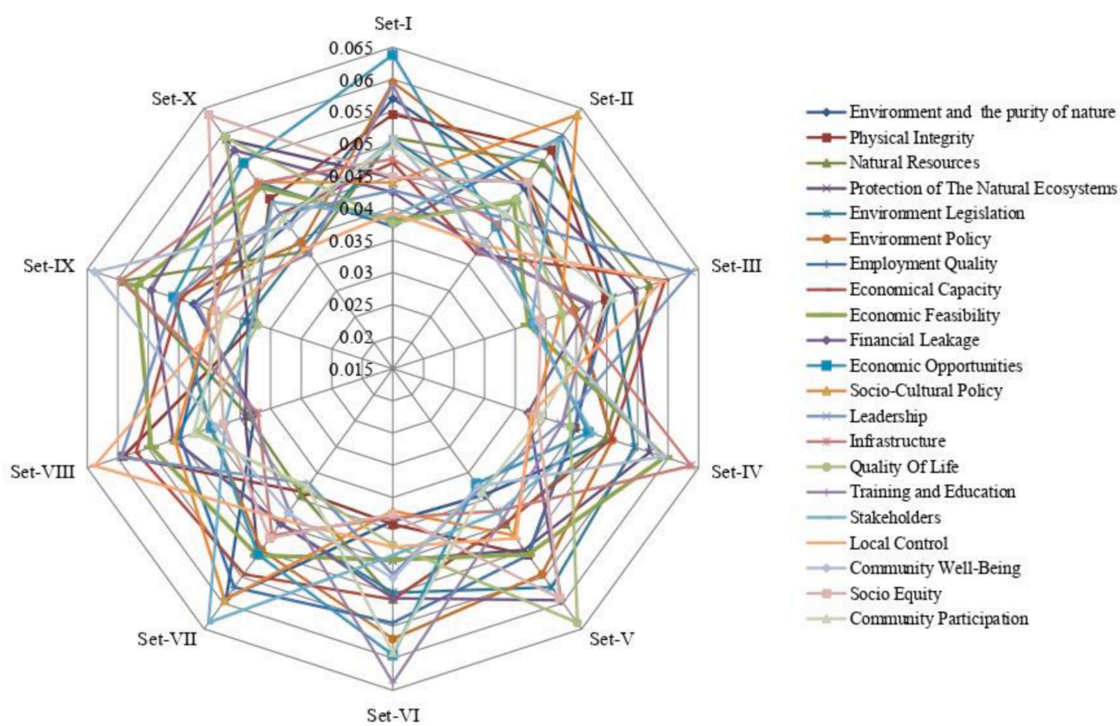

Fig. 3. Degree of significance for each criterion with given weight sets.

most tourists seek to see their lifestyle and spend time with these people. However, the results of expert interviews are provided in the following sections.

Based on Eq. (6) and Table 2, the DEs weights are assessed and then presented in Table 3. The DEs provide their decision matrices $Z = (z_{ij}^{(k)})$ and is given in Table 4. Corresponding to Eq. (7) and Table 4, the AIVPF-DM is constructed and given in Table 5.

SWARA is used to measure the weight of each criterion, and the weights previously performed in Table 6 are evaluated and calculated based on the role of experts. Each expert determined the importance of each criterion. After that, he/she was asked to rank all criteria from the first to the last with him/her implicit information, experiences, and knowledge. The least significant criterion is ranked last, and the most significant criterion is ranked 1 using the SWARA method. The mediocre degree of ranks was used to obtain the overall ranks of the group of experts. Table 7 shows the weights of all criteria as w_j column. The final weight of the criteria is given by

$w_j =$ (0.0570, 0.0545, 0.0509, 0.0447, 0.0507, 0.0595, 0.0371, 0.0470, 0.0381, 0.0424, 0.0638, 0.0440, 0.0427, 0.0476, 0.0376, 0.0591, 0.0387, 0.0392, 0.0508, 0.0448, 0.0498)

Here, the following considered criteria C_4, C_8, C_9, C_{10}, C_{14}, and C_{16}, are cost and remaining criteria were benefit-type that we obtained the normalized AIVPF-DM by Eq. (11) and are mentioned in Table 8.

The RS model for the alternatives is assessed by Eq. (12)–(15) and shown in Table 9.

