land

Article

Tackling Comprehensive Evaluation of Tourism Community Resilience: A Probabilistic Hesitant Linguistic Group Decision Making Approach

Junling Zhang [1], Linying Shen [1,†], Lijun Liu [1,†], Xiaowen Qi [2,*] and Changyong Liang [3]

1 College of Economics and Management, Zhejiang Normal University, Jinhua 321004, China
2 School of Business Administration, Zhejiang University of Finance & Economics, Hangzhou 310018, China
3 School of Management, Hefei University of Technology, Hefei 230009, China
* Correspondence: qixiaowen@zufe.edu.cn
† These authors contributed equally to this work.

Abstract: Community-based tourism (CBT) has been adopted as an effective and practical solution to land use policies by governments that simultaneously pursue upgrading of local economy, conservation of local ecosystem and development of local communities. Confronting with new normality of detrimental eventualities in situated environments, destination management organizations (DMOs) or local governments have to employ effective governance strategies for fostering tourism community resilience in order to sustain development of CBT destinations. In viewing of that facilitating development through evaluation usually manifests as an efficient strategy in governance practices, this paper contributes to fill two main gaps in tackling comprehensive evaluation of tourism community resilience. Firstly, by noticing the fact that current literature overlooks processual characteristics of tourism community resilience, which originate from integration of disaster management and destination management (DM2), we have developed an analytical framework comprised of six attributes for comprehensively evaluating tourism community resilience. Secondly, aiming at the phenomena that cognitive assessments on attributes of tourism community resilience often exhibit complicate uncertainties caused by low-structured or ill-structured problem nature, we have put forward a powerful expression tool of probabilistic dual hesitant fuzzy uncertain unbalanced linguistic set (PDHF_UUBLS) to simultaneously capture evaluators' cognitive characteristics of decision hesitancy, bipolar epistemic notions and relative importance among assessments. Then by formalizing comprehensive evaluation of tourism community resilience as a multiple attributes decision making process, we construct an effective multiple attributes group decision making (MAGDM) approach with assessments in the form of PDHF_UUBLS. Theoretical analyses verify the effectiveness of our constructed MAGDM approach and also show the approach avoids potential information distortion in comparison with other approaches. Overall, this paper provides effective and pertinent solutions, with both analytical framework and methodology, to the urgent task of comprehensive evaluation of tourism community resilience in DM2 agenda, thereby is of apparent significance in governance practice of CBT.

Keywords: land use policy; community-based tourism; tourism community resilience; DM2; comprehensive evaluation; MAGDM; probabilistic hesitant fuzzy set; unbalanced linguistic set; information measure

check for updates

Citation: Zhang, J.; Shen, L.; Liu, L.; Qi, X.; Liang, C. Tackling Comprehensive Evaluation of Tourism Community Resilience: A Probabilistic Hesitant Linguistic Group Decision Making Approach. *Land* **2022**, *11*, 1652. https://doi.org/10.3390/land11101652

Academic Editors: Ana Nieto Masot and José Luis Gurría Gascón

Received: 17 August 2022
Accepted: 20 September 2022
Published: 25 September 2022

1. Introduction

Land use reforms have been continuously and innovatively carried out by many developing countries to tackle social and economic hardship of economically limited settings [1], especially in their rural areas and mountain areas [2]. Community-based tourism (CBT) implementations seek to improve living conditions and economic status of local communities as well as to avoid gradually disappearing in their identities and irreversibly damaging their environments [1,3]. The multiple-faceted and ambitious attributes of CBT intrinsically identify it as pertinent in providing a systematic solution to tourism-led local development, such as tourism planning to support overall socio-economic development, community empowerment and ownership in decision making, communal collaboration in managing and developing tourism assets, conservation of natural resources and cultural heritages, and quality visitor experiences by advocating host-guest interactions [1,3–5]. Therefore, in many developing countries [6], CBT plays a crucial role in supporting land use reforms with special respect to rural revitalization and local sustainable development [1,2]. However, many pioneering investigations have pointed out that the tourism industry holds high-level vulnerability to changes (such as disturbances and uncertainties [7–10], natural hazards [11–13], climate change [14–16] and epidemics [15,17]) within its operating contexts [1,18–20]. The embedded symbiotic mechanisms of CBT development intensify its complex interrelationships with social-ecological resources in support of functioning of tourism systems [10], which further exacerbates the exposure of CBT implementations to detrimental eventualities [15]. On the other side, the augmented vulnerabilities highlight the pressing need for tourism communities to build their resilience when confronting adversities, which is intrinsically required in the official goals of sustainable development [21]. Resilience reflects the ability of a system to adapt to changing environments, as such has been argued as a critical component of sustainable development [18,22–24]. When applying the concept to tourism for strengthening sustainable tourism development, CBT destinations must be viewed as evolving interdependent sub-systems [10] that co-adapt to specifics of situated place and markets, and especially to the aspirations and values of tourism communities [1,18,25,26], so as to successfully maintain and increase carrying capacity [4,10,27–32], competitiveness [27,33–36], and attractiveness [11,26,27,29,35,37–39]. With effective resilience practices, tourism communities will empower themselves to adapt rather than cease to be operating directly [1,11,15,40,41]. As might be assumed, tourism communities could gradually achieve sound resilience practices through diachronic processes of responding to and learning from contextual changes. However, new normality [17] that has been brought about by epidemics and other changes will not leave enough time to the diachronic processes. Moreover, with the traditional wait-and-see attitudes, little will be known by DMOs about the status quo of resilience building practices in tourism communities. More importantly, knowledge sharing and learning opportunities for quick substantial improvements will be blocked out from tourism communities. In fact, evaluating resilience practices of tourism communities is an essential part of learning and measurement for destination governance, which fosters effective self-improvements as well as enables the processes of resilience building to be monitored continuously in a systematic way [42]. With regard to this consideration, construction of appropriate analytical frameworks for addressing desirable attributes of tourism community resilience and corresponding comprehensive evaluation approaches have become urgent matters in governance practices of CBT destinations.

Currently, despite some remarkably instructive studies that operationalized classic resilience theory to address tourism resilience by emphasizing practical utility, there is still no globally agreed-upon framework for resilience evaluation [10], especially with the paucity in CBT schemes [43]. Representatively, in their generic sphere of tourism resilience, Cochrane [18] proposed the fundamentally functional elements for building tourism resilience and emphasized the crucial role that the economic sub-system plays in holistic tourism systems. Given a certain economic configuration in CBT implementations of Ecuador, Ruizballesteros [1] more largely advocated the inextricable functions which socio-ecological system (SES) holds in fostering the success of CBT development, thereby deriving a framework comprised of the factors that nurture their socio-ecological resilience. Further, based on the above work by Ruizballesteros [1], Sheppard and Williams [26] deduced another framework by emphasizing that individual-oriented factors also enhance overall tourism community resilience, but their framework also neglected essential factors that contribute to economic resilience of tourism communities. Similarly, with noticing that CBT implementations currently still often disregard the community's right to enjoy the benefits of tourism and the positive effects that community resilience holds to tourism development, Wakil, Sun, and Chan [10] elaborated the discourse of co-flourishing between community resilience and tourism development by emphasizing the implications of six community capitals of human, social, natural, physical, financial and psychological. Comparative case investigations on community resilience across countries, cultures and types of threats accentuated the role of economic element in community resilience [41], especially for those successful communities associated with tourism development [40]. Through detailed focal case studies on tourism communities, Maclean, Cuthill, and Ross [11] definitely outlined the crucial functioning of diverse and innovative economy in their proposed resilience framework. In his seminal work, Faulkner [7] provided another essentially instructive framework by accentuating the disaster management in tourism destinations management. Obviously, the framework by Faulkner [7] is also essentially right for resilience building [8,44], and Filimonau and De Coteau [20] further advocated to build tourism resilience by drawing on integration of disaster management and destination management (DM2). Straightforwardly, tourism community resilience naturally manifests itself in corresponding stages of the disaster management process [13,20,45]. However, the aforementioned analytical frameworks, which exhibit various generic suitability from different aspects for evaluating tourism community resilience, neglected the processual characteristics of resilience building in tourism communities. This phenomenon has been evidenced by consecutive case studies on representative areas from Peru [15], Sri Lanka [17], Turkey [46], and Australia [13,47], in which processual logic required by disaster management in destinations [7,8] have been overlooked and still only traditional reactive attitudes prevail in the tourism industry [20]. However evidently, proactive preparedness which is commonly included in disaster management processes [7,8,20,44] is capable of drawing on comprehensive knowledge of previous crises and disaster management to offer a holistic perspective with regard to integrated strategies and frameworks, pertinent models, and contingency plans [46,48]. More fittingly to notice, in their most recent study, Jiang, Ritchie, and Verreynne [13] took the processual view to put forward a dynamic capabilities-oriented framework for tourism businesses to develop resilience in a disaster context rather than the view of SES approach [1,25] to accommodate the tourism community in a destination, especially neglected the socio-ecological issues emphasized in above-discussed classic resilience frameworks [1,10,11,18,26,40,41]. Therefore, in this paper, inspired by the above pioneering contributions, we will propose another analytical framework for comprehensive evaluation of tourism community resilience, which includes to emphasize processual attributes that reflect fundamental requirements by integration of disaster management and destination management (DM2) [7,8,13,20,44,46,47,49,50].

More important to notice, in focal literatures, the continuous development of analytical frameworks unanimously preferred qualitative attributes for comprehensive evaluation of tourism community resilience. In fact, the interwoven status of socio-ecological system and economic system in CBT intrinsically characterizes tourism community resilience with context-specific qualitative attributes due to its inextricable manifestation on social resilience [25], thereby bringing out a high degree of complexity in its comprehensive evaluation. Contextual complexity entails obvious difficulties in effectively expressing uncertain cognitive assessments on those qualitative attributes as well as constructing appropriate comprehensive evaluation approaches. It is worth noticing that, multiple attributes decision making (MADM) theory and its extensions to uncertain environments [51], such as fuzzy set-based methods [52–55] and linguistic set-based methods [56–59], have exhibited extensive suitability and flexibility in tackling comprehensive evaluation problems with qualitative attributes of high-degree complexity [60]. During the MADM modelling process for comprehensive evaluation, the foremost task is to develop appropriate expression tools for effectively depicting experts' complex opinions with considering multi-faceted cognitive characteristics, such as decision hesitancy [61], bipolar epistemic notions (membership and nonmembership degrees) [62], differentiated relative importance among hesitant assessments [63,64], etc. Due to the fact that the above cognitive characteristics apply simultaneously in complicate decision making processes, the combined effect on expressing assessments gives rise to development of compound expression tools that are capable of capturing and depicting assessments of high complexity more completely and comprehensively [65,66]. Recently, with special regard to evaluation problems with low-structured or even ill-structured qualitative definitions to which linguistic variables are preferably suggested [67], Pang, Wang, and Xu [63] and Xie et al. [68], respectively extended to introduce the compound expression tools of probabilistic linguistic term sets (PLTS) and dual probabilistic linguistic term set (DPLTS), which manage to utilize several hesitant linguistic labels to denote group basic assessments as well as collective complementary probabilistic opinions to each of the linguistic labels. Moreover, equally important in many practical cases where voting majority rules apply, group opinions of decision units will arrive at a linguistic label or a linguistic interval but obviously there still exists decision hesitancy to the voted [65]. In viewing of the same scenarios in practice, and by concurrently considering uncertain unbalanced linguistic scaling-based approximation [69], decision hesitancy, and bipolar epistemic notions, Zhang, Qi, and Liang [66] generalized to put forward a powerful expression tool called interval-valued dual hesitant fuzzy uncertain unbalanced linguistic set (IVDHF_UUBLS). Although IVDHF_UUBLS attains wide applicability in accommodating comprehensive evaluation problems of high complexity, IVDHF_UUBLS overlooked to address complementary group probabilistic opinions on supportiveness to membership degrees or nonmembership degrees as suggested by Pang, Wang, and Xu [63]. Therefore, in this paper, we will construct another enhanced expression tool of probabilistic dual hesitant fuzzy uncertain unbalanced linguistic set (PDHF_UUBLS) by extending IVDHF_UUBLS to probabilistic information environments.

Taking a step further, when confronted with the same obstacles as in conventional hesitant MADM that two hesitant fuzzy elements for comparison usually do not hold the same length, the fundamental modules (such as distance measures [70], entropy measures [71], similarity measures [70], and correlation measures [72]) required in modelling of group MADM approaches under PDHF_UUBLS environments also demand a certain mechanism that is capable of rationally extending any unmatched set, i.e., membership set or nonmembership set, of hesitant fuzzy elements for comparison to have equal length so as to be ready for further computational operations [73]. Currently, in the settings of probabilistic hesitant information, subjective extension mechanisms (i.e., through filling in a set with enough pairs of corresponding maximum, minimum or average values and zero probability to let the set have the same matched length) are still generally adopted [63,74]. Not only that they can hardly keep the original statistical feature value unchanged after extension, the above traditional subjective mechanisms also will result in zero-value phenomena due to setting of zero probability for all added data of derived utility sets which then are fed into information measures used by decision making processes [75–77], thereby causing more obvious information distortion with increment in the total amount of values added by subjective extension mechanisms. Interestingly, differing from the subjective extension mechanisms, the special extension solution based on least common multiple (LCM), which was originally put forward for neutrosophic hesitant fuzzy decision-making environments [78,79], provides another effective rationale that utilizes LCM to determine the common length of unmatched hesitant fuzzy elements rather than supposedly referring to the subjective choices. Inspired by the LCM extension mechanism, in this paper, we generalize it to our PDHF_UUBLS environments by adopting LCM as the common length for any unmatched membership set or nonmembership set and then uniformly allocating original probabilistic values to the multiplied membership or nonmembership degrees, so as to avoid subjective data interpolation and the potential information distortion caused by zero-value phenomena mentioned above. Furthermore, on the ground of LCM-based extension mechanism, information measures for IVDHF_UUBLS will be developed, by which an effective MAGDM approach under IVDHF_UUBLS environment will also be constructed and verified.

The rest of this paper is organized as follows. In Section 2, we establish an analytical framework by emphasizing processual characteristics of tourism community resilience and formalizing the task of comprehensive evaluation of tourism community resilience through the lens of multiple attributes group decision making. To effectively elicit complicated cognitive opinions of decision makers, Section 3 defines the probabilistic dual hesitant fuzzy uncertain unbalanced linguistic set (PDHF_UUBLS). In Section 4, we firstly extend to develop the LCM-based extension mechanism for PDHF_UUBLS, which enables operational laws for and decision-making approaches based on PDHF_UUBLS to fundamentally avoid potential information distortion in comparison with other methods. Then, the distance measure, entropy measure, and cross entropy measure for PDHF_UUBLS also have been developed in Section 4. Further, aiming at the complicated task of comprehensive evaluation of tourism community resilience, Section 5 constructs an effective multiple attributes group decision making (MAGDM) approach under a PDHF_UUBLS environment. Especially, with respect to common observations where weighting vectors for both evaluative attributes and decision units cannot be subjectively determined in advance due to complexity, programming models have been developed to objectively derive the unknown weighting vectors. Section 6 illustrates our proposed approach. Finally, conclusions are made in Section 7.

2. Problem Description of Comprehensive Evaluation of Tourism Community Resilience

2.1. Analytical Framework for Comprehensive Evaluation of Tourism Community Resilience

From the perspective of systemic thinking, community-based tourism (CBT) could be recognized as the special type of synthetized tourism system that draws on the locally situated social ecological system (SES) and tourism economic system [80], while the tourism economic system is naturally grounded on the SES [10]. Tourism community resilience basically emphasizes the tourism community's capacity of adapting, learning, and self-organizing in confrontation with detrimental eventualities, such as internal crises and external disasters [20,26]. Building tourism community resilience is obviously a non-linear management task [20] and its successful implementation must rely on adaptive governance that advocates co-management schemes [25]. This underlying observation explains that pioneering analytical frameworks suitable for comprehensive evaluation of tourism community resilience have been constructed to be more inclined to adopt qualitative attributes [1,10,11,18,26,41]. On the other side, the amplifying facts that CBT and other practices in tourism industry are truly impacted by crises and disasters have been sufficient to prompt integration of destination management and disaster management (DM2) [7,20]. In fact, in their seminal integrated managerial frameworks, Faulkner [7] and Ritchie [8] have already established the processual linkages between destination resilience building and disaster management [20], thereby characterizing tourism community resilience in CBT with indispensable processual attributes [13]. Despite the seminal integrated DM2 frameworks by [7,8], which accentuated a proactive attitude rather than only the reactive one through a cyclical and revolutionary processual view, most studies only took a reactive stance to evaluate disaster management in CBT destinations [20,50] and case studies in CBT destinations (form emerging markets [17,81] to well established markets [46,82], where small and micro businesses as the majority cannot individually fulfill the requirements of disaster management due to their limited resources and capabilities [13]) also indicated practices of disaster management still basically get along with reactive visions. From the opposite side, this predominantly inopportune prevalence of reactive stance spotlights the significance in carrying out comprehensive evaluation of tourism community resilience for effectively building resilience in CBT contexts. Therefore, inspired by the above-mentioned analytical frameworks relevant to disaster management and destination management in CBT, in the following, for comprehensive evaluation of tourism community resilience, we take view of processual logic from the integrated DM2 frameworks [7,8] and system thinking of SES approach [1,25] to derive a pertinent framework that comprises of six attributes, i.e., developing proactive preparedness, raising reactive readiness, fostering diverse and innovative economy, nurturing sense of community, consolidating organizational structure of tourism community, and advancing leadership as the core of governance. In the following, we elaborate the derivation of the above six attributes and summarize their corresponding descriptors for comprehensive evaluation in Table 1. For more clarity, in Figure 1, we also demonstrate our proposed analytical framework and list concise key points to each of its six attributes.

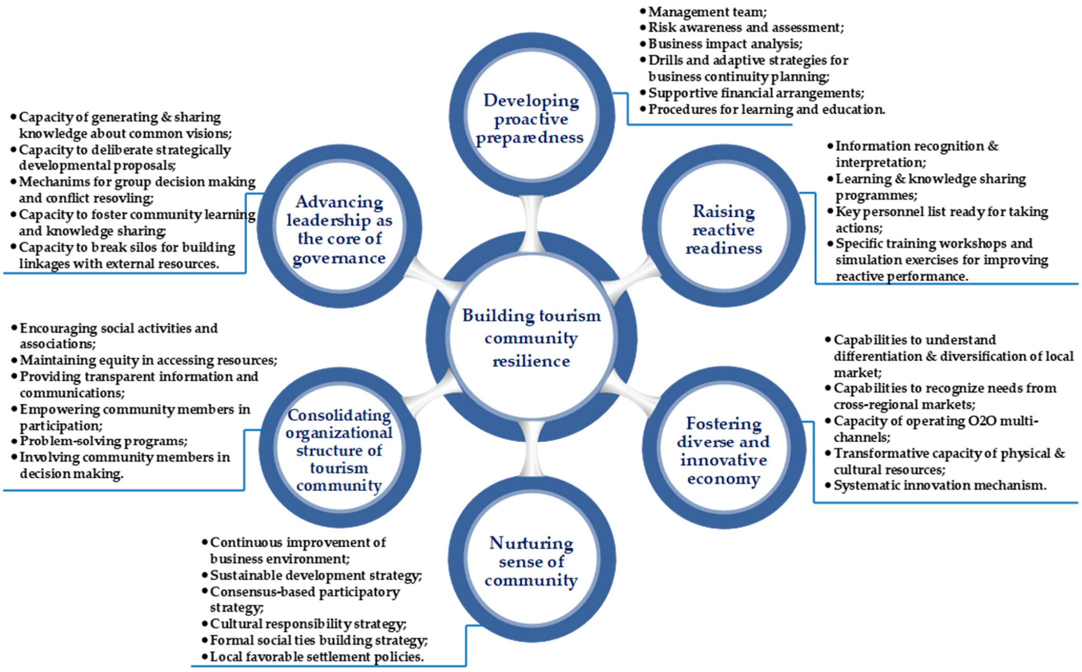

Figure 1. Illustration of proposed analytical framework for comprehensive evaluation of tourism community resilience.