The outcomes of the IVPF-RP objective of the options are computed based on the distance measure by Eq. (16)–(18) and is shown in Table 10.

The interval-valued Pythagorean fuzzy FMF objective of alternatives is estimated by Eq. (19)–(22) and mentioned in Table 11.

The outcomes of all models achieved using the IVPF-SWARA-MULTIMOORA methodology is done by Eq. (23), which is depicted in Table 12. Hence, the final prioritization of alternatives is $R_3 \succ R_1 \succ$

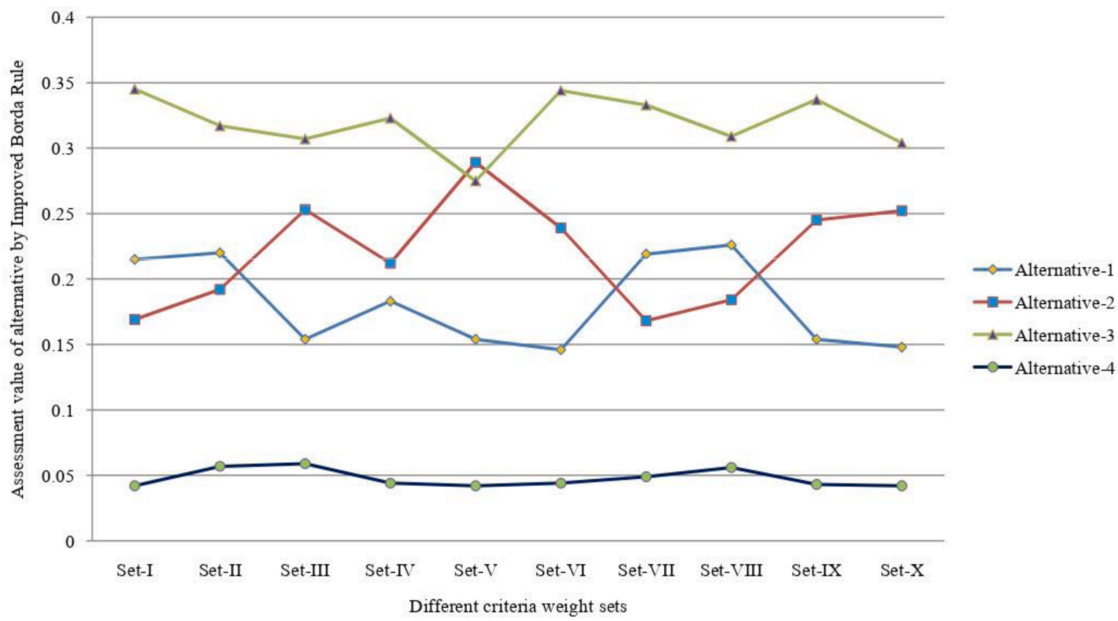

Fig. 4. The assessment degree of each sustainable CBT options over different weight sets.

$R_2 \succ R_4$. Thus, the optimal option is R_3.

5. Comparative Study

Here, the outcomes of the IVPF-SWARA-MULTIMOORA approach are compared with the extant models. To display the usefulness and show the unique qualities of IVPF-SWARA-MULTIMOORA approach, the IVPF-TOPSIS (Garg (2017) and Peng and Li (2019) methods are used.

5.1. IVPF-TOPSIS approach

Steps 1-5: As per the preceding model

Step 6: Compute the distances of each option from IVPF-IS and IVPFA-IS.

Here, the BD and NBD of IVPF-IS (r^+) are considered and given by

$$r^+ = \begin{cases} \left(\left[\max_i \mu_{ij}^-, \max_i \mu_{ij}^+\right], \left[\min_i \nu_{ij}^-, \min_i \nu_{ij}^+\right]\right) & \text{for } \textit{benefit criterion } C_b \\ \left(\left[\min_i \mu_{ij}^-, \min_i \mu_{ij}^+\right], \left[\max_i \nu_{ij}^-, \max_i \nu_{ij}^+\right]\right), & \text{for } \textit{cost criterion } C_n \end{cases} \quad (24)$$

In a similar way, the BD and NBD of IVPFA-IS (r^-) may be taken and given by

$$r^- = \begin{cases} \left(\left[\min_i \mu_{ij}^-, \min_i \mu_{ij}^+\right], \left[\max_i \nu_{ij}^-, \max_i \nu_{ij}^+\right]\right) & \text{for } \textit{benefit criterion } C_b \\ \left(\left[\max_i \mu_{ij}^-, \max_i \mu_{ij}^+\right], \left[\min_i \nu_{ij}^-, \min_i \nu_{ij}^+\right]\right), & \text{for } \textit{cost criterion } C_n \end{cases} \quad (25)$$

To compare the different option(s) $R_i : i = 1(1)m$, the distances between an option R_i and the IVPF-IS r^+, and the IVPFA-IS r^- are calculated by using weighted distance measures, given as

and

Step 7: Assess the relative closeness index.