Developing proactive preparedness. In tourism communities' building resilience against new normality of contextual disturbances [17], proactive preparedness plays a crucial role [83]. Without precautious attitudes and actions, consequences of detrimental eventualities will be prolonged and even exacerbated, thus with greater chance resulting in collapse of functional sub-systems in a tourism community [15,20,81]. The more severe, enduring and surprising the eventualities which tourism communities encounter, the stronger the resources must be prepared to build resilience [7,17,83–85].Proactive preparedness normally refers to, with attitudes of anticipation and active sensing, the process of building readiness through effective planning to deal with detrimental eventualities [7,8,46,86,87]. Since tourism communities generally are facing loss of tangible assets to various extent due to their vulnerability to potential eventualities [13], risk assessment for identifying vulnerability must be included in proactive preparedness in the first place [7,8]. Understanding potential risks and their impacts on tourism communities' vulnerability provides essential directions to formulate effective contingency plans [81]. Thinking systemically, customers, stakeholders and external industrial partners all demand business in tourism communities to adaptively remain vibrant when going through disturbances and uncertainties. Therefore, to avoid fundamental dysfunctions of the local tourism system, business continuity planning must be foremost focused on proactive preparedness of contingencies. Apart from assimilating experiential or officially approved procedures, by considering governmental instructions and guidelines [88,89], to formulate written routine drills [85], business impact analyses also have to be implemented carefully to identify a key set of interdependent basic functions and their alternatives [90]. More importantly, adaptive strategies that enhance tourism communities' resilience should also be reflected into business continuity as sustainable goals in alignment with severity of disturbances. As suggested by Jiang, Ritchie, and Verreynne [13], procedures of business operational adjustment, production adaptation and development, business model adaptation and expansion, and labor retention should be included in a business continuity plan for short-term planning; facilities expansion, infrastructure restoration, infrastructure modernization, and industry innovation for long-term planning. Halibozek and Kovacich [90] reminded that any innovative proposals should meet the cost-efficiency criterion. From the processual view, constructing proactive preparedness is an iterative process and it requires interactively supportive ingredients to form a cycle of reflection [7,81]. To keep instantly effective and complete awareness of contextual changes [20], data collection and reporting systems should be swiftly established through public communication approaches [13,91]. A delegated management team, which is a permanent and integral feature of business continuity planning, should be appointed in charge of plan development [7]. A communication center which facilitates bi-directional informing should also be operationalized as a regular infrastructure rather than only in the ad hoc mode as criticized in many studies [50,88]. In viewing of common specificities in tourism communities where small and micro-businesses constitute the most and generally behave weakly to proactively prepare financial resources for effectively adapting to changing environments [17], arrangements for acquiring financial resources definitely should be covered in business continuity planning, such as business insurance [17,47,83], business contingency funds [47], and government grants and funds [47,85]. Furthermore, clearly knowing and understanding detailed planning for changes by all stakeholders would be crucially essential in forming proactive posture of tourism communities [92], mechanisms for learning and education thus have also been stressed by the literature as an imperative in practices [1].

Raising reactive readiness. Literatures regarding crises and disaster management in the tourism industry have also gone through rather deep discussion and reached a common understating that both proactive preparedness and reactive readiness are indispensable for resilience building in tourism communities [7,8,17,20,81,86,93], because active anticipation and sensing does not necessarily mean the planned actions will be taken quickly and effectively [88]. Reactive readiness-oriented strategies thus focus on quick and efficient execution of planned actions in front of complicated changes or unexpected eventualities [90]. To bounce against those scenarios, tourism communities' proactive infrastructures of awareness (such as early warning systems and data reporting systems) are generally incapable of indicating what actions to directly follow. So tourism communities have to nurture the capacity of information recognition and interpretation for mapping various scenarios to a set of relevant planned actions [85], such as forecasting and case-based reasoning systems [85]. According to social organization perspective of community resilience construction [94], member businesses in a tourism community play a fundamental role in catalyzing holistic community capital through their key functions in increasing the potential of local networks [50]. Analogically, member businesses' performance of reactive readiness therefore determines the overall level of reactive readiness of the tourism community. However, member businesses generally are in lack of such skill sets or knowledge required in planned actions against new normality of changes [17]. Then, it is essential to include learning programs that empower the owner-operators or staffs in order to maintain relevant personnel on the contact list and take key actions by leveraging their knowledge [95]. With special respect to responding speed and effectiveness of stakeholders, skills-related and scenario-specific training workshops are critical tools and should be routinely conducted to practice drills required in action plans, such as training programs regarding disaster or crisis-related events, training of new media communications and tourist/guest handling [50,85]. To gradually understand real scenarios that planned actions apply, Malhotra and Venkatesh [88] suggested simulation exercises might be carried out to inform community members with integral consciousness, thereby improving their agency in reactive preparedness.

Fostering diverse and innovative economy. Successful engagement within markets is vital to the resilience of tourism communities, otherwise any tourism system will come to collapse without pertinent configurations of economy in a tourism community [18]. From the view of developmental dynamics in going through contextual market changes, planned adaptive strategies for continuity of member businesses must be based on, derived from, and manifest on current configurations of economy in tourism communities. By identifying their susceptibility to market changes, many pioneering studies on community resilience have indicated the importance of community's avoiding simple operations in a certain sector, thus encouraging a diverse and innovative economy [11,40,41]. To effectively cope with changes, resilience theories acknowledge the needs for catering to evolutionary interests of customers and simultaneously recognize new opportunities that changes generate [11]. During the processes of pursuing diverse and innovative economy, tourism communities should figure out approaches that nurture customers' willingness to support local business and community members' willingness to support each other with interests of improving everyone's opportunities [40]. More practically with respect to their specificities, tourism communities have to take strategies that consider both the demand side and supply side of the market. From the demand side, continuous improvement mechanisms for tourism products and services are fundamental to keep up with changing demands. To reinforce the mechanisms, market investigation and differentiation is essentially important in acknowledging customers' needs diversely and precisely. Exploring and exploiting regional customers' profiles and feedbacks from both online and offline can help firmly seize the local market since tourism communities are largely locale-specific, while analysis on cross-regional customers can help tourism communities stay well-informed and capture potential needs and overall trends in a broader view. From the aspect of supply side, a strong local focus should be emphasized by innovatively drawing on locally characterized physical and cultural resources [11]. Diverse catalytical streams of tourism economy should be further incorporated, such as research and education applications that value and communicate local landscape and cultural heritage, experiential applications that enjoy local lifestyles, and e-commercial projects that foster market development and enhance robust revenue for all available local specialties. All the projects and applications should be implemented as common projects and operated as a mechanism to benefit the possible majority of tourism community members. In general, diverse and innovative economy is an intrinsic attribute that indicates economic adaptive capability of tourism communities in front of various changes.

Nurturing sense of community. Taking tourism community as human environment interdependent context [96], fostering sense of place can enhance community members' willingness to take responsibility rather than to pull out without persistence in adapting to uncertainties and adversities [11,97], which is a prerequisite for a community to demonstrate collective competence [94]. Environmental psychology has indicated place attachment is commonly adopted in addressing sense of place, and generally two interrelated components of place attachment (e.g., place dependence and place identity) have been proposed within a wider array of theoretical frameworks, embodying functional and emotional ties to a place [98]. As can be seen, tourism communities as economic contexts produce functional place dependence to their community members, who rely heavily on market-oriented tourism systems to gain economic incomes and benefits. Therefore, continuous strategies for business environment improvement should be applied to enhance the tourism systems [10], which can be typically derived as maintenance and development of attractions, improvement on institutional services, improvement on tourist infrastructures, deployment of multimedia destination marketing and branding, etc. Systemic views of human-environment connections also indicate that socio-ecological resources underpin and produce functional dependence to community members [10,26]. So, effective sustainable strategies at local level should be incorporated, such as those often suggested ones including preservation and protection of cultural and natural landscapes [11], mechanisms for environmental management (e.g., appropriate monitoring and protection), advocation of pro-environmental narratives [99], and standardization of waste management [29]. Regarding the emotional people environment contexts in tourism communities, place identity facilitates community members' internalizing collective norms, defending collective interest, then taking shared responsibilities [100]. Place identity manifests when community members gain belief that they share values and goals with the community [101]. In the pioneering study situated in community-based tourism, Ruizballesteros [1] suggested common goals and interests shared are compulsory and should be guaranteed by consensus-based participatory strategy. Emphasizing and nurturing cultural responsibility to the community and its country helps to formalize shared feelings about historical trajectory of the place, thereby developing their place identity as connections to place [11]. To this end, measures thus should be taken not only focused on the ones for protection, but also those for continuous sensemaking, promotion, and development. Considering the fact that tourism development endows community members with combined roles of residents and business practitioners, the job embeddedness theory [102] applies and presents two ways of organizational embeddedness and community (living) embeddedness to construct place identity. However, in comparison with conceptualization of social capital [97], job embeddedness theory more emphasizes building formal (organizational) ties to enhance tourism community members' place identity, thus corresponding strategies that encouraging membership of business associations, industry associations, and other supportive NGOs should be recommended. On the other side, besides that amenities of tourism communities can provide preferable lifestyles, community (living) embeddedness [102] advocates local favorable settlement polices (e.g., the beneficial accommodation policies for newcomer entrepreneurs introduced by local government in China) should be well established to let community members not only be close to the community but become part of it, thereby generating place identity [101].

Consolidating organizational structure of tourism community. Adaptation processes required in building resilience of a tourism community are primarily social and depend on community members' drawing on their social capital [97,103]. Pioneering studies regarding community resilience have pointed out that social capital should not only keep focused on resource potential represented by personal network ties but more importantly and profitably on the concept of organizational structure of a synergized collectivity, transcending the agentic aspect of community members over a perspective centered on the accumulation of stocks of resources [104]. Organizational structure indicates how efficiently a tourism community can organize and work together to advance their common goals [105]. In the context of building resilience in tourism communities [14], organizational structure shows how community members are networked and how well they work together in dealing with adversities and uncertainties [106]. Overall synergetic level of organizational structure in a resilient community manifests on residents' reliable social ties between each other and collective efficacy, which support mutually to catalyze adaptive capacities of community as a social organization [94,106–109]. Social trust always occupies the core of social capital conception [97], and its function is straightforward in building social ties, thereby continuously maintaining and consolidating structures of community networks [97]. Therefore, social trust usually serves to measure the stability of organizational structure when community members work together [94,110]. Often argued effective strategies for fostering social trust in communities generally include encouraging citizens' participation in social activities and voluntary associations to build their social networks among community members [111–113], maintaining citizens' equity in accessing community resources [114], and providing transparent information and communication [114]. However, community networks with solid ties may only foster conditions under which collective efficacy flourishes but network ties are not sufficient for the exercises of collective control and actions [115]. Collective efficacy directly reflects linkages of trust and cohesion with shared expectations of participation and cooperation in organized community actions [107,116,117], thereby indicating collective efficiency of networked tourism community members' working collectively to deal with changes [94,108]. In view of the fact that collective efficacy closely relies on empowerment of community members, extant studies thus suggested to adopt useful strategies for its continuous improvement, mainly including participatory processes regarding community development as vehicles to empower community members [41], problem-solving programs to build community agency and self-organizing capacities [1,26], especially the substantive empowerment that allows community members to involve in decision making activities [84].

Advancing leadership as the core of governance. Special emphasis has been remarked to the importance of leadership in effective governance practices towards resilience building in tourism communities [11,18,25,40,118], because it is crucial in providing directions and synergies of joint actions to adaptation, as well as in initiating and guiding transformation to change [8,11,25]. Standing from the strategic position to achieve long-term shared interests of tourism community members, leadership should be capable of developing common visions and implementing them in sustainable planning [1,80]. Knowledge about the common visions should be well-generated and communicated to catalyze agency and self-organizing for goal accomplishment [11,41]. By acknowledging the complexity in managing and marketing tourism community within a CBT destination, those in leadership have to deliberate strategically developmental proposals that benefit the whole tourism community, such as arrangements of complementary tourism products and services, establishments of common norms and regulations for guaranteeing consistent tourism products and services and creating and nurturing local online brands. To that end, more tactically, group decision-making mechanisms that involve stakeholders of focus should be institutionalized since engaged governance revolves around participation and collaboration [11]. During processes of group decision making, leadership's ability to act as a mediator for conflict resolution is fundamentally important [1,10], especially helping arrive at opportune decisions to tough conditions [8]. The common feature that tourism communities are comprised of small businesses entails the common phenomena that contextual changes facilitate outages of community members' knowledge for keeping up with changes. Generally, participation and collaboration embody processes through which community members and other concerned stakeholders pool their knowledge so as to expand and enrich collectively shared information, knowledge, and ideas [119]. Therefore, leadership should operationalize as another mechanism which fosters knowledge sharing and community learning through training and education, aiming at spillover of knowledge pool for members' innovation and collective competitiveness. In view of that many failures of community-based tourism also have been ascribed to lacking of linkages with external tourism distribution channels and markets [3,120], leadership thus must manifest the capability of breaking silos for building linkages with external resources [95], such as optimal resource bundling for small businesses [121], inward funding and investment [10], and beneficial government policy [10].

For more clarity, we have organized the above six attributes and their descriptors in following Table 1.

Table 1. Analytical framework for comprehensive evaluation of tourism community resilience.

Attributes	Attribute Descriptors for Comprehensive Evaluation
C_1: Developing proactive preparedness	· Rationally configured management team who are in delegation to develop and improve a business continuity plan for their tourism community; [7] · Mechanisms and infrastructures (such as data collection and reporting [13,91], communication center [50,88]) for facilitating risk awareness and assessment; [7,8,81] · Precise business impact analysis that identifies a key set of interdependent basic functions and their alternatives; [90] · Context-specific written action drills for business continuity planning, which assimilate experiential or officially-approved procedures by carefully referring to governmental instructions and guidelines; [85,88,89] · Cost-efficient adaptive strategies for both short-term and long-term business continuity planning; [13,90] · Supportive financial arrangements to help operating businesses (especially, the major small and micro sized ones) proactively prepare financial resources [17,47,83,85]; · Procedures for learning and education to effectively shape proactive posture of the tourism community; [1,92]

Table 1. *Cont.*

Attributes	Attribute Descriptors for Comprehensive Evaluation
C_2: Raising reactive readiness	· Capabilities of information recognition and interpretation for mapping scenario to planned actions [85]; · Learning and knowledge sharing programs that guarantee and empower a key personnel list from member businesses ready for taking actions [95]; · Specific training workshops that practice drills required in action plans in order to improve responding speed and effectiveness of stakeholders [50,85]; · Simulation exercises that refer to real scenarios and aim at raising performance of reactive readiness [88];
C_3: Fostering diverse and innovative economy	· Capabilities to precisely understand differentiation and diversification of needs/motives from local markets; · Capabilities to agilely recognize potential needs and overall trends from cross-regional markets; · Capacity of member businesses to operate by product mix and through O2O multiple channels; · Diversely tourism-oriented transformative capacity of physical and cultural resources; · Systematic innovation mechanism that captures market opportunities and carries out developmental projects to benefit stakeholders in the community;
C_4: Nurturing sense of community	· Practices of strategies for continuous improvement of business environment in the community [10]; · Practices of strategies for sustainable development [10,11,26,29,99]; · Practices of consensus-based participatory strategy for guaranteeing common goals and shared interests [1]; · Practices of strategies for emphasizing and nurturing cultural responsibility [11]; · Practices of strategies for advocating formal ties building in the community [97]; · Practices of strategies for advocating local favorable settlement polices [101,102];
C_5: Consolidating organizational structure of tourism community	· Encouraging participation of community members in social activities and voluntary associations to build social networks [111–113]; · Maintaining community members' equity in accessing community resources [114]; · Providing transparent information and communication [114]; · Empowering community members in participatory processes for community development [41]; · Effective problem-solving programs aiming at building agency and self-organizing capacities of the community [1,26]; · Substantive empowerment that allows community members to partake in decision-making activities [84];
C_6: Advancing leadership as the core of governance	· Capacity of generating and communicating knowledge about shared common visions of the community [11,41]; · Capacity to deliberate strategically developmental proposals that benefit the whole tourism community; · Effective mechanisms that organize stakeholders for group decision making and resolve conflicts [1,8,10,11]; · Capacity to foster community learning and knowledge sharing [119]; · Capacity to break silos for building linkages with external resources [10,95,121];

2.2. Formalizing Comprehensive Evaluation of Tourism Community Resilience

Increasing disturbances and changes in situated internal and external environments, especially the profound detrimental influences brought about by the outbreak of pandemics, have been compelling destination management organizations (DMOs) and local related governments to integrate destination management and disaster management (DM2) [20]. The proposal of integrative action framework of destination management and disaster management has expanded to include a portfolio of unprecedented tasks [20], among which building tourism community resilience emerges as an urgent one. As elaborated above, building resilience cannot be treated as a diachronic process when contextualized with detrimental eventualities of high frequency [17]. As a result, DMOs and local governments all over the globe have to take pertinent strategies to prompt tourism community resilience building. In alignment with various countries' institutional experiences [42], the strategy of promoting development through evaluation provides an appropriate and efficient governance strategy. The fundamental logic underlying the strategy is that, based on the ranking results derived from comprehensive evaluation, awarding and stimulation can be then applied and function as motivational mechanisms in which resilience-building performances of tourism communities would be efficiently improved through iterative knowledge sharing and purposeful learning. Therefore, comprehensive evaluation of tourism community resilience has become an inextricable task in the integrative practices of destination management and disaster management (DM2). Furthermore, complexity in attributes of tourism community resilience as introduced in Section 2.1 leads to decision-making processes in which assessments on those attributes inevitably will be determined qualitatively by elected decision makers (or decision units) according to their trusted expertise. Subsequently, in this paper, we conceptualize the problem of comprehensive evaluation of tourism community resilience with holding the multiple attributes decision making process as shown in Figure 2.

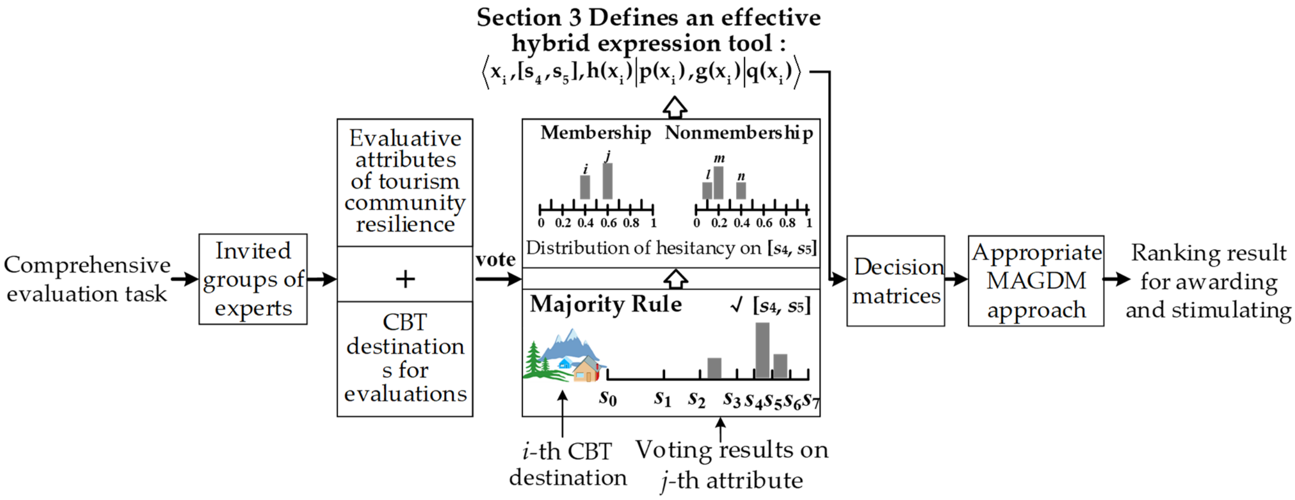

Figure 2. MAGDM-based approach with considering compound assessments of high uncertainty to comprehensive evaluation of tourism community resilience.