From Eqs (24) and (25), the relative closeness index of each option R_i over r^+ and r^- is given by

$$\mathbb{C}(R_i) = \frac{D(R_i, r^-)}{D(R_i, r^-) + D(R_i, r^+)}, \; i = 1(1)m. \quad (28)$$

Step 8: Rank the alternative.

From Table 5 and Eqs (26)-(27), IVPF-IS and IVPFA-IS are estimated. The outcomes of the IVPF-TOPSIS method providing by (Garg (2017) and (Peng and Li, 2019) are shown in Table 13.

Therefore, the ranking of sustainable CBT alternative is $R_2 \succ R_3 \succ R_1 \succ R_4$, and the option R_2 has the higher suitability degree for sustainable CBT alternative.

Afterward, the results of the proposed IVPF-SWARA-MULTIMOORA are compared with different existing methods. In this regard, the IVPF-TOPSIS method was found weaker than IVPF-SWARA-MULTIMOORA. Furthermore, both IVPF-VIKOR and IVPF- TOPSIS cannot overcome the problem of a completely unknown weight vector of the criteria. For this reason, both the IVPF-TOPSIS model and the IVPF-VIKOR model are inferior to the proposed IVPF-SWARA-MULTIMOORA method. It has been discussed before that there are the following advantages for the distance-based IVPF-SWARA-MULTIMOORA method:

- The objective weight methods can be used to derive the weights of attributes, avoiding the subjectivity of the DEs to tackle the MCDM concerns with Garg (2017) and Peng and Li (2019) approaches, while in the proposed framework, we have utilized the SWARA method to assess the subjective weight of attributes.
- The weights of DEs are obtained using the proposed weighting assessment procedure ensuing in more accurate individual tool of

$$D(R_i,\ r^+) = \frac{1}{4}\sum_{j=1}^{n} w_j \Bigg[\left|\left(\widetilde{\mu}_{ij}^-\right)^2 - \left(\mu_{r^+}^-\right)^2\right| + \left|\left(\widetilde{\mu}_{ij}^+\right)^2 - \left(\mu_{r^+}^+\right)^2\right| + \left|\left(\widetilde{\nu}_{ij}^-\right)^2 - \left(\nu_{r^+}^-\right)^2\right| + \left|\left(\widetilde{\nu}_{ij}^+\right)^2 - \left(\nu_{r^+}^+\right)^2\right| + \left|\left(\widetilde{\pi}_{ij}^-\right)^2 - \left(\pi_{r^+}^-\right)^2\right| + \left|\left(\widetilde{\pi}_{ij}^+\right)^2 - \left(\pi_{r^+}^+\right)^2\right|\Bigg] \tag{26}$$

$$D(R_i,\ r^-) = \frac{1}{4}\sum_{j=1}^{n} w_j \Bigg[\left|\left(\widetilde{\mu}_{ij}^-\right)^2 - \left(\mu_{r^-}^-\right)^2\right| + \left|\left(\widetilde{\mu}_{ij}^+\right)^2 - \left(\mu_{r^-}^+\right)^2\right| + \left|\left(\widetilde{\nu}_{ij}^-\right)^2 - \left(\nu_{r^-}^-\right)^2\right| + \left|\left(\widetilde{\nu}_{ij}^+\right)^2 - \left(\nu_{r^-}^+\right)^2\right| + \left|\left(\widetilde{\pi}_{ij}^-\right)^2 - \left(\pi_{r^-}^-\right)^2\right| + \left|\left(\widetilde{\pi}_{ij}^+\right)^2 - \left(\pi_{r^-}^+\right)^2\right|\Bigg]. \tag{27}$$

DEs, unlike randomly chosen weights in Garg (2017) and Peng and Li (2019) approaches.
- Moreover, there are three sub-methods in the IVPF-SWARA-MULTIMOORA method, including the IVPF-RP model, the IVPF-FMF model, and the IVPF-ratio system model. In this regard, a single model such as the IVPF-VIKOR and IVPF-TOPSIS methods is less robust than the method.