According to Figure 2, the problem can be formally expressed as follows. Given an NGO or a local government, there are a set of CBT destinations, i.e., $X = \{x_1, x_2, \ldots, x_n\}$, under its administration. Let $A = \{A_1, A_2, \ldots, A_m\}$ denote the attributes introduced in Section 2, according to which elected decision makers or decision units will comprehensively evaluate status quo of tourism community resilience in each CBT destination. The NGO or local government will invite several groups of experts, $E = \{E_1, E_2, \ldots, E_t\}$, to present their assessments to each CBT destination $x_i(i = 1, \ldots, n)$ under each attribute $A_j(j = 1, \ldots, m)$. To facilitate elicitation of complicated assessments by decision makers, the compound expression tool of PDHF_UUBLS, which will be further thoroughly analyzed in Section 3 is employed to depict the assessments more effectively and integratively. Then, a certain number of decision matrices whose elements are in the form of PDHF_UUBLS will be collected and fed into appropriate multiple attributes group decision making (MAGDM) approaches. In order to construct effective MAGDM approaches under PDHF_UUBLS environments, in the following sections, we will introduce the detailed definitions of PDHF_UUBLS and its desirable information measures.

3. Definition of PDHF_UUBLS

As suggested by the pioneering studies by Zadeh [122] and Xu [56], linguistic variables behave more powerfully in tackling with ill-structured decision making problems. However, complexities in those problems usually outperform linguistic variables and entail additional hybrid complicated characteristics in decision makers' assessments, including decision hesitancy [61], bipolar epistemic notions (membership and nonmembership degrees) [62], differentiated relative importance among hesitant assessments [63,64], etc. As a result, compound expression tools based on linguistic variables to cover specific above-mentioned complicate characteristics have been accumulatively in development recently. With special respect to the decision scenarios where majority rule applies and decision makers are capable of arriving at the most preferred linguistic variable [65], Zhang, Qi, and Liang [66] introduced the powerful compound expression tool of interval-valued dual hesitant fuzzy uncertain unbalanced linguistic set (IVDHF_UUBLS) to simultaneously accommodate uncertain unbalanced linguistic scaling-based approximation, decision hesitancy, and bipolar epistemic notions (membership and nonmembership degrees). Nevertheless, IVDHF_UUBLS overlooked the non-negligible group opinions in the form of probabilistic supportiveness to membership degrees or nonmembership degrees as suggested in Pang, Wang, and Xu [63]. Therefore, in this section, we extend the IVDHF_UUBLS to probabilistic environments, thereby introducing another more powerful compound expression tool of probabilistic dual hesitant fuzzy uncertain unbalanced linguistic set (PDHF_UUBLS), as defined in the following.

Definition 1. *Let X be a fixed set and S be a finite and continuous unbalanced linguistic label set. Then the probabilistic dual hesitant fuzzy uncertain unbalanced linguistic set (PDHF_UUBLS) L_p on X is defined as*

$$L_p = \left\{ \left\langle x_i, \widetilde{s}_{\vartheta(x_i)}, h(x_i)|p(x_i), g(x_i)|q(x_i) \right\rangle | x_i \in X \right\},$$

where $\widetilde{s}_{\vartheta(x_i)} = \left[s_{\alpha_i}, s_{\beta_i}\right]$ represents judgment to object x_i, s_{α_i}, and s_{β_i} are two unbalanced linguistic variables from the predefined unbalanced linguistic label set S, which represents judgments of decision makers (or decision units) to an object. $h(x_i) = \cup_{\mu_{k_i} \in h(x_i)}\{\mu_{k_i}\}$ and $g(x_i) = \cup_{\nu_{t_i} \in g(x_i)}\{\nu_{t_i}\}$ are two sets of some values in [0,1], which respectively denote the two sets of possible membership degrees and non-membership degrees to what the x_i belongs to $\widetilde{s}_{\vartheta(x_i)}$. $p(x_i) = \cup_{p_{k_i} \in p(x_i)}\{p_{k_i}\}$ and $q(x_i) = \cup_{q_{t_i} \in q(x_i)}\{q_{t_i}\}$ are the corresponding complementary probabilistic information to $h(x_i)$ and $g(x_i)$.

Moreover, the above $h(x_i)|p(x_i)$ and $g(x_i)|q(x_i)$ hold the following conditions: μ_{k_i}, $\nu_{t_i} \in [0,1]$, $0 \le \mu_{k_i}^+ + \nu_{t_i}^+ \le 1$, where $\mu_{k_i}^+ = \cup_{\mu_{k_i} \in h(x_i)} \max\{\mu_{k_i}\}$, $\nu_{t_i}^+ = \cup_{\nu_{t_i} \in g(x_i)} \max\{\nu_{t_i}\}$; $p_{k_i}, q_{t_i} \in [0,1]$, $\sum_{k_i=1}^{\#h_i} p_{k_i} \le 1$, $\sum_{t_i=1}^{\#g_i} q_{t_i} \le 1$. The symbols of $\#h_i$ and $\#g_i$ are the total numbers of elements in $h(x_i)|p(x_i)$ and $g(x_i)|q(x_i)$, respectively.

For convenience, when X has only one element, L_p reduces to $lp = (\widetilde{s}_\vartheta, h|p, g|q)$, where $\widetilde{s}_\vartheta = [s_\alpha, s_\beta]$, $h = \{\mu_k\}$ and $g = \{\nu_t\}$, which is called a probabilistic dual hesitant fuzzy uncertain unbalanced linguistic element (PDHF_UUBLE).

Inspired by the principle in the score function and accuracy function introduced by Ju et al. [123], we can define the following score function and accuracy function for our PDHF_UUBLS.

Given a $lp = (\widetilde{s}_\vartheta, h|p, g|q)$, the concept of linguistic hierarchies, i.e., $LH = \cup_t l(t, n(t))$ is used. $l(t, n(t))$ is a linguistic hierarchy with t indicating the level of hierarchy, and $n(t)$ denotes the granularity of the linguistic term set of t. By use of the transformation function designed by Herrera, Herrera-Viedma and Martinez [69], we have $I^- = \frac{1}{n(t_1)-1}\Delta_{t_0}^{-1}\left(TF_{t_0}^{t_1}(\psi(s_\alpha))\right)$, $I^+ = \frac{1}{n(t_1)-1}\Delta_{t_0}^{-1}\left(TF_{t_0}^{t_1}(\psi(s_\beta))\right)$, where t_1 are the corresponding levels of unbalanced linguistic terms s_α and s_β in a specific LH. Then, the score function $E(lp)$ and deviation degree function $\sigma(lp)$ of PDHF_UUBLE can be defined as:

$$E(lp) = \frac{I^- + I^+}{2} \times (\overline{\mu} - \overline{\nu}) = \frac{I^- + I^+}{2} \times \left(\sum_{k=1}^{l_h} \mu_k p_k \Big/ \sum_{k=1}^{l_h} p_k - \sum_{t=1}^{l_g} \nu_t q_t \Big/ \sum_{t=1}^{l_g} q_t \right) \quad (1)$$

$$\sigma(lp) = \frac{I^- + I^+}{2} \times \left(\left(\sum_{k=1}^{l_h} (\mu_k - \overline{\mu})^2 (p_k \Big/ \sum_{k=1}^{l_h} p_k) \right)^{1/2} + \left(\sum_{t=1}^{l_g} (\nu_k - \overline{\nu})^2 (q_t \Big/ \sum_{t=1}^{l_g} q_t) \right)^{1/2} \right) \tag{2}$$

where l_h and l_g are the numbers of values in h and g, respectively. The larger the score $E(lp)$, the smaller the deviation degree $\sigma(lp)$, the greater the PDHF_UUBLE lp.

Then the comparative rules between any two PDHF_UUBLEs of $lp_1 = (\widetilde{s}_{\vartheta_1}, h_1|p_1, g_1|q_1)$ and $lp_2 = (\widetilde{s}_{\vartheta_2}, h_2|p_2, g_2|q_2)$ can be described as:

(I) If $E(lp_1) < E(lp_2)$, then $lp_1 \prec lp_2$;

(II) If $E(lp_1) = E(lp_2)$, then

(i) If $\sigma(lp_1) < \sigma(lp_2)$, then $lp_1 \succ lp_2$;

(ii) If $\sigma(lp_1) = \sigma(lp_2)$, then $lp_1 \sim lp_2$.

4. Information Measures for PDHF_UUBLS Based on LCM-Based Extension Mechanism

Similar to other conventional and compound tools for expressing decision hesitancy, the PDHF_UUBLS proposed in this paper still encounters situations where corresponding membership sets or nonmembership sets of two PDHF_UUBLEs for comparison do not match in length of set. The underlying logic of widely adopted methods were straightforward to complement any unmatched set with its maximum, minimum, or medium, respectively, representing the decision attitudes of optimism, pessimism, or neutrality [63,74]. Although it can simplify the processing of unmatched situations, the usage of above methods obviously distorts the original statistical feature values in general application. More importantly under probabilistic environments, the commonly used mechanism to assign zero probability to all newly added values for the purpose of maintaining basic statistical feature value will cause the zero-value phenomena for all added data in each derived utility set which then fed into information measures used by decision-making processes [75–77], thereby causing more apparent information distortion with the increment in the amount of added values. To tackle the potential distortion caused by the above-mentioned widely adopted extension methods, inspired by the least common multiple (LCM) solution, which was recently put forward for the neutrosophic hesitant fuzzy decision making environments [78,79], we here generalize it to probabilistic decision making scenarios so as to propose a LCM-based extension mechanism for our PDHF_UUBLS. In the following, we adopt LCM as the common length for any unmatched membership set or nonmembership set then uniformly allocate original probabilistic values to the multiplied membership or nonmembership degrees, so that fundamental statistical feature values of extended sets can be maintained, and potential information distortion caused by zero-value phenomena can be avoided.

4.1. LCM-Based Extension Mechanism for PDHF_UUBLS

Suppose now we have $A = \left\{ \langle x_i, \widetilde{s}_{\vartheta_A}(x_i), h_A(x_i)|p_A(x_i), g_A(x_i)|q_A(x_i) \rangle | x_i \in X \right\}$ and $B = \left\{ \langle x_i, \widetilde{s}_{\vartheta_B}(x_i), h_B(x_i)|p_B(x_i), g_B(x_i)|q_B(x_i) \rangle | x_i \in X \right\}$ as any two PDHF_UUBLSs on X, in which we have $\widetilde{s}_{\vartheta_A}(x_i) = [s_{\alpha_{Ai}}, s_{\beta_{Ai}}]$, $\widetilde{s}_{\vartheta_B}(x_i) = [s_{\alpha_{Bi}}, s_{\beta_{Bi}}]$,$h_A(x_i)|p_A(x_i) = \cup\left\{ \mu_{k_{Ai}} \middle| p_{k_{Ai}} \right\}$, $g_A(x_i)|q_A(x_i) = \cup\left\{ \nu_{t_{Ai}} \middle| q_{t_{Ai}} \right\}$,$h_B(x_i)|p_B(x_i) = \cup\left\{ \mu_{k_{Bi}} \middle| p_{k_{Bi}} \right\}$, $g_B(x_i)|q_B(x_i) = \cup\left\{ \nu_{t_{Bi}} \middle| q_{t_{Bi}} \right\}$. $h_A(x_i)$, $g_A(x_i)$, $h_B(x_i)$, $g_B(x_i)$ hold conditions: $\mu_{k_{Ai}}$, $\nu_{t_{Ai}}$, $\mu_{k_{Bi}}$, $\nu_{t_{Bi}} \in [0,1]$, $0 \le \mu^+_{k_{Ai}} + \nu^+_{t_{Ai}} \le 1$, $0 \le \mu^+_{k_{Bi}} + \nu^+_{t_{Bi}} \le 1$ where $\mu^+_{k_{Ai}} = \cup\max\{\mu_{k_{Ai}}\}$, $\nu^+_{t_{Ai}} = \cup\max\{\nu_{t_{Ai}}\}$, $\mu^+_{k_{Bi}} = \cup\max\{\mu_{k_{Bi}}\}$ and $\nu^+_{t_{Bi}} = \cup\max\{\nu_{t_{Bi}}\}$ for $x_i \in X$. $p_A(x_i)$, $q_A(x_i)$, $p_B(x_i)$, $q_B(x_i)$ hold conditions: $p_{k_{Ai}}$, $q_{t_{Ai}}$, $p_{k_{Bi}}$, $q_{t_{Bi}} \in [0,1]$; $\sum_{k_{Ai}=1}^{l_{h_{Ai}}} p_{k_{Ai}} \le 1$, $\sum_{t_{Ai}=1}^{l_{g_{Ai}}} q_{t_{Ai}} \le 1$, $\sum_{k_{Bi}=1}^{l_{h_{Bi}}} p_{k_{Bi}} \le 1$, $\sum_{t_{Bi}=1}^{l_{g_{Bi}}} q_{t_{Bi}} \le 1$. Let $l_{h_{Ai}}$, $l_{g_{Ai}}$, $l_{h_{Bi}}$, $l_{g_{Bi}}$ denote the lengths of $h_A(x_i)|p_A(x_i)$, $g_A(x_i)|q_A(x_i)$, $h_B(x_i)|p_B(x_i)$, $g_B(x_i)|q_B(x_i)$, respectively. More specifically, $l_{h_{Ai}}$, $l_{g_{Ai}}$, $l_{h_{Bi}}$, $l_{g_{Bi}}$ also indicate the numbers of elements in $h_A(x_i)$, $g_A(x_i)$, $h_B(x_i)$ and $g_B(x_i)$ or in $p_A(x_i)$, $q_A(x_i)$, $p_B(x_i)$, $q_B(x_i)$ respectively. Here, we use l_{h_i} as the least common multiple of $l_{h_{Ai}}$ and $l_{h_{Bi}}$, while use l_{g_i} as the least common multiple of $l_{g_{Ai}}$ and $l_{g_{Bi}}$.

Then we can extend the PDHF_UUBLSs of A and B to A^* and B^*, we have:

$$A^* = \left\{ \langle x_i, \tilde{s}_{\vartheta_A}(x_i), h_A^*(x_i)|p_A^*(x_i), g_A^*(x_i)|q_A^*(x_i) \rangle | x_i \in X \right\},$$

$$B^* = \left\{ \langle x_i, \tilde{s}_{\vartheta_B}(x_i), h_B^*(x_i)|p_B^*(x_i), g_B^*(x_i)|q_B^*(x_i) \rangle | x_i \in X \right\},$$

$$h_A^*(x_i)|p_A^*(x_i) = \cup\left\{ \mu_{k_{Ai}}^* \middle| p_{k_{Ai}}^* \right\},\ g_A^*(x_i)|q_A^*(x_i) = \cup\left\{ \nu_{t_{Ai}}^* \middle| q_{t_{Ai}}^* \right\},$$

$$h_B^*(x_i)|p_B^*(x_i) = \cup\left\{ \mu_{k_{Bi}}^* \middle| p_{k_{Bi}}^* \right\},\ g_B^*(x_i)|q_B^*(x_i) = \cup\left\{ \nu_{t_{Bi}}^* \middle| q_{t_{Bi}}^* \right\}.$$

Here we take $h_A^*(x_i)|p_A^*(x_i)$ as an example,

$$h_A^*(x_i)|p_A^*(x_i) = \cup\left\{ \mu_{k_{Ai}}^* \middle| p_{k_{Ai}}^* \right\} = \left\{ \underbrace{\mu_{1_{Ai}}\left|\frac{p_{1_{Ai}}}{l_{h_{Ai}}^*}\right., \ldots, \mu_{1_{Ai}}\left|\frac{p_{1_{Ai}}}{l_{h_{Ai}}^*}\right.}_{l_{h_{Ai}}^*}, \ldots, \underbrace{\mu_{k_{Ai}}\left|\frac{p_{k_{Ai}}}{l_{h_{Ai}}^*}\right., \ldots, \mu_{k_{Ai}}\left|\frac{p_{k_{Ai}}}{l_{h_{Ai}}^*}\right.}_{l_{h_{Ai}}^*}, \ldots, \underbrace{\mu_{l_{h_{Ai}}}\left|\frac{p_{l_{h_{Ai}}}}{l_{h_{Ai}}^*}\right., \ldots, \mu_{l_{h_{Ai}}}\left|\frac{p_{l_{h_{Ai}}}}{l_{h_{Ai}}^*}\right.}_{l_{h_{Ai}}^*} \right\}.$$

Similarity, we obtain $g_A^*(x_i)|q_A^*(x_i)$, $h_B^*(x_i)|p_B^*(x_i)$ and $g_B^*(x_i)|q_B^*(x_i)$ as follows,

$$g_A^*(x_i)|q_A^*(x_i) = \cup\left\{ \nu_{t_{Ai}}^* \middle| q_{t_{Ai}}^* \right\} = \left\{ \underbrace{\nu_{1_{Ai}}\left|\frac{q_{1_{Ai}}}{l_{g_{Ai}}^*}\right., \ldots, \nu_{1_{Ai}}\left|\frac{q_{1_{Ai}}}{l_{g_{Ai}}^*}\right.}_{l_{g_{Ai}}^*}, \ldots, \underbrace{\nu_{t_{Ai}}\left|\frac{q_{t_{Ai}}}{l_{g_{Ai}}^*}\right., \ldots, \nu_{t_{Ai}}\left|\frac{q_{t_{Ai}}}{l_{g_{Ai}}^*}\right.}_{l_{g_{Ai}}^*}, \ldots, \underbrace{\nu_{l_{g_{Ai}}}\left|\frac{q_{l_{g_{Ai}}}}{l_{g_{Ai}}^*}\right., \ldots, \nu_{l_{g_{Ai}}}\left|\frac{q_{l_{g_{Ai}}}}{l_{g_{Ai}}^*}\right.}_{l_{g_{Ai}}^*} \right\},$$

$$h_B^*(x_i)|p_B^*(x_i) = \cup\left\{ \mu_{k_{Bi}}^* \middle| p_{k_{Bi}}^* \right\} = \left\{ \underbrace{\mu_{1_{Bi}}\left|\frac{p_{1_{Bi}}}{l_{h_{Bi}}^*}\right., \ldots, \mu_{1_{Bi}}\left|\frac{p_{1_{Bi}}}{l_{h_{Bi}}^*}\right.}_{l_{h_{Bi}}^*}, \ldots, \underbrace{\mu_{k_{Bi}}\left|\frac{p_{k_{Bi}}}{l_{h_{Bi}}^*}\right., \ldots, \mu_{k_{Bi}}\left|\frac{p_{k_{Bi}}}{l_{h_{Bi}}^*}\right.}_{l_{h_{Bi}}^*}, \ldots, \underbrace{\mu_{l_{h_{Bi}}}\left|\frac{p_{l_{h_{Bi}}}}{l_{h_{Bi}}^*}\right., \ldots, \mu_{l_{h_{Bi}}}\left|\frac{p_{l_{h_{Bi}}}}{l_{h_{Bi}}^*}\right.}_{l_{h_{Bi}}^*} \right\},$$

$$g_B^*(x_i)|q_B^*(x_i) = \cup\left\{ \nu_{t_{Bi}}^* \middle| q_{t_{Bi}}^* \right\} = \left\{ \underbrace{\nu_{1_{Bi}}\left|\frac{q_{1_{Bi}}}{l_{g_{Bi}}^*}\right., \ldots, \nu_{1_{Bi}}\left|\frac{q_{1_{Bi}}}{l_{g_{Bi}}^*}\right.}_{l_{g_{Bi}}^*}, \ldots, \underbrace{\nu_{t_{Bi}}\left|\frac{q_{t_{Bi}}}{l_{g_{Bi}}^*}\right., \ldots, \nu_{t_{Bi}}\left|\frac{q_{t_{Bi}}}{l_{g_{Bi}}^*}\right.}_{l_{g_{Bi}}^*}, \ldots, \underbrace{\nu_{l_{g_{Bi}}}\left|\frac{q_{l_{g_{Bi}}}}{l_{g_{Bi}}^*}\right., \ldots, \nu_{l_{g_{Bi}}}\left|\frac{q_{l_{g_{Bi}}}}{l_{g_{Bi}}^*}\right.}_{l_{g_{Bi}}^*} \right\},$$

where $l_{h_{Ai}}^* = \frac{l_{h_i}}{l_{h_{Ai}}}$, $l_{h_{Bi}}^* = \frac{l_{h_i}}{l_{h_{Bi}}}$, $l_{g_{Ai}}^* = \frac{l_{g_i}}{l_{g_{Ai}}}$, $l_{g_{Bi}}^* = \frac{l_{g_i}}{l_{g_{Bi}}}$.