5.2. Sensitivity investigation

Next, a sensitivity investigation is done to examine the developed framework. Ten sets of attribute weights are considered and mentioned in Table 14. Table 14 and Fig 3 describe that one of the attribute has the utmost weight for each set, whereas the others have minimum weights. By utilizing the procedure, an elegant process of attribute weights set is constructed to explore the sensitivity of the proposed methodology for the different values of weights.

The results obtained from the sensitivity analysis (see Table 15 and Fig. 4) show that the assessment degree could vary with various criteria weight sets and preference order of sustainable CBT. For instance, when DEs offers the weight sets-I, II, VII, and VIII, the ranking of sustainable CBT alternative is $R_3 \succ R_1 \succ R_2 \succ R_4$, in weight sets-III, IV, VI, IX, and X, the ranking of sustainable CBT alternative is $R_3 \succ R_2 \succ R_1 \succ R_4$, and in criteria weight set-V, ranking of sustainable CBT alternative is $R_3 \succ R_1 \succ R_2 \succ R_4$. This analysis concludes that the sustainable CBT alternatives assessment had the sensitivity to consider the weight sets. As a result, the framework introduced in this study is stable and efficient with altered criteria weight sets.

6. Conclusions

This study was mainly aimed at providing a comprehensive framework for evaluating sustainable CBT in the Indian-Himalayan region context. To identify the main criteria and to evaluate the sustainable CBT, this work conducted a survey through holding interviews with DEs and reviewing the relevant literature. The survey resulted in 21 main criteria for the evaluation of sustainable CBT. These 21 criteria were classified into economic, environmental, and socio-cultural categories. To investigate, rank, evaluate, and select the sustainable CBT criteria, this study combined the SWARA and MULTIMOORA methods under IVPFSs. The 21 criteria identified in this study are as follow: environment and the purity of nature, physical integrity, natural resources, protection of the natural ecosystems, environment legislation, environment policy, employment quality, economic capacity, economic feasibility, financial leakage, economic opportunities, socio-cultural policy, leadership, infrastructure development, quality of life, training and education, stakeholder's involvement, local control community, well-being, social equity, and community participation. The outcomes of the study indicated that the top five significant criteria to evaluate the sustainable CBT framework were economic opportunities (0.0638), environment policy (0.0595), training and education (0.0591), environment, and the purity of nature (0.057), and physical integrity (0.0545).

This study had limitations for further work. The obvious limitation was that the complete procedure proposed in this research through MCDM had not been subsequently tested qualitatively or quantitatively in all registered homestay in India. Future research could be undertaken to test, understand, and refine the model and its use in developing sustainable CBT through homestay program in India. Future research could also focus, identify, and test the model of the sustainable development criteria for each homestay in India according to the thematic groups such as urban homestay, coastal homestay, or adventure homestay. Respondents with different backgrounds and years of experience in a specific field had different perceptions about the same sustainability criteria.

The findings of this research could be applied as a model for the sustainable development of CBT. The statistic of the new registering homestay is increasing each year, and in line with that, the number of inactive homestays is also increasing every year. It shows that there are still stagnated homestay, which needs to be well addressed. This research aims to encourage cooperation among stakeholders to ensure that homestay can really be successful and be able to sustain the development.

The expansion of new homestay and new activities offered in the homestay program is a good indicator of growing interest in and demand for CBT. India is a country that is rich in natural, agricultural, and cultural heritage. The homestay program has huge potential to develop as a valuable tourism product with its own uniqueness. There is no other place that can offer the same activities as what homestay can offer. The biggest asset is the traditional culture that everyone anticipates experiencing either from local or international tourists. This homestay program development can support the economy and provide a good opportunity for communities to involve in tourism programs. That involvement is not only helping the development of the tourism industry, but significantly it will improve the local community's quality of life.