Further, given that t_{Ai}, t_{Bi} are corresponding levels of unbalanced linguistic terms $\tilde{s}_{\vartheta_A}(x_i)$ and $\tilde{s}_{\vartheta_B}(x_i)$, $I_{Ai}^- = \frac{1}{n(t_{Ai})-1}\Delta_{t_0}^{-1}\left(TF_{t_0}^{t_{Ai}}(\psi(s_{\alpha_{Ai}}))\right)$, $I_{Ai}^+ = \frac{1}{n(t_{Ai})-1}\Delta_{t_0}^{-1}\left(TF_{t_0}^{t_{Ai}}(\psi(s_{\beta_{Ai}}))\right)$, $I_{Bi}^- = \frac{1}{n(t_{Bi})-1}\Delta_{t_0}^{-1}\left(TF_{t_0}^{t_{Bi}}(\psi(s_{\alpha_{Bi}}))\right)$, $I_{Bi}^+ = \frac{1}{n(t_{Bi})-1}\Delta_{t_0}^{-1}\left(TF_{t_0}^{t_{Bi}}(\psi(s_{\beta_{Bi}}))\right)$ in corresponding LH respectively. According to Equations (1) and (2), we have Theorem 1 described as follows.

Theorem 1. *Suppose* A^* *and* B^* *be the corresponding extended forms of* A *and* B. *Then relationships between them satisfy:*

(1) $l\left(\tilde{h}_A^*(x_i)\right) = l\left(\tilde{h}_B^*(x_i)\right)$, $l(\tilde{g}_A^*(x_i)) = l(\tilde{g}_B^*(x_i))$;

(2) $E(A^*) = E(A)$, $E(B^*) = E(B)$;

(3) $\sigma(A^*) = \sigma(A)$, $\sigma(B^*) = \sigma(B) \Rightarrow \tilde{h}_A(x_i) \sim \tilde{h}_A^*(x_i)$, $\tilde{g}_A(x_i) \sim \tilde{g}_A^*(x_i)$, $\tilde{h}_B(x_i) \sim \tilde{h}_B^*(x_i)$, $\tilde{g}_B(x_i) \sim \tilde{g}_B^*(x_i)$.

Theorem 1 indicates that our proposed LCM-based extension mechanism for PDHF_UUBLS is capable of maintaining consistency of any two PDHF_UUBLEs for comparisons in further operations that required by information measures and host MAGDM approaches.

Now with the support of the above LCM-based extension mechanism, we can put forward some key information measures for PDHF_UUBLS.

4.2. Novel Distance Measures for PDHF_UUBLS

In this section, we propose a more generalized distance measure as shown in Definition 2 and its weighted version in Definition 3. Their desirable properties are verified in Theorem 2.

Definition 2. *Let* A *and* B *be two PDHF_UUBLSs defined on the universe of* $X = \{x_1, x_2, \ldots, x_n\}$, A^* *and* B^* *be the corresponding extended forms of* A *and* B, *then the generalized normalized distance between* A *and* B *can be defined as:*

$$d^{GN}(A,B) = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{1}{2}\left(\left|\frac{I_{Ai}^{-}+I_{Ai}^{+}}{2}-\frac{I_{Bi}^{-}+I_{Bi}^{+}}{2}\right|^{\lambda}+\frac{1}{2}\left(\frac{1}{l_{\tilde{h}_i}}\sum_{k_{Ai},k_{Bi}=1}^{l_{\tilde{h}_i}}\left|\mu_{k_{Ai}}^{*}p_{k_{Ai}}^{*}-\mu_{k_{Bi}}^{*}p_{k_{Bi}}^{*}\right|^{\lambda}+\frac{1}{l_{\tilde{g}_i}}\sum_{t_{Ai},t_{Bi}=1}^{l_{\tilde{g}_i}}\left|\nu_{t_{Ai}}^{*}q_{t_{Ai}}^{*}-\nu_{t_{Bi}}^{*}q_{t_{Bi}}^{*}\right|^{\lambda}\right)\right)\right)^{\frac{1}{\lambda}}. \tag{3}$$

If $\lambda = 1$, *then the above generalized normalized distance between* A *and* B *reduces to the hesitant normalized Hamming distance as*

$$d^{NH}(A,B) = \frac{1}{n}\sum_{i=1}^{n}\frac{1}{2}\left(\left|\frac{I_{Ai}^{-}+I_{Ai}^{+}}{2}-\frac{I_{Bi}^{-}+I_{Bi}^{+}}{2}\right|+\frac{1}{2}\left(\frac{1}{l_{\tilde{h}_i}}\sum_{k_{Ai},k_{Bi}=1}^{l_{\tilde{h}_i}}\left|\mu_{k_{Ai}}^{*}p_{k_{Ai}}^{*}-\mu_{k_{Bi}}^{*}p_{k_{Bi}}^{*}\right|+\frac{1}{l_{\tilde{g}_i}}\sum_{t_{Ai},t_{Bi}=1}^{l_{\tilde{g}_i}}\left|\nu_{t_{Ai}}^{*}q_{t_{Ai}}^{*}-\nu_{t_{Bi}}^{*}q_{t_{Bi}}^{*}\right|\right)\right). \tag{4}$$

If $\lambda = 2$, *then the above generalized normalized distance between* A *and* B *reduces to the hesitant normalized Euclidean distance as*

$$d^{NE}(A,B) = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{1}{2}\left(\left|\frac{I_{Ai}^{-}+I_{Ai}^{+}}{2}-\frac{I_{Bi}^{-}+I_{Bi}^{+}}{2}\right|^{2}+\frac{1}{2}\left(\frac{1}{l_{\tilde{h}_i}}\sum_{k_{Ai},k_{Bi}=1}^{l_{\tilde{h}_i}}\left|\mu_{k_{Ai}}^{*}p_{k_{Ai}}^{*}-\mu_{k_{Bi}}^{*}p_{k_{Bi}}^{*}\right|^{2}+\frac{1}{l_{\tilde{g}_i}}\sum_{t_{Ai},t_{Bi}=1}^{l_{\tilde{g}_i}}\left|\nu_{t_{Ai}}^{*}q_{t_{Ai}}^{*}-\nu_{t_{Bi}}^{*}q_{t_{Bi}}^{*}\right|^{2}\right)\right)\right)^{\frac{1}{2}}. \tag{5}$$

Furthermore, similar to the facts that evaluative attributes often have relative importance to each other, if there is weight information on each dimension of the two PDHF_UUBLSs under comparison, we need to take the weight information into account. Thus in the following Definition 3, we introduce the weighted distance measure between PDHF_UUBLSs. Let $w = \{w_1, w_2, \ldots, w_n\}$ be the weighting vector of $x_i (i = 1, 2, \ldots, n)$ with $w_i \geq 0$ and $\sum_{i=1}^{n} w_i = 1$. Then the weighted generalized normalized distance can be defined as follows.

Definition 3. *Let* A *and* B *be two PDHF_UUBLSs defined on the universe of* $X = \{x_1, x_2, \ldots, x_n\}$, *then the weighted generalized normalized distance between* A *and* B *is defined as:*

$$d^{WGN}(A,B) = \frac{1}{n}\sum_{i=1}^{n}w_i\left(\frac{1}{2}\left(\left|\frac{I_{Ai}^{-}+I_{Ai}^{+}}{2}-\frac{I_{Bi}^{-}+I_{Bi}^{+}}{2}\right|^{\lambda}+\frac{1}{2}\left(\frac{1}{l_{\tilde{h}_i}}\sum_{k_{Ai},k_{Bi}=1}^{l_{\tilde{h}_i}}\left|\mu_{k_{Ai}}^{*}p_{k_{Ai}}^{*}-\mu_{k_{Bi}}^{*}p_{k_{Bi}}^{*}\right|^{\lambda}+\frac{1}{l_{\tilde{g}_i}}\sum_{t_{Ai},t_{Bi}=1}^{l_{\tilde{g}_i}}\left|\nu_{t_{Ai}}^{*}q_{t_{Ai}}^{*}-\nu_{t_{Bi}}^{*}q_{t_{Bi}}^{*}\right|^{\lambda}\right)\right)\right)^{\frac{1}{\lambda}}. \tag{6}$$

Theorem 2. *The distance measure* d *defined in Definition 2 and Definition 3 satisfies following properties:*

(1) $0 \leq d(A,B) \leq 1$;
(2) $d(A,B) = 0$ *if and only if* A *and* B *are perfectly consistent;*
(3) $d(A,B) = d(B,A)$.

4.3. Entropy Measure and Cross Entropy Measure for PDHF_UUBLS

Fuzzy entropy measure provides an effective way to indicate the uncertainty degree and fuzziness of a fuzzy set [124,125]. Various extended versions of fuzzy entropy measures have been successfully developed and play indispensable roles in establishing appropriate and effective uncertain decision making approaches, including [53,126–128], among others. Therefore, in order to facilitate construction of effective decision-making approaches with comprehensive evaluations in the form of PDHF_UUBLS, we further develop some entropy and cross-entropy measures for PDHF_UUBLS.

Definition 4. *Given* $A = \left\{ \langle x_i, \widetilde{s}_{\vartheta_A}(x_i), h_A(x_i)|p_A(x_i), g_A(x_i)|q_A(x_i) \rangle | x_i \in X \right\}$ *as a set in the form of PDHF_UUBLS, the fuzzy entropy measure of* A *can be defined as* $E^1(A)$*:*

$$\begin{aligned} E^1(A) = -\tfrac{1}{2\ln 2}\textstyle\sum_{i=1}^{n} \Big(& I_{Ai}^- \ln I_{Ai}^- + (1 - I_{Ai}^-)\ln(1 - I_{Ai}^-) + I_{Ai}^+ \ln I_{Ai}^+ + (1 - I_{Ai}^+)\ln(1 - I_{Ai}^+) \\ & + \textstyle\sum_{k_{Ai}=1}^{l_{h_{Ai}}} p_{k_{Ai}} (\mu_{k_{Ai}} \ln \mu_{k_{Ai}} + (1 - \mu_{k_{Ai}})\ln(1 - \mu_{k_{Ai}})) + \textstyle\sum_{t_{Ai}=1}^{l_{g_{Ai}}} q_{t_{Ai}} \left(\nu_{t_{Ai}} \ln \nu_{t_{Ai}} + (1 - \nu_{t_{Ai}})\ln(1 - \nu_{t_{Ai}}) \right) \Big) \end{aligned} \tag{7}$$

Regarding the above fuzzy entropy measure $E^1(A)$, we have the following fundamental observations as shown in following Theorem 3.

Theorem 3. *The entropy* $E^1(A)$ *on* A *satisfies the following basic requirements:*

(1) $0 \le E^1(A) \le 1$;

(2) $E^1(A) = 0$, *if and only if* $A = \left\{ \langle x_i, ([s_g, s_g], \{1|1\}, \{0|0\}) \rangle | x_i \in X \right\}$ *or* $A = \left\{ \langle x_i, ([s_g, s_g], \{0|0\}, \{1|1\}) \rangle | x_i \in X \right\}$;

(3) $E^1(A) = 1$, *if* $A = \left\{ \left\langle x_i, \left([s_{g/2}, s_{g/2}], \{1|1\}, \{0|0\} \right) \right\rangle | x_i \in X \right\}$;

(4) $E^1(A) \le E^1(B)$ *if* $I_{Ai}^+ \le I_{Bi}^+ \le 0.5$ *or* $I_{Ai}^- \ge I_{Bi}^- \ge 0.5$, *and* $h_A(x_i)|p_A(x_i) = h_B(x_i)|p_B(x_i)$, $g_A(x_i)|q_A(x_i) = g_B(x_i)|q_B(x_i)$, $l_{h_{Ai}} = l_{h_{Bi}}$;

(5) $E^1(A) = E^1(A^c)$, *where* $A^c = \left\{ \langle x_i, 1 - \widetilde{s}_{\vartheta_A}(x_i), g_A(x_i)|q_A(x_i), h_A(x_i)|p_A(x_i) \rangle | x_i \in X \right\}$.

Further, by use of the distance measures of PDHF_UUBLS, we also can propose another novel entropy measure $E^2(A)$ for PDHF_UUBLS in the following Definition 5.

Definition 5. *Given* $A = \left\{ \langle x_i, \widetilde{s}_{\vartheta_A}(x_i), h_A(x_i)|p_A(x_i), g_A(x_i)|q_A(x_i) \rangle | x_i \in X \right\}$ *as a set in the form of PDHF_UUBLS, and let* $A^F = \left\{ \left\langle x_i, \left([s_{g/2}, s_{g/2}], \{1|1\}, \{0|0\} \right) \right\rangle | x_i \in X \right\}$ *denote the corresponding fuzziest PDHF_UUBLS, then based on the distance measures of PDHF_UUBLS, we can define entropy measure* $E^2(A)$ *for PDHF_UUBLS as*

$$E^2(A) = 1 - d(A, A^F), \tag{8}$$

where $d(A, A^F)$ *can be calculated by use of a distance measure selected from* ***Definition 2****.*

Regarding the above fuzzy entropy measure $E^2(A)$, we all also can prove it satisfies the basic requirements listed in Theorem 3, thus omitted here for brevity.

Furthermore, in order to measure information difference between two PDHF_UUBLSs, we here also put forward a cross-entropy measure for our PDHF_UUBLSs, as described in the following Definition 6.

Definition 6. *Let* A *and* B *be any two PDHF_UUBLSs,* A^* *and* B^* *are the extended forms of* A *and* B *transformed by LCM-based extension mechanism introduced in Section 4.1, then cross entropy measure* $CE(A, B)$ *between* A *and* B *can be defined as:*

$$
\begin{aligned}
&\mathrm{CE}(\mathrm{A},\mathrm{B}) = \mathrm{CE}(\mathrm{A}^*,\mathrm{B}^*) \\
&= \frac{1}{\mathrm{T}}\sum_{i=1}^{\mathrm{T}}\Bigg(\Bigg(\frac{(1+q(\mathrm{I}_{\mathrm{A}i}^-))\ln(1+q(\mathrm{I}_{\mathrm{A}i}^-))+(1+q(\mathrm{I}_{\mathrm{B}i}^-))\ln(1+q(\mathrm{I}_{\mathrm{B}i}^-))}{2} - \frac{2+q(\mathrm{I}_{\mathrm{A}i}^-)+q(\mathrm{I}_{\mathrm{B}i}^-)}{2}\ln\frac{2+q(\mathrm{I}_{\mathrm{A}i}^-)+q(\mathrm{I}_{\mathrm{B}i}^-)}{2}\Bigg)+ \\
&\Bigg(\frac{(1+q(\mathrm{I}_{\mathrm{A}i}^+))\ln(1+q(\mathrm{I}_{\mathrm{A}i}^+))+(1+q(\mathrm{I}_{\mathrm{B}i}^+))\ln(1+q(\mathrm{I}_{\mathrm{B}i}^+))}{2} - \frac{2+q(\mathrm{I}_{\mathrm{A}i}^+)+q(\mathrm{I}_{\mathrm{B}i}^+)}{2}\ln\frac{2+q(\mathrm{I}_{\mathrm{A}i}^+)+q(\mathrm{I}_{\mathrm{B}i}^+)}{2}\Bigg) \\
&+\frac{1}{l_{h_i}}\sum_{k_A=1,k_B=1}^{l_{h_i}}\Bigg(\frac{(1+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}}))\ln(1+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}}))+(1+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}}))\ln(1+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}}))}{2} \\
&-\frac{2+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}})+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}})}{2}\ln\frac{2+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}})+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}})}{2}\Bigg)+ \\
&\frac{1}{l_{g_i}}\sum_{t_A=1,t_B=1}^{l_{g_i}}\Bigg(\frac{(1+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}}))\ln(1+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}}))+(1+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}}))\ln(1+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}}))}{2} \\
&-\frac{2+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}})+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}})}{2}\ln\frac{2+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}})+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}})}{2}\Bigg)\Bigg).
\end{aligned}
\tag{9}
$$

The above cross-entropy measure $\mathrm{CE}(\mathrm{A},\mathrm{B})$ holds the fundamental conditions shown in the following Theorem 4.

Theorem 4. *The cross entropy* $\mathrm{CE}(\mathrm{A},\mathrm{B})$ *satisfies the following conditions:*
(1) $\mathrm{CE}(\mathrm{A},\mathrm{B}) \geq 0$*; (2)* $\mathrm{CE}(\mathrm{A},\mathrm{B}) = 0$ *when* $\widetilde{s}_{\vartheta_A}(x_i) = \widetilde{s}_{\vartheta_B}(x_i)$, $h_A(x_i) = h_B(x_i)$, $p_A(x_i) = p_B(x_i)$, $g_A(x_i) = g_B(x_i)$ *and* $q_A(x_i) = q_B(x_i)$.

Proof of Theorem 4. (1) According to Shannon's inequality, we have

$$
\begin{aligned}
&-\mathrm{CE}(\mathrm{A},\mathrm{B}) \\
&= \frac{1}{\mathrm{T}}\sum_{i=1}^{\mathrm{T}}\Bigg(\Bigg(\frac{(1+q(\mathrm{I}_{\mathrm{A}i}^-))\ln\frac{1}{(1+q(\mathrm{I}_{\mathrm{A}i}^-))}+(1+q(\mathrm{I}_{\mathrm{B}i}^-))\ln\frac{1}{(1+q(\mathrm{I}_{\mathrm{B}i}^-))}}{2} - \frac{2+q(\mathrm{I}_{\mathrm{A}i}^-)+q(\mathrm{I}_{\mathrm{B}i}^-)}{2}\ln\frac{2}{2+q(\mathrm{I}_{\mathrm{A}i}^-)+q(\mathrm{I}_{\mathrm{B}i}^-)}\Bigg) \\
&+\Bigg(\frac{(1+q(\mathrm{I}_{\mathrm{A}i}^+))\ln\frac{1}{(1+q(\mathrm{I}_{\mathrm{A}i}^+))}+(1+q(\mathrm{I}_{\mathrm{B}i}^+))\ln\frac{1}{(1+q(\mathrm{I}_{\mathrm{B}i}^+))}}{2} - \frac{2+q(\mathrm{I}_{\mathrm{A}i}^+)+q(\mathrm{I}_{\mathrm{B}i}^+)}{2}\ln\frac{2}{2+q(\mathrm{I}_{\mathrm{A}i}^+)+q(\mathrm{I}_{\mathrm{B}i}^+)}\Bigg) \\
&+\frac{1}{l_{h_i}}\sum_{k_A=1,k_B=1}^{l_{h_i}}\Bigg(\frac{(1+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}}))\ln\frac{1}{(1+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}}))}+(1+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}}))\ln\frac{1}{(1+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}}))}}{2} \\
&-\frac{2+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}})+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}})}{2}\ln\frac{2}{2+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}})+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}})}\Bigg)+ \\
&\frac{1}{l_{g_i}}\sum_{t_A=1,t_B=1}^{l_{g_i}}\Bigg(\frac{(1+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}}))\ln\frac{1}{(1+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}}))}+(1+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}}))\ln\frac{1}{(1+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}}))}}{2} \\
&-\frac{2+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}})+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}})}{2}\ln\frac{2}{2+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}})+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}})}\Bigg)\Bigg) \leq \\
&\frac{1}{\mathrm{T}}\sum_{i=1}^{\mathrm{T}}\Bigg(\Bigg(\frac{\ln\frac{(1+q(\mathrm{I}_{\mathrm{A}i}^-))}{(1+q(\mathrm{I}_{\mathrm{A}i}^-))}+\ln\frac{(1+q(\mathrm{I}_{\mathrm{B}i}^-))}{(1+q(\mathrm{I}_{\mathrm{B}i}^-))}}{2} - \ln\frac{2+q(\mathrm{I}_{\mathrm{A}i}^-)+q(\mathrm{I}_{\mathrm{B}i}^-)}{2}\frac{2}{2+q(\mathrm{I}_{\mathrm{A}i}^-)+q(\mathrm{I}_{\mathrm{B}i}^-)}\Bigg) \\
&+\Bigg(\frac{\ln\frac{(1+q(\mathrm{I}_{\mathrm{A}i}^+))}{(1+q(\mathrm{I}_{\mathrm{A}i}^+))}+\ln\frac{(1+q(\mathrm{I}_{\mathrm{B}i}^+))}{(1+q(\mathrm{I}_{\mathrm{B}i}^+))}}{2} - \ln\frac{2+q(\mathrm{I}_{\mathrm{A}i}^+)+q(\mathrm{I}_{\mathrm{B}i}^+)}{2}\frac{2}{2+q(\mathrm{I}_{\mathrm{A}i}^+)+q(\mathrm{I}_{\mathrm{B}i}^+)}\Bigg) \\
&+\frac{1}{l_{h_i}}\sum_{k_A=1,k_B=1}^{l_{h_i}}\Bigg(\frac{\ln\frac{(1+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}}))}{(1+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}}))}+\ln\frac{(1+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}}))}{(1+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}}))}}{2} - \ln\frac{2+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}})+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}})}{2}\frac{2}{2+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}})+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}})}\Bigg)+
\end{aligned}
$$

$$\frac{1}{l_{g_i}}\sum_{t_A=1,t_B=1}^{l_{g_i}}\left(\frac{\ln\frac{(1+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}}))}{(1+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}}))}+\ln\frac{(1+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}}))}{(1+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}}))}}{2}-\ln\frac{2+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}})+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}})}{2}\frac{2}{2+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}})+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}})}\right)\Bigg)\Bigg)$$

$$=\frac{1}{T}\sum_{i=1}^{T}\left(\left(\frac{\ln 1+\ln 1}{2}-\ln 1\right)+\left(\frac{\ln 1+\ln 1}{2}-\ln 1\right)+\frac{1}{l_{h_i}}\sum_{k_A=1,k_B=1}^{l_{h_i}}\left(\frac{\ln 1+\ln 1}{2}-\ln 1\right)+\frac{1}{l_{g_i}}\sum_{t_A=1,t_B=1}^{l_{g_i}}\left(\frac{\ln 1+\ln 1}{2}-\ln 1\right)\right)=0$$

Then, we can obtain $CE(A,B)\geq 0$.
(2) The proofs are relatively simple, thus omitted here for brevity.□

5. Multiple Attributes Group Decision-Making Approach under PDHF_UUBLS Environment

In this section, we focus on construction of effective approach for MAGDM with decision information in the form of PDHF_UUBLS. Let $Ex=\{Ex^1,Ex^2,\ldots,Ex^o\}$ denote a set of decision makers, $A=\{A_1,A_2,\ldots,A_m\}$ represent a set of alternatives under evaluation, $C=\{C_1,C_2,\ldots,C_n\}$ stand for a set of attributes based on which decision makers will comprehensively consider each alternative. We here use $w=\{w_1,w_2,\ldots,w_n\}$ to denote the weighting vector for C and $\eta=\{\eta^1,\eta^2,\ldots,\eta^o\}$ to denote the weighting vector for Ex. w holds the conditions of $w_i\geq 0,\sum_{i=1}^{n}w_i=1$ and η holds the conditions of $\eta_j\geq 0,\sum_{j=1}^{o}\eta^j=1$. Then, we use $R^\kappa=\left(r_{ij}^\kappa\right)_{n\times m}$ to represent the individual decision matrix provided by decision maker Ex^κ with his/her assessments regarding alternatives $A_j(j=1\ldots m)$ under all attributes $C_i(i=1\ldots n)$ in the form of PDHF_UUBLS, where $r_{ij}^\kappa=\left(\tilde{s}_{ij}^\kappa,h_{ij}^\kappa\middle|p_{ij}^\kappa,g_{ij}^\kappa\middle|q_{ij}^\kappa\right)$ and $\tilde{s}_{ij}^\kappa=[s^\kappa_{\alpha_{ij}},s^\kappa_{\beta_{ij}}]$, $h_{ij}^\kappa=\cup\{\mu_{ij}^\kappa\}$, $g_{ij}^\kappa=\cup\{\nu_{ij}^\kappa\}$. It is important to be pointed out that with a high degree of complexity in certain comprehensive evaluation problems both w and η usually cannot be obtained in advance, that is, both are unknown. Therefore, in the following, we firstly devise programming models to rationally obtain unknown weighting vectors, and then construct an effective MAGDM approach based on formerly discussed methods.

5.1. Programming Model for Obtaining Attributes' Weighting Vector

Suppose that all assessments in the form of PDHF_UUBLS by κth decision maker or decision unit have been collected in the decision matrix of $R^\kappa=\left(r_{ij}^\kappa\right)_{n\times m}$. In addition, based on former knowledge and experience, the κth decision maker or decision will generally have minimum acceptable values and maximal expectation values for each attribute, thereby deriving corresponding positive ideal target $A^{\kappa+}$ and negative ideal target $A^{\kappa-}$:

$$\begin{aligned}A^{\kappa+}&=\{r_1^{\kappa+},\ldots,r_i^{\kappa+},\ldots,r_n^{\kappa+}\}\\&=\{(\tilde{s}_1^{\kappa+},h_1^{\kappa+}|p_1^{\kappa+},g_1^{\kappa+}|q_1^{\kappa+}),\ldots,(\tilde{s}_i^{\kappa+},h_i^{\kappa+}|p_i^{\kappa+},g_i^{\kappa+}|q_i^{\kappa+}),\ldots,(\tilde{s}_n^{\kappa+},h_n^{\kappa+}|p_n^{\kappa+},g_n^{\kappa+}|q_n^{\kappa+})\}\\A^{\kappa-}&=\{r_1^{\kappa-},\ldots,r_i^{\kappa-},\ldots,r_n^{\kappa-}\}\\&=\{(\tilde{s}_1^{\kappa-},h_1^{\kappa-}|p_1^{\kappa-},g_1^{\kappa-}|q_1^{\kappa-}),\ldots,(\tilde{s}_i^{\kappa-},h_i^{\kappa-}|p_i^{\kappa-},g_i^{\kappa-}|q_i^{\kappa-}),\ldots,(\tilde{s}_n^{\kappa-},h_n^{\kappa-}|p_n^{\kappa-},g_n^{\kappa-}|q_n^{\kappa-})\}\end{aligned}$$

Now, in alignment with the seminal principles from widely-used TOPSIS method [129–131], we can obtain distance ratio Ind_{ij}^κ between κth decision matrix $R^\kappa=\left(r_{ij}^\kappa\right)_{n\times m}$ and the above ideal targets according to

$$Ind_{ij}^\kappa=\frac{d(r_{ij}^\kappa,r_i^{\kappa-})}{d(r_{ij}^\kappa,r_i^{\kappa+})},\tag{10}$$

where $d(r_{ij}^{\kappa}, r_i^{\kappa-})$ and $d(r_{ij}^{\kappa}, r_i^{\kappa+})$ are distance measures introduced in Definition 2. Additionally, the optimal weighting vector w^{κ} should maximize the total amount of all weighted Ind_{ij}^{κ}, and a programming model (M-1) can thus be constructed to obtain optimal weighting vector according to each decision matrix as follows,

$$(M-1):\begin{cases} \max F(w^{\kappa}) = \sum\limits_{i=1}^{n}\sum\limits_{j=1}^{m} Ind_{ij}^{\kappa} w_i^{\kappa} \\ s.t. \sum_{i=1}^{n} (w_i^{\kappa})^2 = 1, w_i^{\kappa} \geq 0, i = 1,2,\ldots,n, \kappa = 1,2,\ldots,o \end{cases}.$$

Regarding the solution to above model (M-1), we have the following Theorem 5.

Theorem 5. *The optimal solution to model (M-1) is*

$$w_i^{\kappa} = \frac{\sum_{j=1}^{m} Ind_{ij}^{\kappa}}{\sum_{i=1}^{n}\sum_{j=1}^{m} Ind_{ij}^{\kappa}} (j = 1,2,\ldots,m; i = 1,2,\ldots,n; \kappa = 1,2,\ldots,o). \tag{11}$$

Proof of Theorem 5. To solve the programming model (M-1), we here can apply the Lagrange Multiplier Method to derive its optimal solution.

Firstly, the following Lagrange function is constructed as following

$$L(w_i^{\kappa}, \zeta) = \sum_{i=1}^{n}\sum_{j=1}^{m} Ind_{ij}^{\kappa} w_i^{\kappa} + \frac{\zeta}{2}\left(\sum_{i=1}^{n} (w_i^{\kappa})^2 - 1\right). \tag{12}$$

where ζ is the Lagrange multiplier. Take the first-order derivative on w_i^{κ} and ζ, then set these partial derivatives equal to zero, we have

$$\begin{cases} \frac{\partial L}{\partial w_i^{\kappa}} = \sum_{i=1}^{n}\sum_{j=1}^{m} Ind_{ij}^{\kappa} + \zeta w_i^{\kappa} = 0 \\ \frac{\partial L}{\partial \zeta} = \sum_{i=1}^{n} (w_i^{\kappa})^2 - 1 = 0 \end{cases}.$$

By solving the above equations, we obtain a simple and exact formula for calculating the attribute's weight:

$$w_i^{\kappa *} = \frac{\sum_{j=1}^{m} Ind_{ij}^{\kappa}}{\sqrt{\sum_{i=1}^{n}\left(\sum_{j=1}^{m} Ind_{ij}^{\kappa}\right)^2}}. \tag{13}$$

Then, through normalization, we attain the optimal solution as shown in Equation (11).□

5.2. A Hybrid Method for Deriving Decision Makers' Unknown Weighting Vector

Due to the common difficulties in reasonably assigning subjective weights to decision makers or decision units, domain studies have been advocating appropriate models to objectively determine decision makers' unknown weighting vector, especially under uncertain decision settings [53,66,132]. The entropy measures and cross entropy measures defined in Section 4 for PDHF_UUBLS provide two fundamental ways to deduce relative importance among decision makers [53]: (1) Entropy measure for PDHF_UUBLS is capable of indicating overall fuzziness degree of each decision maker's decision matrix. Decision maker with less fuzziness degree of his/her decision matrix should be allocated with bigger weight. (2) Cross entropy measure for PDHF_UUBLS is capable of indicating the information divergence between any two PDHF_UUBLS decision matrices. According to the widely adopted deviation maximizing methodology, the smaller the divergence between a specific decision maker's decision matrix and those matrices by others, the closer the overall opinion of the decision maker to the collective one, a larger weight thus should be given to him/her.

Therefore, we here first apply the entropy measure $E(A)$ defined in Section 4.3 to indicate fuzziness degree of each decision matrix R^{κ}. Then, we can obtain entropy-based weighting vector $\widetilde{\eta}^{\kappa}(\kappa = 1, 2, \ldots, o)$ for decision makers by utilizing the following formula:

$$\widetilde{\eta}^{\kappa} = \frac{\sum_{j=1}^{m}\sum_{i=1}^{n}\left(1 - E(r_{ij}^{\kappa})\right)}{\sum_{\kappa=1}^{o}\sum_{j=1}^{m}\sum_{i=1}^{n}\left(1 - E(r_{ij}^{\kappa})\right)}. \tag{14}$$

Secondly, we take the cross-entropy measure $CE(R^{\kappa}, R^{\gamma})$ in Section 4.3 to compute overall divergence degree between decision matrix R^{κ} (given by the κth decision maker) and matrices R^{γ} (given by the other decision makers, i.e., $\gamma = 1 \ldots o, \gamma \neq \kappa$). Then, we put forward another method to derive the cross entropy-based weighting vector $\overline{\eta}^{\kappa}(\kappa = 1, 2, \ldots, o)$ for decision makers, that is, the following programming model (M-2):

$$(M-2): \begin{cases} \max F(\overline{\eta}^{\kappa}) = \sum\limits_{\kappa=1}^{o} \frac{1}{o}\left(\sum\limits_{\gamma=1,\gamma\neq\kappa}^{o} (1 - CE(R^{\kappa}, R^{\gamma}))\overline{\eta}^{\kappa}\right) \\ s.t. \sum_{\kappa=1}^{o} (\overline{\eta}^{\kappa})^2 = 1, \overline{\eta}^{\kappa} \geq 0, \kappa = 1, 2, \ldots, o \end{cases},$$

where $CE(R^{\kappa}, R^{\gamma}) = \frac{1}{mn}\sum_{j=1}^{m}\sum_{i=1}^{n} CE(r_{ij}^{\kappa}, r_{ij}^{\gamma})$, $CE(r_{ij}^{\kappa}, r_{ij}^{\gamma})$ are calculated by Equation (9).

Regarding the model (M-2), we have following Theorem 6.

Theorem 6. *The optimal solution to (M-2) is:*

$$\overline{\eta}^{\kappa} = \frac{\sum_{\gamma=1,\gamma\neq\kappa}^{o}\left(1 - \frac{1}{mn}\sum_{j=1}^{m}\sum_{i=1}^{n} CE(r_{ij}^{\kappa}, r_{ij}^{\gamma})\right)}{\sum_{\kappa=1}^{o}\sum_{\gamma=1,\gamma\neq\kappa}^{o}\left(1 - \frac{1}{mn}\sum_{j=1}^{m}\sum_{i=1}^{n} CE(r_{ij}^{\kappa}, r_{ij}^{\gamma})\right)}. \tag{15}$$

Proof of Theorem 6. To solve the model (M-2), we firstly construct the Lagrange function as follows:

$$L(\overline{\lambda}^{\kappa}, \varsigma) = \sum_{\kappa=1}^{o} \frac{1}{t}\left(\sum_{\gamma=1,\gamma\neq\kappa}^{o}\left(1 - \frac{1}{mn}\sum_{j=1}^{m}\sum_{i=1}^{n} CE(r_{ij}^{\kappa}, r_{ij}^{\gamma})\right)\right)\overline{\lambda}^{\kappa} + \frac{1}{2}\varsigma\sum_{\kappa=1}^{o}\left((\overline{\lambda}^{\kappa})^2 - 1\right). \tag{16}$$

By deriving differentiation on Equation (16) with respect to $\widetilde{\eta}^{\kappa}(\kappa = 1, 2, \ldots, o)$ and ς, then setting these partial derivatives equal to zero, the following set of equations is obtained:

$$\begin{cases} \frac{\partial L}{\partial \overline{\eta}^{\kappa}} = \frac{1}{t}\left(\sum_{\gamma=1,\gamma\neq\kappa}^{o}\left(1 - \frac{1}{mn}\sum_{j=1}^{m}\sum_{i=1}^{n} CE(r_{ij}^{\kappa}, r_{ij}^{\gamma})\right)\right) + \varsigma\sum_{\kappa=1}^{o}\overline{\lambda}^{\kappa} = 0 \\ \frac{\partial L}{\partial \varsigma} = \sum_{\kappa=1}^{o}\left((\overline{\lambda}^{\kappa})^2 - 1\right) = 0 \end{cases}. \tag{17}$$

By solving Equation (17), we can get a simple and exact formula for determining the weighting vector for decision makers, as follows:

$$\overline{\lambda}^{\kappa} = \frac{\frac{1}{t}\left(\sum_{\gamma=1,\gamma\neq\kappa}^{o}\left(1 - \frac{1}{mn}\sum_{j=1}^{m}\sum_{i=1}^{n} CE(r_{ij}^{\kappa}, r_{ij}^{\gamma})\right)\right)}{\sqrt{\sum_{\kappa=1}^{o}\left(\frac{1}{t}\left(\sum_{\gamma=1,\gamma\neq\kappa}^{o}\left(1 - \frac{1}{mn}\sum_{j=1}^{m}\sum_{i=1}^{n} CE(r_{ij}^{\kappa}, r_{ij}^{\gamma})\right)\right)\right)^2}}. \tag{18}$$

Then, through normalization, we have the optimal solution shown in Equation (15).□

Now, to simultaneously consider the two objective weighting vectors obtained in Equations (14) and (15), the following hybrid model is generally adopted:

$$\eta^{\kappa} = \alpha\widetilde{\eta}^{\kappa} + \beta\overline{\eta}^{\kappa}(\kappa = 1, 2, \ldots, o), \tag{19}$$

where α and $\beta, 0 \leq \alpha,\ \beta \leq 1,\ \alpha + \beta = 1$, are attitudinal parameters and their configurations are subject to decision organizations. Literatures normally suggest $\alpha = \beta = 0.5$ [53].

5.3. MAGDM Approach under PDHF_UUBLS Environment

Based on the strength of above-developed methods, we now can construct the following **Approach 1** for MAGDM under PDHF_UUBLS environment with unknown weighting vectors for both evaluative attributes and decision makers.

Approach 1. *MAGDM under PDHF_UUBLS environment with unknown weighting vectors for both attributes and decision makers*

Step 1. Invite all decision makers to elaborate their positive ideal alternatives $A^{\kappa+}(\kappa = 1, 2, \ldots, o)$ and negative ideal alternatives $A^{\kappa-}$ $(\kappa = 1, 2, \ldots, o)$, which are denoted in the form of

$$\begin{aligned} A^{\kappa+} &= \{r_1^{\kappa+}, \ldots, r_i^{\kappa+}, \ldots, r_n^{\kappa+}\} \\ &= \{(\tilde{s}_1^{\kappa+}, h_1^{\kappa+}|p_1^{\kappa+}, g_1^{\kappa+}|q_1^{\kappa+}), \ldots, (\tilde{s}_i^{\kappa+}, h_i^{\kappa+}|p_i^{\kappa+}, g_i^{\kappa+}|q_i^{\kappa+}), \ldots, (\tilde{s}_n^{\kappa+}, h_n^{\kappa+}|p_n^{\kappa+}, g_n^{\kappa+}|q_n^{\kappa+})\} \end{aligned}$$

and

$$\begin{aligned} A^{\kappa-} &= \{r_1^{\kappa-}, \ldots, r_i^{\kappa-}, \ldots, r_n^{\kappa-}\} \\ &= \{(\tilde{s}_1^{\kappa-}, h_1^{\kappa-}|p_1^{\kappa-}, g_1^{\kappa-}|q_1^{\kappa-}), \ldots, (\tilde{s}_i^{\kappa-}, h_i^{\kappa-}|p_i^{\kappa-}, g_i^{\kappa-}|q_i^{\kappa-}), \ldots, (\tilde{s}_n^{\kappa-}, h_n^{\kappa-}|p_n^{\kappa-}, g_n^{\kappa-}|q_n^{\kappa-})\} \end{aligned}$$

Step 2. Objectively calculate the weighting vector of $w^\kappa = (w_1^\kappa, w_2^\kappa, \ldots, w_n^\kappa)$ $(\kappa = 1, 2, \ldots, o)$ for evaluative attributes based on each decision matrix according to programming model (M-1);

Step 3. Objectively compute the weighting vector of $\eta^\kappa(\kappa = 1, 2, \ldots, o)$ for decision makers according to Equation(19);

Step 4. Obtain κth decision-maker's comprehensive decision results on each alternatives under evaluation. By utilizing the weighting vectors $w^\kappa = (w_1^\kappa, w_2^\kappa, \ldots, w_n^\kappa)$ $(\kappa = 1, 2, \ldots, o)$ obtained in **Step 2** and the following **PDHFUUBLWA** operator, we can aggregate r_{ij}^κ to get the κth decision-maker's decision results r_j^κ on the alternative A_j, where

$$\begin{aligned} r_j^\kappa &= \left(\tilde{s}_j^\kappa, h_j^\kappa \middle| p_j^\kappa, g_j^\kappa \middle| q_j^\kappa\right) = \mathrm{PDHFUUBLWA}(r_{1j}^\kappa, r_{2j}^\kappa, \ldots, r_{nj}^\kappa) = \bigoplus_{i=1}^{n}\left(w_i^\kappa r_{ij}^\kappa\right) \\ &\cup_{(\tilde{s}_{ij}^\kappa, h_{ij}^\kappa|p_{ij}^\kappa, g_{ij}^\kappa|q_{ij}^\kappa) \in r_{ij}^\kappa} \left(\left[s_{\sum_{i=1}^n w_i^\kappa \Delta_{t_0}^{-1}(TF_{t_0}^{t_{ij}}(\psi(s_{\alpha_{ij}}^\kappa)))}, s_{\sum_{i=1}^n w_i^\kappa \Delta_{t_0}^{-1}(TF_{t_0}^{t_{ij}}(\psi(s_{\beta_{ij}}^\kappa)))} \right], \right. \\ &\left. \left\{ 1 - \prod_{i=1}^n \left(1 - \mu_{ij}^\kappa\right)^{w_i^\kappa} \middle| \prod_{i=1}^n \frac{p_{ijl_{ij\kappa}}^\kappa}{\sum_{l_{ij\kappa}=1}^{L_{ij\kappa}} p_{ijl_{ij\kappa}}^\kappa} \right\}, \left\{ \prod_{i=1}^n \left(\nu_{ij}^\kappa\right)^{w_i^\kappa} \middle| \prod_{i=1}^n \frac{q_{ijl_{ij\kappa}}^\kappa}{\sum_{l_{ij\kappa}=1}^{L_{ij\kappa}} q_{ijl_{ij\kappa}}^\kappa} \right\} \right). \end{aligned}$$

The above **PDHFUUBLWA** operator is the extended version of conventional weighted arithmetic aggregator [66] to decision making under our PDHF_UUBLS environment. For more details about aggregation operators, one can refer to [133–135].