The developed tool was implemented in a case study in the Indian-Himalayan region context to illustrate the practicality and rationality; it was found adaptable in handling qualitative and uncertain data. The implementation procedure and the outcomes described the ability of the developed model in treating multi-fact dimensions of the considered criteria. This work developed a new decision-making framework, called the IVPF-SWARA-MULTIMOORA model, on IVPFSs settings; therefore, future work can develop diverse types of decision-making models such as Double Normalization-based Multiple Aggregation (DNMA), Gained and Lost Dominance Score (GDLS), COPRAS, etc. on different settings of fuzzy sets, namely HFSs, FFSs, IVIFSs, PFSs, etc .

Credit author statement

Conceptualization: Jun He and Zilong Huang; **Methodology:** Arunodaya Raj Mishra; **Investigation:** Melfi Alrasheedi; **Formal analysis:** Melfi Alrasheedi; **Resources:** Jun He and Zilong Huang; **Software:** Arunodaya Raj Mishra; Data Curation: Jun He and Zilong Huang; **Writing - Original Draft:** Melfi Alrasheedi; **Writing - Review & Editing:** Melfi Alrasheedi; **Visualization:** Arunodaya Raj Mishra; **Supervision:** Zilong Huang; **Validation:** Arunodaya Raj Mishra.

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Appendix 1

Definition 1 (Yager, 2013, 2014). A PFS $\overline{\mathrm{A}}$ on fixed Q is described as

$$\overline{\mathrm{A}} = \left\{\left\langle q_i, \overline{\mathrm{A}}(\mu_{\overline{\mathrm{A}}}(q_i), \nu_{\overline{\mathrm{A}}}(q_i))\right\rangle \middle| q_i \in Q\right\}, \tag{1}$$

where $\mu_{\overline{\mathrm{A}}} : Q \to [0, 1]$ and $\nu_{\overline{\mathrm{A}}} : Q \to [0, 1]$ denote the Belongingness Degree (BD) and Non-Belongingness Degree (NBD) of the object $q_i \in Q$ to $\overline{\mathrm{A}}$, respectively, under the constraint $0 \leq (\mu_{\overline{\mathrm{A}}}(q_i))^2 + (\nu_{\overline{\mathrm{A}}}(q_i))^2 \leq 1$. For each $q_i \in Q$, the degree of hesitation is specified by $\pi_{\overline{\mathrm{A}}}(q_i) = \sqrt{1 - \mu^2_{\overline{\mathrm{A}}}(q_i) - \nu^2_{\overline{\mathrm{A}}}(q_i)}$.

Definition 2 (Zhang, 2016). Let $Q = \{q_1, q_2, ..., q_n\}$ be a fixed set and $Int[0, 1]$ denotes the set of all closed subintervals of the interval $[0, 1]$. An IVPFS α in Q is given by

$$\alpha = \left\{\left\langle y_i, \left[\mu^-_\alpha(q_i), \mu^+_\alpha(q_i)\right], \left[\nu^-_\alpha(q_i), \nu^+_\alpha(q_i)\right]\right\rangle : q_i \in Q\right\}, \tag{2}$$

where $0 \leq \mu^-_\alpha(q_i) \leq \mu^+_\alpha(q_i) \leq 1$, $0 \leq \nu^-_\alpha(q_i) \leq \nu^+_\alpha(q_i) \leq 1$ and $0 \leq (\mu^+_\alpha(q_i))^2 + (\nu^+_\alpha(q_i))^2 \leq 1$. Here, $\mu_\alpha(q_i) = [\mu^-_\alpha(q_i), \mu^+_\alpha(q_i)]$ and $\nu_\alpha(q_i) = [\nu^-_\alpha(q_i), \nu^+_\alpha(q_i)]$ signify the interval-valued BD and NBD of an object q_i to Q, correspondingly (See Fig. 2). The special cases of IVPFS are (i) an IVPFS is reduced to an IVIFS if $0 \leq \mu^+_\alpha(q_i) + \nu^+_\alpha(q_i) \leq 1$. (ii) An IVPFS is reduced to a PFS if $\mu^-_\alpha(q_i) = \mu^+_\alpha(q_i)$ and $\nu^-_\alpha(q_i) = \nu^+_\alpha(q_i)$.