Step 5. Obtain collective results of all alternatives by applying decision makers' weighting vector. Giving the decision makers' weighting vector $\eta = \{\eta^1, \eta^2, \ldots, \eta^o\}$, which has been determined in **Step 3**, we now can aggregate all the individual overall decision results r_j^κ $(\kappa = 1,2,\ldots,o)$ from **Step 4** into the overall group decision results r_j $(j = 1,2,\ldots,m)$ by use of the same **PDHFUUBLWA** operator as used in **Step 4**, where

$$r_j = \left(\widetilde{s}_j, h_j \middle| p_j, g_j \middle| q_j\right) = \mathrm{PDHFUUBLWA}(r_j^1, r_j^2, \ldots, r_j^\kappa) = \mathop{\oplus}_{\kappa=1}^{o}\left(\eta^\kappa r_j^\kappa\right)$$
$$\cup_{(\widetilde{s}_j^\kappa, h_j^\kappa | p_j^\kappa, g_j^\kappa | q_j^\kappa) \in r_j^\kappa}\left(\left[s_{\sum_{\kappa=1}^{o}\eta^\kappa \Delta_{t_0}^{-1}(TF_{t_0}^{t_j}(\psi(s_{\alpha_j}^\kappa)))}, s_{\sum_{\kappa=1}^{o}\eta^\kappa \Delta_{t_0}^{-1}(TF_{t_0}^{t_j}(\psi(s_{\beta_j}^\kappa)))}\right],\right.$$
$$\left.\left\{1 - \prod_{\kappa=1}^{o}\left(1 - \mu_j^\kappa\right)^{\eta^\kappa} \middle| \prod_{\kappa=1}^{o} \frac{p_{jl_{j\kappa}}^\kappa}{\sum_{l_{j\kappa}=1}^{L_{j\kappa}} p_{jl_{j\kappa}}^\kappa}\right\}, \left\{\prod_{\kappa=1}^{o}\left(\nu_{ij}^\kappa\right)^{\eta^\kappa} \middle| \prod_{\kappa=1}^{o} \frac{q_{jl_{j\kappa}}^\kappa}{\sum_{l_{j\kappa}=1}^{L_{j\kappa}} q_{jl_{j\kappa}}^\kappa}\right\}\right).$$

Step 6. According to Equations (1) and (2), calculate $E(r_j)$ and $\sigma(r_j)$ of the group overall assessments r_j $(j = 1,2,\ldots,m)$ to determine the final ranking order of all the alternatives A_j $(j = 1,2,\ldots,m)$.

For more clarity, the processing steps of the **Approach 1** have been demonstrated in following Figure 3.

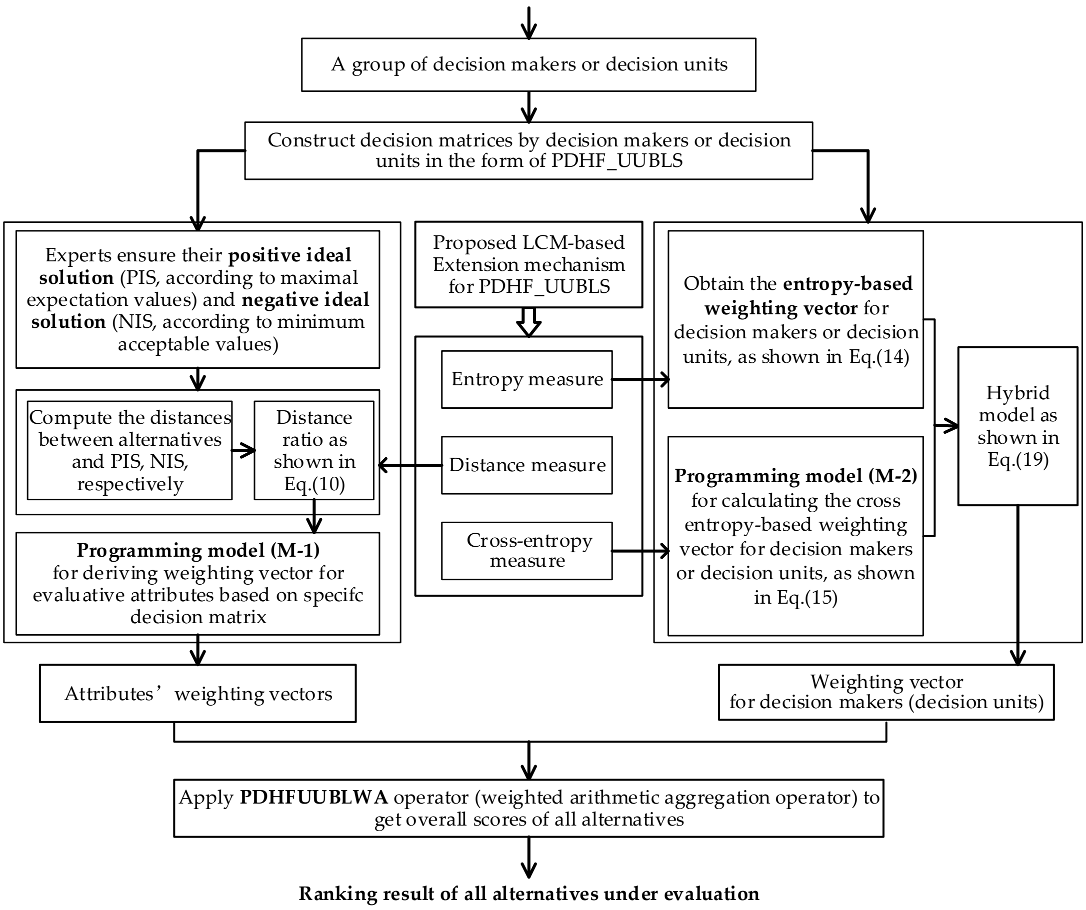

Figure 3. Flowchart of Approach 1 for MAGDM under PDHF_UUBLS environment.

6. Illustrative Example

With regard to the formalized task of comprehensive evaluation of tourism community resilience (as shown in Figure 1), in this section, the Approach 1 constructed in Section 5.3 has been applied to illustrate its effectiveness. Due to the complexity and ill-structured property of the special type problem as shown in Figure 1, the local NGO (or local government) has invited three groups of domain experts as three decision units, Ex^κ $(\kappa = 1,2,3)$, to partake the task in order to attain authoritativeness and authenticity. There are totally four

CBT destinations, $A = \{A_1, A_2, A_3, A_4\}$, under its administration of the NGO (or local government). According to Table 1, the derived six attributes, $C = \{C_1, C_2, C_3, C_4, C_5, C_6\}$, are adopted to evaluate the status quo of tourism community resilience in the four destinations.

The three decision units $Ex^{\kappa}(\kappa = 1, 2, 3)$ have been empowered with the expression tool of our proposed PDHF_UUBLS in elicitation of their collective complicate assessments. It should be noted that all three decision units have the right to choose proper unbalanced linguistic scales, that is, different unbalanced linguistic term sets (ULTSs) [69], according to their preferences. Suppose that decision unit Ex^2 preferred the ULTS of S_1 = {N,AN,VL,QL,L,M, H,QH,VH,AT,T}, while decision unit Ex^1 and decision unit Ex^3 adopted the ULTS of S_2 = {N,VL,L,AL,AM,M,QM,AH,H,VH,T}. The relationship between ULTSs of S_1 and S_2 in the form of linguistic hierarchy is shown in Figure 4. Similar to Section 3, more details about transformation function and operational laws for various unbalanced linguistic term sets in a linguistic hierarchy can be referred to [69] and [66]. Then assessments of three decision units were collected in three decision matrices of $R^{\kappa} = \left(r_{ij}^{\kappa}\right)_{6\times 4}$ $(\kappa = 1, 2, 3)$ in the form of PDHF_UUBLS, as shown in Tables 2–4.

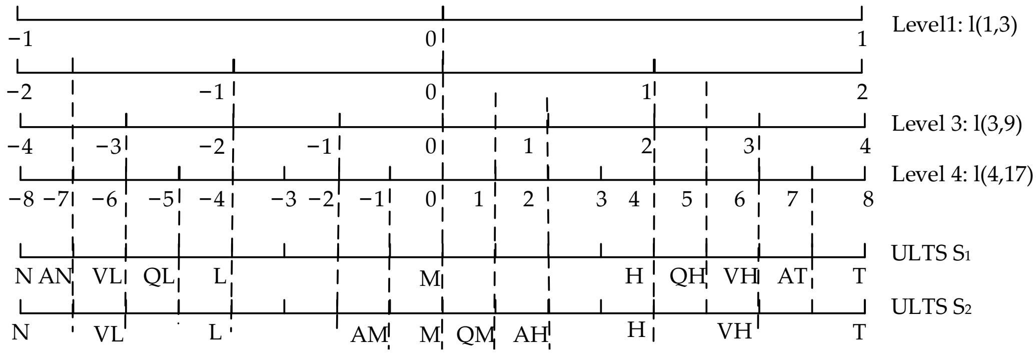

Figure 4. ULTSs of S_1, S_2 and their mapping relations in linguistic hierarchy.

Table 2. Decision matrix R^1 provided by decision unit Ex^1.

Ex^1	A_1	A_2	A_3	A_4
C_1	([QM,H], {0.5 | 0.9}, {0.4 | 0.6, 0.5 | 0.4})	([AH,VH], {0.5 | 0.4,0.6 | 0.6}, {0.4 | 1})	([AM,H], {0.7 | 0.8, 0.8 | 0.2}, {0.2 | 1})	([H,T], {0.6 | 0.2,0.7 | 0.8}, {0.1 | 0.7,0.3 | 0.3})
C_2	([AH,VH], {0.5 | 0.3,0.6 | 0.7}, {0.3 | 0.8})	([VH,T], {0.6 | 1}, {0.2 | 0.5,0.4 | 0.5})	([AH,H], {0.8 | 0.4,0.9 | 0.6}, {0.1 | 0.9})	([VH,T], {0.7 | 1}, {0.1 | 0.6,0.2 | 0.4})
C_3	([H,VH], {0.2 | 0.5,0.4 | 0.4}, {0.4 | 0.5,0.6 | 0.5})	([VL,AL], {0.5 | 0.8,0.7 | 0.2}, {0.3 | 0.9})	([AH,T], {0.7 | 0.9,0.8 | 0.1}, {0.2 | 1})	([H,VH], {0.4 | 0.2,0.6 | 0.7}, {0.3 | 0.6,0.4 | 0.4})
C_4	([AM,QM], {0.7 | 1}, {0.1 | 0.3,0.3 | 0.6})	([H,VH], {0.3 | 0.7,0.4 | 0.2}, {0.6 | 0.9})	([QM,AH], {0.4 | 0.5,0.7 | 0.5}, {0.2 | 0.5,0.3 | 0.5})	([QM,H], {0.6 | 0.1,0.8 | 0.9}, {0.1 | 0.5,0.2 | 0.5})
C_5	([L,AL], {0.5 | 0.5,0.6 | 0.5}, {0.3 | 0.7})	([QM,AH], {0.3 | 0.6,0.5 | 0.3}, {0.1 | 0.4,0.3 | 0.6})	([VH,T], {0.6 | 1}, {0.2 | 0.1,0.3 | 0.7,0.4 | 0.2})	([QM,VH], {0.4 | 0.9}, {0.4 | 0.8,0.6 | 0.2})
C_6	([M,H], {0.9 | 1}, {0.1 | 1})	([M,AH], {0.4 | 1}, {0.5 | 0.5,0.6 | 0.5})	([H,VH], {0.5 | 0.7,0.6 | 0.3}, {0.3 | 0.8,0.4 | 0.1})	([VH,T], {0.6 | 0.3,0.7 | 0.2,0.8 | 0.5}, {0.2 | 1})

Table 3. Decision matrix R^2 provided by decision unit Ex^2.

Ex^2	A_1	A_2	A_3	A_4
C_1	([H,QH], {0.4 ǀ 0.7}, {0.5 ǀ 0.8})	([QH,T], {0.2 ǀ 0.6,0.3 ǀ 0.4}, {0.5 ǀ 0.5,0.7 ǀ 0.5})	([L,M], {0.4 ǀ 0.8,0.6 ǀ 0.1}, {0.2 ǀ 0.3,0.4 ǀ 0.6})	([QH,AT], {0.6 ǀ 0.3,0.8 ǀ 0.7}, {0.1 ǀ 0.5,0.2 ǀ 0.5})
C_2	([QL,L], {0.1 ǀ 0.2,0.3 ǀ 0.8}, {0.7 ǀ 1})	([L,M], {0.6 ǀ 0.7,0.7 ǀ 0.2}, {0.3 ǀ 0.9})	([QH,AT], {0.4 ǀ 0.3,0.7 ǀ 0.5}, {0.3 ǀ 0.6})	([QH,VH], {0.7 ǀ 1}, {0.1 ǀ 0.8,0.3 ǀ 0.1})
C_3	([QH,VH], {0.6 ǀ 0.9,0.7 ǀ 0.1}, {0.1 ǀ 0.1,0.2 ǀ 0.8,0.3 ǀ 0.1})	([AT,T], {0.4 ǀ 0.6,0.5 ǀ 0.3}, {0.3 ǀ 0.8,0.4 ǀ 0.2})	([H,QH], {0.7 ǀ 0.1,0.8 ǀ 0.9}, {0.1 ǀ 0.5,0.2 ǀ 0.5})	([AT,T], {0.6 ǀ 0.5,0.7 ǀ 0.4}, {0.1 ǀ 0.8,0.2 ǀ 0.1,0.3 ǀ 0.1})
C_4	([AN,L], {0.3 ǀ 0.6,0.5 ǀ 0.2}, {0.4 ǀ 0.4,0.5 ǀ 0.6})	([H,VH], {0.5 ǀ 0.2,0.6 ǀ 0.7}, {0.4 ǀ 1})	([VH,T], {0.5 ǀ 0.6,0.8 ǀ 0.4}, {0.1 ǀ 0.8})	([VH,AT], {0.8 ǀ 0.9}, {0.2 ǀ 1})
C_5	([H,AT], {0.4 ǀ 0.2,0.7 ǀ 0.7}, {0.2 ǀ 0.5,0.3 ǀ 0.5})	([H,QH], {0.2 ǀ 0.2,0.3 ǀ 0.8}, {0.5 ǀ 0.6,0.6 ǀ 0.1,0.7 ǀ 0.3})	([M,H], {0.9 ǀ 1}, {0.1 ǀ 1})	([H,VH], {0.5 ǀ 0.7,0.7 ǀ 0.1}, {0.2 ǀ 0.6,0.3 ǀ 0.4})
C_6	([VL,M], {0.6 ǀ 0.2,0.7 ǀ 0.2,0.8 ǀ 0.6}, {0.1 ǀ 0.1,0.2 ǀ 0.7})	([M,H], {0.5 ǀ 0.1,0.7 ǀ 0.9}, {0.3 ǀ 1})	([H,VH], {0.7 ǀ 0.9}, {0.1 ǀ 0.2,0.3 ǀ 0.8})	([H,AT], {0.6 ǀ 0.8,0.7 ǀ 0.2}, {0.3 ǀ 1})

Table 4. Decision matrix R^3 provided by decision unit Ex^3.

Ex^3	A_1	A_2	A_3	A_4
C_1	([QM,AH], {0.3 ǀ 0.7,0.4 ǀ 0.3}, {0.4 ǀ 0.6,0.6 ǀ 0.3})	([L,M], {0.6 ǀ 0.1,0.7 ǀ 0.8,0.8 ǀ 0.1}, {0.2 ǀ 1})	([AH,T], {0.5 ǀ 0.3,0.7 ǀ 0.7}, {0.1 ǀ 0.5,0.2 ǀ 0.5})	([H,VH], {0.4 ǀ 1}, {0.4 ǀ 0.1,0.5 ǀ 0.5,0.6 ǀ 0.4})
C_2	([AH,H], {0.4 ǀ 0.5,0.5 ǀ 0.5}, {0.5 ǀ 1})	([QM,H], {0.4 ǀ 0.1,0.6 ǀ 0.9}, {0.2 ǀ 0.5,0.4 ǀ 0.5})	([VL,L], {0.3 ǀ 1}, {0.4 ǀ 0.8,0.7 ǀ 0.1})	([VH,T], {0.7 ǀ 0.5,0.8 ǀ 0.5}, {0.2 ǀ 1})
C_3	([L,QM], {0.4 ǀ 0.8}, {0.4 ǀ 0.4,0.6 ǀ 0.6})	([AH,T], {0.7 ǀ 0.9}, {0.1 ǀ 0.2,0.3 ǀ 0.7})	([AM,T], {0.6 ǀ 0.9,0.7 ǀ 0.1}, {0.1 ǀ 0.1,0.3 ǀ 0.8})	([AH,H], {0.3 ǀ 0.2,0.4 ǀ 0.8}, {0.4 ǀ 0.5,0.6 ǀ 0.5})
C_4	([H,T], {0.5 ǀ 0.8,0.7 ǀ 0.2}, {0.3 ǀ 0.9})	([L,AM], {0.5 ǀ 0.4,0.7 ǀ 0.6}, {0.3 ǀ 1})	([QM,AH], {0.3 ǀ 0.3,0.5 ǀ 0.7}, {0.5 ǀ 0.7})	([H,T], {0.5 ǀ 0.1,0.7 ǀ 0.9}, {0.2 ǀ 0.4,0.3 ǀ 0.4})
C_5	([AM,QM], {0.5 ǀ 1}, {0.2 ǀ 0.1,0.3 ǀ 0.6,0.4 ǀ 0.3})	([AH,T], {0.5 ǀ 0.8,0.8 ǀ 0.1}, {0.1 ǀ 0.5,0.2 ǀ 0.5})	([AM,AH], {0.5 ǀ 0.1,0.7 ǀ 0.8}, {0.1 ǀ 0.5,0.2 ǀ 0.3})	([VH,T], {0.4 ǀ 0.8,0.6 ǀ 0.2}, {0.1 ǀ 0.6,0.4 ǀ 0.2})
C_6	([VL,AL], {0.1 ǀ 0.1,0.3 ǀ 0.9}, {0.4 ǀ 0.6,0.6 ǀ 0.4})	([AH,VH], {0.5 ǀ 0.8}, {0.1 ǀ 0.2,0.2 ǀ 0.6})	([L,AM], {0.2 ǀ 0.4,0.5 ǀ 0.6}, {0.5 ǀ 1})	([VH,T], {0.6 ǀ 1},{0.4 ǀ 1})

Subsequently, we apply the **Approach 1** to solve the above specific problem. Detailed steps are illustrated below.

Step 1. The invited decision makers are absolutely trusted and they normally have rational observations on minimum acceptable values and maximal expectation value for each evaluative attribute according to their professional knowledge and abundant field experiences. Therefore, each decision unit is collectively capable of determining their positive ideal destination and negative ideal destination as referential targets. Sometimes the virtual targets actually reflect the standards of governance intervention.

Here suppose all positive ideal destination $A^{\kappa+}$ and negative ideal destination $A^{\kappa-}$ provided by κth decision unit have been established as follows.

A^{1+} =
{([VH,T],{0.8 | 0.3,0.9 | 0.7},{0.1 | 1}),([AT,T],{0.8 | 1},{0.1 | 0.5,0.2 | 0.5}),([H,T], {0.7 | 1},{0.1 | 0.8,0.2 | 0.2}),([H,VH],{0.7 | 1},{0.3 | 1}), ([H,T],{0.8 | 1},{0.2 | 1}), ([VH,T],{0.9 | 1},{0.1 | 1});};

A^{1-} =
{([AM,QM],{0.5 | 0.6,0.6 | 0.4},{0.4 | 1}),([QM,AH],{0.5 | 1},{0.5 | 1}),([VL,L],{0.6 | 0.5, 0.7 | 0.5},{0.3 | 1}),([AL,AM],{0.4 | 1},{0.5 | 0.5,0.6 | 0.5}),([VL,L],{0.6 | 1},{0.4 | 1}), ([AL,M],{0.8 | 1},{0.1 | 0.5, 0.2 | 0.5});};

A^{2+} =
{([VH,AT],{0.8 | 1},{0.2 | 1}),([VH,T],{0.7 | 0.4,0.8 | 0.6},{0.1 | 0.5,0.2 | 0.5}),([AT,T], {0.8 | 1},{0.1 | 0.8,0.2 | 0.2}),([AT,T],{0.8 | 0.5,0.9 | 0.5},{0.1 | 1}),([VH,AT],{0.7 | 1}, {0.3 | 1}), ([QH,AT],{ 0.6 | 0.3,0.8 | 0.7},{0.2 | 1});};

A^{2-} =
{([VL,QL],{0.4 | 1},{0.5 | 0.8,0.6 | 0.2}),([AN,QL],{0.4 | 0.5, 0.5 | 0.5},{0.5 | 1}),([L,M],{0.9 | 1},{0.1 | 1}),([AN,VL],{0.4 | 1},{0.6 | 1}),([L,M], {0.6 | 0.3, 0.7 | 0.7},{0.3 | 1}),([AN,QL],{0.5 | 1},{0.4 | 0.5, 0.5 | 0.5});};

A^{3+} =
{([H,T],{0.9 | 1},{0.1 | 1}),([H,VH],{0.8 | 0.8,0.9 | 0.2},{0.1 | 1}),([VH,T],{0.7 | 1}, {0.2 | 0.5,0.3 | 0.5}),([H,T],{0.8 | 0.5, 0.9 | 0.5},{0.1 | 1}), ([VH,T],{0.9 | 1},{0.1 | 1}), ([VH,T],{0.7 | 0.3, 0.8 | 0.7},{0.1 | 0.2, 0.2 | 0.8});};

A^{3-} =
{([VL,AL],{0.7 | 0.5,0.8 | 0.5},{0.2 | 1}),([VL,L],{0.2 | 1},{0.7 | 0.1,0.8 | 0.9}),([VL,AL], {0.4 | 0.8, 0.5 | 0.2},{0.5 | 1}),([VL,AL],{0.6 | 1},{0.4 | 1}),([VL,L],{0.6 | 1},{0.4 | 1}),([VL,L], {0.3 | 0.3, 0.4 | 0.7},{0.5 | 1});}.

Step 2. Based on the decision matrices $R^{\kappa} = \left(r_{ij}^{\kappa}\right)_{6\times 4}$ and the above $A^{\kappa+}$ and $A^{\kappa-}$, by use of the programming model (M-1), we can objectively calculate the unknown weighting vector: $w^{\kappa} = (w_1^{\kappa}, w_2^{\kappa}, \ldots, w_n^{\kappa})(n = 1, 2, \ldots, 6; \kappa = 1, 2, 3)$ for evaluative attributes as

$$w^1 = (0.1359, 0.2317, 0.135, 0.2, 0.1277, 0.1696),$$

$$w^2 = (0.1375, 0.175, 0.1699, 0.2038, 0.1586, 0.1551),$$

$$w^3 = (0.156, 0.1909, 0.1875, 0.1601, 0.1736, 0.1319).$$

Step 3. In accordance with widely adopted configurations of $\alpha = \beta = 0.5$ [53], we can apply the hybrid model in Equation (19) to objectively obtain the unknown weighting vector $\eta^{\kappa}(\kappa = 1, 2, 3)$ for the three decision units, where $\tilde{\eta}^1 = 0.3421$, $\tilde{\eta}^2 = 0.3125$, $\tilde{\eta}^3 = 0.3455$; $\overline{\eta}^1 = 0.3341$, $\overline{\eta}^2 = 0.3329$, $\overline{\eta}^3 = 0.3331 \Rightarrow \eta^1 = 0.3381$, $\eta^2 = 0.3227$, $\eta^3 = 0.3393$.

Step 4. Next, with the formerly derived weighting vectors of $w^{\kappa} = (w_1^{\kappa}, w_2^{\kappa}, \ldots, w_n^{\kappa})$ $(\kappa = 1, 2, 3)$ in **Step I-2**, we utilize the **PDHFUUBLWA** operator introduced in **Approach 1** to aggregate r_{ij}^{κ} such that we get overall decision result r_j^{κ} of the κth decision unit on each destination $A_j(j = 1, 2, 3, 4)$. Her for brevity, we only list the overall result of first decision unit on the first destination as following

$$r_1^1 = ([s_{0.4272}, s_{3.3664}],$$
$$\{0.6339|0.0675, 0.6442|0.0675, 0.6478|0.054, 0.6577|0.054, 0.6523 \mid 0.1575,$$
$$0.6621|0.1575, 0.6656|0.126, 0.675 \mid 0.126\}, \{0.2161|0.0504, 0.2692|0.1008,$$
$$0.2283|0.0504, 0.2844|0.1008, 0.2228|0.0336, 0.2775|0.0672, 0.2353 \mid 0.0336,$$
$$0.2931 \mid 0.0672\}).$$

Step 5. Now, with the above obtained weighting vector of $\eta^{\kappa}(\kappa = 1, 2, 3)$ for the three decision units in **Step I-3**, we also apply the **PDHFUUBLWA** operator to aggregate all the individual overall decision results of $r_j^{\kappa}(\kappa = 1, 2, 3)$ into the collective group decision results of r_j $(j = 1, 2, 3, 4)$. Due to the redundancy of $r_j(j = 1, 2, 3, 4)$ output by computer program, specific data have been omitted here for brevity.

Step 6. Lastly, according to the comparative rules defined in Section 2, by applying the score function in Equation (1) to the group overall assessments $r_j(j = 1, 2, 3, 4)$ obtained in Step I-5, we get scores of $E(r_j)$ as

$$E(r_1) = 0.1247,\ E(r_2) = 0.1637,\ E(r_3) = 0.3012,\ E(r_4) = 0.3448.$$

Then, we get the final ranking orders of all destinations under evaluation as $A_1 \prec A_2 \prec A_3 \prec A_4$. Further, based on the ranking result, the NGO or local government can apply effective governance strategies to foster continuous improvements on tourism community resilience in these CBT destinations, such as awarding and stimulating, knowledge sharing and purposeful learning, among others.

7. Conclusions

As rational responses to new normal disturbances in situated environments, integrated development of disaster management and destination management has substantially enriched the CBT governance agenda of DMOs or local governments, among which fostering tourism community resilience through evaluation emerges as an efficient governance strategy but also an urgent and complicate task. For tackling the complicate problem of comprehensive evaluation of tourism community resilience, we have established solutions to several key issues.

(i) Integration of disaster management and destination management (DM2) intrinsically endows the processual characteristics of tourism community resilience, which however have been missing in the literature. To reflect desirable processual characteristics in comprehensive evaluation of tourism community resilience, we thus have constructed an analytical framework that comprises six attributes, i.e., developing proactive preparedness, raising reactive readiness, fostering diverse and innovative economy, nurturing sense of community, consolidating organizational structure of tourism community, and advancing leadership as the core of governance.

(ii) In view of the natural compatibility between uncertain multiple attributes decision making methodology and low/ill-structured problem definition in essence of comprehensive evaluation of tourism community resilience, we have formalized the latter complicate task with a typical process of multiple attributes group decision making.

(iii) In view of the common phenomena that decision makers or decision units exhibit complicate uncertainties when confronting with problems of high complexity, we have put forward a powerful expression tool of probabilistic dual hesitant fuzzy uncertain unbalanced linguistic set (PDHF_UUBLS) to simultaneously capture evaluators' cognitive characteristics of decision hesitancy, bipolar epistemic notions and relative importance among assessments. More importantly, to facilitate rational operationalization of PDHF_UUBLS, we have extended to develop a least common multiply (LCM) under probabilistic hesitant decision settings and theoretically verified the mechanism avoids potential information distortion that occurs in other generally-adopted methods.

(iv) To further support effective decision-making modelling with assessments in the form of PDHF_UUBLS, we have defined some crucial information measures for PDHF_UUBLS, distance measure, entropy measure and cross entropy measure. Also theoretically analyses have verified their desirable properties.

(v) Based on the former building blocks, we further constructed an effective MAGDM approach with special consideration of normal obstacles that weighting vectors for both evaluative attributes and decision units cannot be subjectively determined in advance due to high complexity. We thus have devised corresponding programming models for objectively obtaining those unknown weighting vectors.

Generally speaking, this paper answers to the call of DM2 implementation and provides effective and pertinent solutions to essential tasks of CBT governance agenda. Further investigations will be deployed to establish connections between questionnaire-based methodology and our proposed MAGDM approach, especially with more case studies with regard to CBT implementations in remote areas. Possible efforts could also be spared to construct hierarchical indicator system for tourism community resilience evaluation and develop corresponding decision making frameworks according to specific organization scenarios. Computerization will be another indispensable job to do for facilitating applicability in various CBT destinations.

Author Contributions: Conceptualization, J.Z., X.Q., L.S. and L.L.; methodology, X.Q.; software, X.Q.; validation, X.Q. and J.Z.; formal analysis, X.Q.; investigation, J.Z.; resources, J.Z., L.S. and L.L.; writing—original draft preparation, J.Z. and X.Q.; writing—review and editing, J.Z. and X.Q.; visualization, J.Z. and X.Q.; supervision, C.L.; project administration, J.Z.; funding acquisition, J.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by **THE NATIONAL SOCIAL SCIENCE FUND OF CHINA**, grant number **17BJY159**.

Data Availability Statement: The desirable data have been described in text.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Ruizballesteros, E. Social-ecological resilience and community-based tourism: An approach from Agua Blanca, Ecuador. *Tour. Manag.* **2011**, *32*, 655–666. [CrossRef]
2. Lee, T.H.; Jan, F.-H. Can community-based tourism contribute to sustainable development? Evidence from residents' perceptions of the sustainability. *Tour. Manag.* **2019**, *70*, 368–380. [CrossRef]
3. Tolkach, D.; King, B. Strengthening Community-Based Tourism in a new resource-based island nation: Why and how? *Tour. Manag.* **2015**, *48*, 386–398. [CrossRef]
4. Okazaki, E. A Community-Based Tourism Model: Its Conception and Use. *J. Sustain. Tour.* **2008**, *16*, 511–529. [CrossRef]
5. Mtapuri, O.; Camilleri, M.A.; Dluzewska, A. Advancing community-based tourism approaches for the sustainable development of destinations. *Sustain. Dev.* **2022**, *30*, 423–432. [CrossRef]
6. Mayaka, M.; Croy, W.G.; Cox, J.W. Participation as motif in community-based tourism: A practice perspective. *J. Sustain. Tour.* **2018**, *26*, 416–432. [CrossRef]
7. Faulkner, B. Towards a framework for tourism disaster management. *Tour. Manag.* **2001**, *22*, 135–147. [CrossRef]
8. Ritchie, B.W. Chaos, crises and disasters: A strategic approach to crisis management in the tourism industry. *Tour. Manag.* **2004**, *25*, 669–683. [CrossRef]
9. Pappas, N.; Papatheodorou, A. Tourism and the refugee crisis in Greece: Perceptions and decision-making of accommodation providers. *Tour. Manag.* **2017**, *63*, 31–41. [CrossRef]
10. Wakil, M.A.; Sun, Y.; Chan, E.H.W. Co-flourishing: Intertwining community resilience and tourism development in destination communities. *Tour. Manag. Perspect.* **2021**, *38*, 100803. [CrossRef]
11. Maclean, K.; Cuthill, M.; Ross, H. Six attributes of social resilience. *J. Environ. Plan. Manag.* **2014**, *57*, 144–156. [CrossRef]
12. Cartier, E.A.; Taylor, L.L. Living in a wildfire: The relationship between crisis management and community resilience in a tourism-based destination. *Tour. Manag. Perspect.* **2020**, *34*, 100635. [CrossRef]
13. Jiang, Y.; Ritchie, B.W.; Verreynne, M.-L. Developing disaster resilience: A processual and reflective approach. *Tour. Manag.* **2021**, *87*, 104374. [CrossRef]

14. Wyss, R.; Luthe, T.; Abegg, B. Building resilience to climate change-the role of cooperation in alpine tourism networks. *Local Environ.* **2015**, *20*, 908–922. [CrossRef]
15. Gabriel-Campos, E.; Werner-Masters, K.; Cordova-Buiza, F.; Paucar-Caceres, A. Community eco-tourism in rural Peru: Resilience and adaptive capacities to the COVID-19 pandemic and climate change. *J. Hosp. Tour. Manag.* **2021**, *48*, 416–427. [CrossRef]
16. Jopp, R.; DeLacy, T.; Mair, J. Developing a framework for regional destination adaptation to climate change. *Curr. Issues Tour.* **2010**, *13*, 591–605. [CrossRef]
17. Karunarathne, A.C.I.D.; Ranasinghe, J.P.R.C.; Sammani, U.G.O.; Perera, K.J.T. Impact of the COVID-19 pandemic on tourism operations and resilience: Stakeholders' perspective in Sri Lanka. *Worldw. Hosp. Tour. Themes* **2021**, *13*, 369–382. [CrossRef]
18. Cochrane, J. The Sphere of Tourism Resilience. *Tour. Recreat. Res.* **2010**, *35*, 173–185. [CrossRef]
19. Ritchie, B.W.; Jiang, Y. A review of research on tourism risk, crisis and disaster management: Launching the annals of tourism research curated collection on tourism risk, crisis and disaster management. *Ann. Tour. Res.* **2019**, *79*, 102812. [CrossRef]
20. Filimonau, V.; De Coteau, D. Tourism resilience in the context of integrated destination and disaster management (DM2). *Int. J. Tour. Res.* **2020**, *22*, 202–222. [CrossRef]
21. Toprak, Z. Brundtland Report. In *Encyclopedia of Corporate Social Responsibility*; Idowu, S.O., Capaldi, N., Zu, L., Gupta, A.D., Eds.; Springer: Berlin/Heidelberg, Germany, 2013. [CrossRef]
22. Folke, C.; Carpenter, S.; Elmqvist, T.; Gunderson, L.; Holling, C.S.; Walker, B. Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations. *AMBIO A J. Hum. Environ.* **2002**, *31*, 437–440, 434. [CrossRef] [PubMed]
23. Gunderson, L.; Light, S.S. Adaptive management and adaptive governance in the everglades ecosystem. *Policy Sci.* **2006**, *39*, 323–334. [CrossRef]
24. Holling, C.S. Understanding the Complexity of Economic, Ecological, and Social Systems. *Ecosystems* **2001**, *4*, 390–405. [CrossRef]
25. Folke, C.; Hahn, T.; Olsson, P.; Norberg, J. Adaptive governance of social-ecological systems. *Annu. Rev. Environ. Resour.* **2005**, *30*, 441–473. [CrossRef]
26. Sheppard, V.A.; Williams, P.W. Factors that strengthen tourism resort resilience. *J. Hosp. Tour. Manag.* **2016**, *28*, 20–30. [CrossRef]
27. Sgroi, F. Forest resources and sustainable tourism, a combination for the resilience of the landscape and development of mountain areas. *Sci. Total Environ.* **2020**, *736*, 139539. [CrossRef] [PubMed]
28. Choi, Y.E.; Song, K.; Kim, M.; Lee, J. Transformation Planning for Resilient Wildlife Habitats in Ecotourism Systems. *Sustainability* **2017**, *9*, 487. [CrossRef]
29. Nurzaman, A.; Shaw, R.; Roychansyah, M.S. Measuring community resilience against coastal hazards: Case study in Baron Beach, Gunungkidul Regency. *Prog. Disaster Sci.* **2020**, *5*, 100067. [CrossRef]
30. Yang, E.; Kim, J.; Pennington-Gray, L.; Ash, K. Does tourism matter in measuring community resilience? *Ann. Tour. Res.* **2021**, *89*, 103222. [CrossRef]
31. Yan, L.-b.; Kasanin-Grubin, M. Land degradation and management of red beds in China: Two case studies. *J. Mt. Sci.* **2019**, *16*, 2591–2604. [CrossRef]
32. Alrwajfah, M.M.; Almeida-García, F.; Cortés-Macías, R. The satisfaction of local communities in World Heritage Site destinations. The case of the Petra region, Jordan. *Tour. Manag. Perspect.* **2021**, *39*, 100841. [CrossRef]
33. Marshall, N.A.; Marshall, P.A.; Abdulla, A.; Rouphael, T.; Ali, A. Preparing for climate change: Recognising its early impacts through the perceptions of dive tourists and dive operators in the Egyptian Red Sea. *Curr. Issues Tour.* **2011**, *14*, 507–518. [CrossRef]
34. Zehrer, A.; Hallmann, K. A stakeholder perspective on policy indicators of destination competitiveness. *J. Destin. Mark. Manag.* **2015**, *4*, 120–126. [CrossRef]
35. Jamaliah, M.M.; Powell, R.B. Ecotourism resilience to climate change in Dana Biosphere Reserve, Jordan. *J. Sustain. Tour.* **2018**, *26*, 519–536. [CrossRef]
36. Raisi, H.; Baggio, R.; Barratt-Pugh, L.; Willson, G. A network perspective of knowledge transfer in tourism. *Ann. Tour. Res.* **2020**, *80*, 102817. [CrossRef]
37. Calgaro, E.; Lloyd, K.; Dominey-Howes, D. From vulnerability to transformation: A framework for assessing the vulnerability and resilience of tourism destinations. *J. Sustain. Tour.* **2014**, *22*, 341–360. [CrossRef]
38. Choi, Y.E.; Oh, C.-O.; Chon, J. Applying the resilience principles for sustainable ecotourism development: A case study of the Nakdong Estuary, South Korea. *Tour. Manag.* **2021**, *83*, 104237. [CrossRef]
39. Romão, J.; Machino, K.; Nijkamp, P. Assessment of wellness tourism development in Hokkaido: A multicriteria and strategic choice analysis. *Asia-Pac. J. Reg. Sci.* **2017**, *1*, 265–290. [CrossRef]
40. Buikstra, E.; Ross, H.; King, C.A.; Baker, P.G.; Hegney, D.; McLachlan, K.; Rogers-Clark, C. The components of resilience—Perceptions of an Australian rural community. *J. Community Psychol.* **2010**, *38*, 975–991. [CrossRef]
41. Berkes, F.; Ross, H. Community Resilience: Toward an Integrated Approach. *Soc. Nat. Resour.* **2013**, *26*, 5–20. [CrossRef]
42. Aydin, S.; Kahraman, C.; Kaya, I. A new fuzzy multicriteria decision making approach: An application for European Quality Award assessment. *Knowl.-Based Syst.* **2012**, *32*, 37–46. [CrossRef]
43. Musavengane, R.; Kloppers, R. Social capital: An investment towards community resilience in the collaborative natural resources management of community-based tourism schemes. *Tour. Manag. Perspect.* **2020**, *34*, 100654. [CrossRef]
44. Jiang, Y.; Ritchie, B.W. Disaster collaboration in tourism: Motives, impediments and success factors. *J. Hosp. Tour. Manag.* **2017**, *31*, 70–82. [CrossRef]