The function $\pi_\alpha(q_i) = [\pi^-_\alpha(q_i), \pi^+_\alpha(q_i)]$ denotes the IPF-index of q_i to α, where $\pi^-_{\mathrm{A}}(y_i) = \sqrt{1 - (\mu^+_{\mathrm{A}}(y_i))^2 - (\nu^+_{\mathrm{A}}(y_i))^2}$, and $\pi^+_{\mathrm{A}}(y_i) = \sqrt{1 - (\mu^-_{\mathrm{A}}(y_i))^2 - (\nu^-_{\mathrm{A}}(y_i))^2}$. For simplicity, Interval-Valued Pythagorean Fuzzy Number (IVPFN) is signified by $\alpha = ([\mu^-_\alpha, \mu^+_\alpha], [\nu^-_\alpha, \nu^+_\alpha])$ which fulfills $0 \leq (\mu^+_\alpha)^2 + (\nu^+_\alpha)^2 \leq 1$.

Definition 3 (Zhang, 2016). Let $\alpha_1 = ([\mu^-_{\alpha_1}, \mu^+_{\alpha_1}], [\nu^-_{\alpha_1}, \nu^+_{\alpha_1}])$,$\alpha_2 = ([\mu^-_{\alpha_2}, \mu^+_{\alpha_2}], [\nu^-_{\alpha_2}, \nu^+_{\alpha_2}])$ and $\alpha_3 = ([\mu^-_{\alpha_3}, \mu^+_{\alpha_3}], [\nu^-_{\alpha_3}, \nu^+_{\alpha_3}])$ be the IVPFNs. Therefore, some operations are described as follows:

$$\alpha_1 \oplus \alpha_2 = \left(\begin{array}{l}\left[\sqrt{\left(\mu^-_{\alpha_1}\right)^2 + \left(\mu^-_{\alpha_2}\right)^2 - \left(\mu^-_{\alpha_1}\right)^2\left(\mu^-_{\alpha_2}\right)^2},\right.\\ \left.\sqrt{\left(\mu^+_{\alpha_1}\right)^2 + \left(\mu^+_{\alpha_2}\right)^2 - \left(\mu^+_{\alpha_1}\right)^2\left(\mu^+_{\alpha_2}\right)^2}\right], \left[\nu^-_{\alpha_1}\nu^-_{\alpha_2}, \nu^+_{\alpha_1}\nu^+_{\alpha_2}\right]\end{array}\right),$$

$$\alpha_1 \otimes \alpha_2 = \left(\begin{array}{l}\left[\mu^-_{\alpha_1}\mu^-_{\alpha_2}, \mu^+_{\alpha_1}\mu^+_{\alpha_2}\right],\\ \left[\sqrt{\left(\nu^-_{\alpha_1}\right)^2 + \left(\nu^-_{\alpha_2}\right)^2 - \left(\nu^-_{\alpha_1}\right)^2\left(\nu^-_{\alpha_2}\right)^2}, \sqrt{\left(\nu^+_{\alpha_1}\right)^2 + \left(\nu^+_{\alpha_2}\right)^2 - \left(\nu^+_{\alpha_1}\right)^2\left(\nu^+_{\alpha_2}\right)^2}\right]\end{array}\right),$$

$$\lambda\alpha_1 = \left(\left[\sqrt{1 - \left(1 - \left(\mu^-_{\alpha_1}\right)^2\right)^\lambda}, \sqrt{1 - \left(1 - \left(\mu^+_{\alpha_1}\right)^2\right)^\lambda}\right], \left[\left(\nu^-_{\alpha_1}\right)^\lambda, \left(\nu^+_{\alpha_1}\right)^\lambda\right]\right),$$

$$(\alpha_1)^\lambda = \left(\left[\left(\mu^-_{\alpha_1}\right)^\lambda, \left(\mu^-_{\alpha_1}\right)^\lambda\right], \left[\sqrt{1 - \left(1 - \left(\nu^-_{\alpha_1}\right)^2\right)^\lambda}, \sqrt{1 - \left(1 - \left(\nu^+_{\alpha_1}\right)^2\right)^\lambda}\right]\right),$$

$$(\alpha_1)^c = \left(\left[\nu^-_{\alpha_1}, \nu^+_{\alpha_1}\right], \left[\mu^-_{\alpha_1}, \mu^+_{\alpha_1}\right]\right).$$

Definition 4 (Peng and Yang, 2016). Consider $\alpha = ([\mu^-_\alpha, \mu^+_\alpha], [\nu^-_\alpha, \nu^+_\alpha])$ be an IVPFN. Then, the score and accuracy functions of the IVPFN α are given by

$$\mathbb{S}(\alpha) = \frac{1}{2}\left((\mu^-_\alpha)^2 + (\mu^+_\alpha)^2 - (\nu^-_\alpha)^2 - (\nu^+_\alpha)^2\right),\ \hbar(\alpha) = \frac{1}{2}\left((\mu^-_\alpha)^2 + (\mu^+_\alpha)^2 + (\nu^-_\alpha)^2 + (\nu^+_\alpha)^2\right), \tag{3}$$

respectively, where $\mathbb{S}(\alpha) \in [-1, 1]$ and $\hbar(\alpha) \in [0, 1]$.

Since $\mathbb{S}(\alpha) \in [-1, 1]$, therefore, we normalize the score function as follows:

Definition 5: Let $\alpha = ([\mu_\alpha^-, \mu_\alpha^+], [\nu_\alpha^-, \nu_\alpha^+])$ be an IVPFN. Then

$$\mathbb{S}^*(\alpha) = \frac{1}{2}(\mathbb{S}(\alpha) + 1) \tag{4}$$

is said to be a normalized score function, where $\mathbb{S}(\alpha)$ is given by Definition 4 and $\mathbb{S}^*(\alpha) \in [0, 1]$.

Definition 6 (Peng and Yang (2016). Let $\alpha_1 = ([\mu_{\alpha_1}^-, \mu_{\alpha_1}^+], [\nu_{\alpha_1}^-, \nu_{\alpha_1}^+])$ and $\alpha_2 = ([\mu_{\alpha_2}^-, \mu_{\alpha_2}^+], [\nu_{\alpha_2}^-, \nu_{\alpha_2}^+])$ be the IVPFNs, then we define the distance between α_1 and α_2 is given by

$$D(\alpha_1, \alpha_2) = \frac{1}{4}\left[\left|\left(\mu_{\alpha_1}^-\right)^2 - \left(\mu_{\alpha_2}^-\right)^2\right| + \left|\left(\mu_{\alpha_1}^+\right)^2 - \left(\mu_{\alpha_2}^+\right)^2\right| + \left|\left(\nu_{\alpha_1}^-\right)^2 - \left(\nu_{\alpha_2}^-\right)^2\right| \right.$$
$$\left. + \left|\left(\nu_{\alpha_1}^+\right)^2 - \left(\nu_{\alpha_2}^+\right)^2\right| + \left|\left(\pi_{\alpha_1}^-\right)^2 - \left(\pi_{\alpha_2}^-\right)^2\right| + \left|\left(\pi_{\alpha_1}^+\right)^2 - \left(\pi_{\alpha_2}^+\right)^2\right|\right]. \tag{5}$$

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Jun He. From 2001 to 2005, he studied in Liaoning University and received his doctor's degree in 2005. From 2001 to 2011, he worked in Shenyang Normal University. Currently, he works in Liaoning University. He has published more than 80 papers. His research focuses on Economics of Regulation and Regional Economics.

Zilong Huang. From 2007 to 2011, he studied in Shenyang Ligong University and received his bachelor's degree in 2011. From 2012 to 2015, he studied in Liaoning University and received his master's degree in 2015. Currently, he is studying for his doctor's degree in Liaoning University. His research focuses on Economics of Regulation.

Arunodaya Raj Mishra PhD in mathematics from Jaypee Universuty of Engineering & Technology, Guna, MP, India. His main research includes fuzzy sets theory, multi-criteria decision-making, IFSs, IVIFs, PFSs, NSs, sustainability, sustainable development and decision making methods, information measures, entropy measures, divergence measures and similarity and dissimilarity measures. He has published more than 51 peer-reviewed papers, many in high-quality international journals including Journal of Cleaner Production, Sustainable Development, Sustainable Production & Consumption, Applied Soft Computing, etc.

Melfi Alrasheedi received the Ph.D. degree in Operations Research (multi-criteria decision analysis) from Brunel University, UK, & Msc degree in Applied Statistics from Oregon State University, USA. He is currently the head of Department of Quantitative Methods, School of Business, King Faisal University, Saudi Arabia. He has published several peer-reviewed papers in high-quality international journals including Journal of Cleaner Production, Sustainable Development, Automation in Construction, Journal of Retailing and Consumer Services, Mathematics, Computers and Industrial Engineering.