45. Duchek, S. Organizational resilience: A capability-based conceptualization. *Bus. Res.* **2020**, *13*, 215–246. [CrossRef]
46. Çakar, K. Critical success factors for tourist destination governance in times of crisis: A case study of Antalya, Turkey. *J. Travel Tour. Mark.* **2018**, *35*, 786–802. [CrossRef]
47. Jiang, Y.W.; Ritchie, B.W.; Verreynne, M.L. Building dynamic capabilities in tourism organisations for disaster management: Enablers and barriers. *J. Sustain. Tour.* **2022**, *in press*. [CrossRef]
48. Paraskevas, A.; Altinay, L. Signal detection as the first line of defence in tourism crisis management. *Tour. Manag.* **2013**, *34*, 158–171. [CrossRef]
49. Ritchie, B. Tourism Disaster Planning and Management: From Response and Recovery to Reduction and Readiness. *Curr. Issues Tour.* **2008**, *11*, 315–348. [CrossRef]
50. Mair, J.; Ritchie, B.W.; Walters, G. Towards a research agenda for post-disaster and post-crisis recovery strategies for tourist destinations: A narrative review. *Curr. Issues Tour.* **2016**, *19*, 1–26. [CrossRef]
51. Zimmermann, H.J. *Fuzzy Set Theory and Its Applications*; Springer: Dordrecht, The Netherlands, 2001. [CrossRef]
52. Xu, Z. *Hesitant Fuzzy Sets Theory*; Springer International Publishing: Berlin/Heidelberg, Germany, 2014. [CrossRef]
53. Qi, X.; Liang, C.; Zhang, J. Generalized cross-entropy based group decision making with unknown expert and attribute weights under interval-valued intuitionistic fuzzy environment. *Comput. Ind. Eng.* **2015**, *79*, 52–64. [CrossRef]
54. Jin, F.; Ni, Z.; Chen, H.; Li, Y.; Zhou, L. Multiple attribute group decision making based on interval-valued hesitant fuzzy information measures. *Comput. Ind. Eng.* **2016**, *101*, 103–115. [CrossRef]
55. Liu, P. Multiple attribute group decision making method based on interval-valued intuitionistic fuzzy power Heronian aggregation operators. *Comput. Ind. Eng.* **2017**, *108*, 199–212. [CrossRef]
56. Xu, Z.S. A method for multiple attribute decision making with incomplete weight information in linguistic setting. *Knowl.-Based Syst.* **2007**, *20*, 719–725. [CrossRef]
57. Ju, Y.B.; Wang, A.H.; Liu, X.Y. Evaluating emergency response capacity by fuzzy AHP and 2-tuple fuzzy linguistic approach. *Expert. Syst. Appl.* **2012**, *39*, 6972–6981. [CrossRef]
58. Qi, X.W.; Zhang, J.L.; Liang, C.Y. Multiple Attributes Group Decision-Making Approaches Based on Interval-Valued Dual Hesitant Fuzzy Unbalanced Linguistic Set and Their Applications. *Complexity* **2018**, *2018*, 3172716. [CrossRef]
59. Liu, P.; Rong, L. Multiple Attribute Group Decision-Making Approach Based on Multi-granular Unbalanced Hesitant Fuzzy Linguistic Information. *Int. J. Fuzzy Syst.* **2020**, *22*, 604–618. [CrossRef]
60. Liao, H.; Xu, Z. *Hesitant Fuzzy Decision Making Methodologies and Applications*; Springer: Singapore, 2017. [CrossRef]
61. Torra, V. Hesitant fuzzy sets. *Int. J. Intell. Syst.* **2010**, *25*, 529–539. [CrossRef]
62. Zhu, B.; Xu, Z.; Xia, M. Dual Hesitant Fuzzy Sets. *J. Appl. Math.* **2012**, *2012*, 879629. [CrossRef]
63. Pang, Q.; Wang, H.; Xu, Z.S. Probabilistic linguistic linguistic term sets in multi-attribute group decision making. *Inf. Sci.* **2016**, *369*, 128–143. [CrossRef]
64. Liao, H.; Jiang, L.; Xu, Z.; Xu, J.; Herrera, F. A linear programming method for multiple criteria decision making with probabilistic linguistic information. *Inf. Sci.* **2017**, *415–416*, 341–355. [CrossRef]
65. Wang, J.Q.; Wu, J.T.; Wang, J.; Zhang, H.Y.; Chen, X.H. Interval-valued hesitant fuzzy linguistic sets and their applications in multi-criteria decision-making problems. *Inf. Sci.* **2014**, *288*, 55–72. [CrossRef]
66. Zhang, J.; Qi, X.; Liang, C. Tackling Complexity in Green Contractor Selection for Mega Infrastructure Projects: A Hesitant Fuzzy Linguistic MADM Approach with considering Group Attitudinal Character and Attributes' Interdependency. *Complexity* **2018**, *2018*, 4903572. [CrossRef]
67. Xu, Z. Uncertain linguistic aggregation operators based approach to multiple attribute group decision making under uncertain linguistic environment. *Inf. Sci.* **2004**, *168*, 171–184. [CrossRef]
68. Xie, W.Y.; Xu, Z.S.; Ren, Z.L. Dual probabilistic linguistic term set and its application on multi-criteria group decision making problems. In Proceedings of the 2017 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), Singapore, 10–13 December 2017; pp. 1469–1474. [CrossRef]
69. Herrera, F.; Herrera-Viedma, E.; Martinez, L. A fuzzy linguistic methodology to deal with unbalanced linguistic term sets. *IEEE Trans. Fuzzy Syst.* **2008**, *16*, 354–370. [CrossRef]
70. Liao, H.C.; Xu, Z.S.; Zeng, X.J. Distance and similarity measures for hesitant fuzzy linguistic term sets and their application in multi-criteria decision making. *Inf. Sci.* **2014**, *271*, 125–142. [CrossRef]
71. Gou, X.J.; Xu, Z.S.; Liao, H.C. Hesitant fuzzy linguistic entropy and cross-entropy measures and alternative queuing method for multiple criteria decision making. *Inf. Sci.* **2017**, *388*, 225–246. [CrossRef]
72. Liao, H.; Gou, X.; Xu, Z.; Zeng, X.-J.; Herrera, F. Hesitancy degree-based correlation measures for hesitant fuzzy linguistic term sets and their applications in multiple criteria decision making. *Inf. Sci.* **2020**, *508*, 275–292. [CrossRef]
73. Xu, Z.S.; Xia, M.M. Distance and similarity measures for hesitant fuzzy sets. *Inf. Sci.* **2011**, *181*, 2128–2138. [CrossRef]
74. Mao, X.-B.; Wu, M.; Dong, J.-Y.; Wan, S.-P.; Jin, Z. A new method for probabilistic linguistic multi-attribute group decision making: Application to the selection of financial technologies. *Appl. Soft Comput.* **2019**, *77*, 155–175. [CrossRef]
75. Xie, W.Y.; Xu, Z.S.; Ren, Z.L.; Herrera-Viedma, E. The probe for the weighted dual probabilistic linguistic correlation coefficient to invest an artificial intelligence project. *Soft Comput.* **2020**, *24*, 15389–15408. [CrossRef]
76. Wang, Z.C.; Ran, Y.; Chen, Y.F.; Yang, X.; Zhang, G.B. Group risk assessment in failure mode and effects analysis using a hybrid probabilistic hesitant fuzzy linguistic MCDM method. *Expert. Syst. Appl.* **2022**, *188*, 116013. [CrossRef]

77. Chen, L.; Yang, D. Dynamic Pythagorean fuzzy probabilistic linguistic TOPSIS method with psychological preference and its application for COVID-19 vaccination. *Soft Comput. Lett.* **2021**, *3*, 100022. [CrossRef]
78. Ye, J. Multiple-attribute decision-making method using similarity measures of single-valued neutrosophic hesitant fuzzy sets based on least common multiple cardinality. *J. Intell. Fuzzy Syst.* **2018**, *34*, 4203–4211. [CrossRef]
79. Cui, W.; Ye, J. Multiple-Attribute Decision-Making Method Using Similarity Measures of Hesitant Linguistic Neutrosophic Numbers Regarding Least Common Multiple Cardinality. *Symmetry* **2018**, *10*, 330. [CrossRef]
80. Luthe, T.; Wyss, R. Assessing and planning resilience in tourism. *Tour. Manag.* **2014**, *44*, 161–163. [CrossRef]
81. Carty, K.S. Towards a proactive, capabilities-based continuity framework for the hospitality and tourism industry. *Worldw. Hosp. Tour. Themes* **2021**, *13*, 418–430. [CrossRef]
82. Hall, C.; Prayag, G.; Amore, A. *Tourism and Resilience: Individual, Organisational and Destination Perspectives*; Channel View Publications: Bristol, UK, 2018. [CrossRef]
83. Usher, L.E.; Yusuf, J.-E.; Covi, M. Assessing tourism business resilience in Virginia Beach. *Int. J. Tour. Cities* **2020**, *6*, 397–414. [CrossRef]
84. Norris, F.H.; Stevens, S.P.; Pfefferbaum, B.; Wyche, K.F.; Pfefferbaum, R.L. Community Resilience as a Metaphor, Theory, Set of Capacities, and Strategy for Disaster Readiness. *Am. J. Community Psychol.* **2008**, *41*, 127–150. [CrossRef] [PubMed]
85. Gani, A.; Singh, R.; Najar, A.H. Rebuilding Tourist destinations from Crisis: A comparative Study of Jammu and Kashmir and Assam, India. *Worldw. Hosp. Tour. Themes* **2021**, *13*, 437–454. [CrossRef]
86. Becken, S.; Hughey, K.F.D. Linking tourism into emergency management structures to enhance disaster risk reduction. *Tour. Manag.* **2013**, *36*, 77–85. [CrossRef]
87. Bec, A.; Moyle, C.-L.J.; Moyle, B.D. Community Resilience to Change: Development of an Index. *Soc. Indic. Res.* **2019**, *142*, 1103–1128. [CrossRef]
88. Malhotra, R.; Venkatesh, U. Pre-crisis period planning: Lessons for hospitality and tourism. *Worldw. Hosp. Tour. Themes* **2009**, *1*, 66–74. [CrossRef]
89. Jiang, Y.; Ritchie, B.W.; Verreynne, M.-L. A Resource-Based Typology of Dynamic Capability: Managing Tourism in a Turbulent Environment. *J. Travel Res.* **2022**, *61*, 1006–1023. [CrossRef]
90. Halibozek, E.P.; Kovacich, G.L. Chapter 14-Contingency Planning. In *The Manager's Handbook for Corporate Security*, 2nd ed.; Halibozek, E.P., Kovacich, G.L., Eds.; Butterworth-Heinemann: Boston, MA, USA, 2017; pp. 289–309. [CrossRef]
91. Djalante, R.; Holley, C.; Thomalla, F. Adaptive governance and managing resilience to natural hazards. *Int. J. Disaster Risk Sci.* **2011**, *2*, 1–14. [CrossRef]
92. Battisti, M.; Deakins, D. The relationship between dynamic capabilities, the firm's resource base and performance in a post-disaster environment. *Int. Small Bus. J.* **2017**, *35*, 78–98. [CrossRef]
93. Sawalha, I.H.S. Managing adversity: Understanding some dimensions of organizational resilience. *Manag. Res. Rev.* **2015**, *38*, 346–366. [CrossRef]
94. Mancini, J.A.; Bowen, G.L. Community resilience: A social organization theory of action and change. In *Pathways of Human Development: Exploration of Change*; Mancini, J.A., Roberto, K.A., Eds.; Lexington Books: New York, NY, USA, 2009; pp. 245–265. Available online: https://rowman.com/ISBN/9780739136881/Pathways-of-Human-Development-Explorations-of-Change (accessed on 16 August 2022).
95. Orchiston, C.; Prayag, G.; Brown, C. Organizational resilience in the tourism sector. *Ann. Tour. Res.* **2016**, *56*, 145–148. [CrossRef]
96. Mancini, J.A.; Nelson, J.P.; Bowen, G.L.; Martin, J.A. Preventing Intimate Partner Violence: A Community Capacity Approach. *J. Aggress. Maltreatment Trauma* **2006**, *13*, 203–227. [CrossRef]
97. Smith, J.W.; Anderson, D.H.; Moore, R.L. Social Capital, Place Meanings, and Perceived Resilience to Climate Change. *Rural Sociol.* **2012**, *77*, 380–407. [CrossRef]
98. Wallis, A.; Fischer, R.; Abrahamse, W. Place Attachment and Disaster Preparedness: Examining the Role of Place Scale and Preparedness Type. *Environ. Behav.* **2021**, *54*, 670–711. [CrossRef]
99. Liu, J.; Qu, H.; Huang, D.; Chen, G.; Yue, X.; Zhao, X.; Liang, Z. The role of social capital in encouraging residents' pro-environmental behaviors in community-based ecotourism. *Tour. Manag.* **2014**, *41*, 190–201. [CrossRef]
100. Roth, J.; Steffens, M.C. When I Becomes We. *Soc. Psychol.* **2014**, *45*, 253–264. [CrossRef]
101. Wen, T.; Zhang, Q.; Li, Y. Why small tourism enterprises behave responsibly: Using job embeddedness and place attachment to predict corporate social responsibility activities. *Curr. Issues Tour.* **2021**, *24*, 1435–1450. [CrossRef]
102. Lee, T.W.; Mitchell, T.R.; Sablynski, C.J.; Burton, J.P.; Holtom, B.C. The Effects of Job Embeddedness on Organizational Citizenship, Job Performance, Volitional Absences, and Voluntary Turnover. *Acad. Manag. J.* **2004**, *47*, 711–722. [CrossRef]
103. Magis, K. Community Resilience: An Indicator of Social Sustainability. *Soc. Nat. Resour.* **2010**, *23*, 401–416. [CrossRef]
104. Sampson, R.J.; Graif, C. Neighborhood Social Capital as Differential Social Organization: Resident and Leadership Dimensions. *Am. Behav. Sci.* **2009**, *52*, 1579–1605. [CrossRef]
105. Ungar, M. The social ecology of resilience: Addressing contextual and cultural ambiguity of a nascent construct. *Am. J. Orthopsychiatry* **2011**, *81*, 1–17. [CrossRef] [PubMed]
106. Brodsky, A.E.; Welsh, E.; Carrillo, A.; Talwar, G.; Scheibler, J.; Butler, T. Between Synergy and Conflict: Balancing the Processes of Organizational and Individual Resilience in an Afghan Women's Community. *Am. J. Community Psychol.* **2011**, *47*, 217–235. [CrossRef]

107. Chandra, A.; Acosta, J.D.; Meredith, L.S.; Sanches, K.; Howard, S.; Uscher-Pines, L.; Williams, M.V.; Yeung, D. *Understanding Community Resilience in the Context of National Health Security: A Literature Review*; RAND Corporation: Santa Monica, CA, USA, 2010. [CrossRef]
108. Leykin, D.; Lahad, M.; Cohen, O.; Goldberg, A.; Aharonson-Daniel, L. Conjoint Community Resiliency Assessment Measure-28/10 Items (CCRAM28 and CCRAM10): A Self-report Tool for Assessing Community Resilience. *Am. J. Community Psychol.* **2013**, *52*, 313–323. [CrossRef]
109. Yang, B.; Feldman, M.W.; Li, S. The status of perceived community resilience in transitional rural society: An empirical study from central China. *J. Rural Stud.* **2020**, *80*, 427–438. [CrossRef]
110. Flagg, C.; Painter II, M.A. White Ethnic Diversity in Small Town Iowa: A Multilevel Analysis of Community Attachment. *Rural Sociol.* **2019**, *84*, 226–256. [CrossRef]
111. McGehee, N.G.; Lee, S.; O'Bannon, T.L.; Perdue, R.R. Tourism-related Social Capital and Its Relationship with Other Forms of Capital: An Exploratory Study. *J. Travel Res.* **2010**, *49*, 486–500. [CrossRef]
112. Jones, S. Community-based ecotourism: The Significance of Social Capital. *Ann. Tour. Res.* **2005**, *32*, 303–324. [CrossRef]
113. Moscardo, G. Analyzing the Role of Festivals and Events in Regional Development. *Event Manag.* **2008**, *11*, 23–32. [CrossRef]
114. Nunkoo, R.; Ramkissoon, H. Power, trust, social exchange and community support. *Ann. Tour. Res.* **2012**, *39*, 997–1023. [CrossRef]
115. Bursik, R.J. The Informal Control of Crime Through Neighborhood Networks. *Sociol. Focus* **1999**, *32*, 85–97. [CrossRef]
116. Perkins, D.D.; Long, D.A. Neighborhood Sense of Community and Social Capital. In *Psychological Sense of Community: Research, Applications, and Implications*; Fisher, A.T., Sonn, C.C., Bishop, B.J., Eds.; Springer US: Boston, MA, USA, 2002; pp. 291–318. [CrossRef]
117. Benight, C.C. Collective efficacy following a series of natural disasters. *Anxiety Stress Coping* **2004**, *17*, 401–420. [CrossRef]
118. Islam, M.W.; Ruhanen, L.; Ritchie, B.W. Adaptive co-management: A novel approach to tourism destination governance? *J. Hosp. Tour. Manag.* **2018**, *37*, 97–106. [CrossRef]
119. Bai, Y.; Lin, L.; Li, P.P. How to enable employee creativity in a team context: A cross-level mediating process of transformational leadership. *J. Bus. Res.* **2016**, *69*, 3240–3250. [CrossRef]
120. Ashley, C.; Mitchell, J. *Tourism and Poverty Reduction: Pathways to Prosperity*, 1st ed.; Routledge: London, UK, 2009. [CrossRef]
121. Premaratne, S.P. Networks, Resources, and Small Business Growth: The Experience in Sri Lanka. *J. Small Bus. Manag.* **2001**, *39*, 363–371. [CrossRef]
122. Zadeh, L.A. The concept of a linguistic variable and its application to approximate reasoning-I. *Inf. Sci.* **1975**, *8*, 199–249. [CrossRef]
123. Ju, Y.; Liu, X.; Yang, S. Interval-valued dual hesitant fuzzy aggregation operators and their applications to multiple attribute decision making. *J. Intell. Fuzzy Syst.* **2014**, *27*, 1203–1218. [CrossRef]
124. De Luca, A.; Termini, S. A definition of a nonprobabilistic entropy in the setting of fuzzy sets theory. *Inf. Control* **1972**, *20*, 301–312. [CrossRef]
125. Szmidt, E.; Kacprzyk, J. Entropy for intuitionistic fuzzy sets. *Fuzzy Sets Syst.* **2001**, *118*, 467–477. [CrossRef]
126. Wu, J.-Z.; Zhang, Q. Multicriteria decision making method based on intuitionistic fuzzy weighted entropy. *Expert Syst. Appl.* **2011**, *38*, 916–922. [CrossRef]
127. Jin, F.; Pei, L.; Chen, H.; Zhou, L. Interval-valued intuitionistic fuzzy continuous weighted entropy and its application to multi-criteria fuzzy group decision making. *Knowl.-Based Syst.* **2014**, *59*, 132–141. [CrossRef]
128. Liu, P.; Liu, W. Multiple-attribute group decision-making method of linguistic q-rung orthopair fuzzy power Muirhead mean operators based on entropy weight. *Int. J. Intell. Syst.* **2019**, *34*, 1755–1794. [CrossRef]
129. Zhang, J.; Hegde, G.; Shang, J.; Qi, X. Evaluating Emergency Response Solutions for Sustainable Community Development by Using Fuzzy Multi-Criteria Group Decision Making Approaches: IVDHF-TOPSIS and IVDHF-VIKOR. *Sustainability* **2016**, *8*, 291. [CrossRef]
130. Xian, S.; Guo, H. Novel supplier grading approach based on interval probability hesitant fuzzy linguistic TOPSIS. *Eng. Appl. Artif. Intell.* **2020**, *87*, 103299. [CrossRef]
131. Shih, H.-S.; Olson, D. *TOPSIS and its Extensions: A Distance-Based MCDM Approach*; Springer Cham: Cham, Switzerland, 2022. [CrossRef]
132. Qi, X.; Liang, C.; Zhang, J. Multiple attribute group decision making based on generalized power aggregation operators under interval-valued dual hesitant fuzzy linguistic environment. *Int. J. Mach. Learn. Cybern.* **2016**, *7*, 1147–1193. [CrossRef]
133. Yager, R.R. On the Inclusion of Importances in OWA Aggregations. In *The Ordered Weighted Averaging Operators*; Yager, R.R., Kacprzyk, J., Eds.; Springer: Boston, MA, USA, 1997. [CrossRef]
134. Xu, Z.S.; Da, Q.L. An overview of operators for aggregating information. *Int. J. Intell. Syst.* **2003**, *18*, 953–969. [CrossRef]
135. Yager, R.R. Induced aggregation operators. *Fuzzy Sets Syst.* **2003**, *137*, 59–69. [CrossRef]