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RESEARCH ARTICLE

Evaluation of Sustainable Potential Bearing Capacity of Tourism Environment Under Uncertainty: A Multiphase Intuitionistic Fuzzy EDAS Technique Based on Hamming Distance and Logarithmic Distance Measures

RONG YAN[1], YONGGUANG HAN[1], FANG LI[2,3], AND PENGFEI LI[3]

[1]Intelligent Construction Technology Application and Promotion Center, Chongqing City Vocational College, Chongqing 402160, China
[2]Jiujiang Vocational and Technical College, Jiujiang, Jiangxi 332001, China
[3]University of Perpetual Help System DALTA, Manila 547099, Philippines

Corresponding author: Fang Li (18379233269@163.com)

ABSTRACT The proposal of the ‘‘dual carbon’’ goal is a deep reflection of the inherent requirements for achieving sustainable development, and has become an important constraint and policy direction for the development of all industries and sectors during the 14th Five Year Plan period and even longer. Tourism destinations are important spatial carriers for the tourism industry to achieve the ‘‘dual carbon’’ goals, and the tourism environment is the foundation for the sustainable development of tourism activities and an important prerequisite for the sustainable development of tourism destinations. Therefore, in the context of ‘‘dual carbon’’, evaluating the current status and future development potential of sustainable carrying capacity of destination tourism environment is of great practical significance for achieving the ‘‘dual carbon’’ goal. The sustainable potential bearing capacity evaluation of tourism environment is a multiple-attribute group decision-making (MAGDM) problem. Recently, the Evaluation based on Distance from Average Solution (EDAS) technique has been employed to manage MAGDM issues. The intuitionistic fuzzy sets (IFSs) are utilized as a tool for portraying uncertain information during the sustainable potential bearing capacity evaluation of tourism environment. In this paper, the intuitionistic fuzzy number EDAS (IFN-EDAS) technique is cultivated to manage the MAGDM based on Hamming distance and Logarithmic distance under IFSs. Finally, a numerical study for sustainable potential bearing capacity evaluation of tourism environment is supplied to validate the proposed technique. The main contributions of this paper are outlined: (1) the EDAS technique has been extended to IFSs based on Hamming distance and Logarithmic distance; (2) the CRITIC technique is utilized to derive weight based on Hamming distance and Logarithmic distance under IFSs. (3) the IFN-EDAS technique based on Hamming distance and Logarithmic distance is founded to manage the MAGDM based on the Hamming distance and Logarithmic distance under IFSs; (4) a numerical study for sustainable potential bearing capacity evaluation of tourism environment and some comparative analysis is supplied to validate the proposed technique.

INDEX TERMS Multiple-attribute group decision-making (MAGDM), intuitionistic fuzzy sets (IFSs), EDAS technique, CRITIC technique, sustainable potential bearing capacity evaluation.

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I. INTRODUCTION

Currently, how to cope with the continuous changes in climate and achieve the goals set by ‘‘dual carbon’’ has become an important issue faced by both international and domestic parties [1], [2], [3]. Against the backdrop of China's vigorous promotion of carbon reduction, the unique characteristics of the tourism industry determine that it will play a crucial role in supporting the achievement of China's "dual carbon" goals [4], [5]. As one of the largest and most important industries in the world, the tourism industry's significant carbon emissions in transportation, accommodation, catering, and other areas seriously affect the achievement of low-carbon goals and the sustainable development of tourism destinations [6], [7], [8]. The tourism environment on which the tourism industry relies for survival determines the direction of tourism development and has a crucial impact on the entire destination. At the same time, the Outline of the 14th Five Year Plan for the Development of China's Tourism Industry points out that, on the basis of emphasizing the improvement of urban quality, cities should be purposefully and systematically built into low-carbon cities. Based on the concept of green development, green and low-carbon should be integrated into the entire process of urban construction, development, and management [9], [10], [11]. In the future, the tourism industry will be cultivated as an important leading industry for low-carbon and ecological civilization construction. In the government report of the 2021 Two Sessions, it was pointed out to solidly carry out various tasks of "carbon neutrality" and "carbon peaking", and formulate action plans to achieve carbon peaking before 2030 and carbon neutrality before 2060. The proposal of the "dual carbon" goal is an important opportunity and challenge for the low-carbon and green transformation of the tourism industry, which is conducive to promoting low-carbon and sustainable development in various tourism industry chains and tourist destinations, thereby contributing strength and value to China's future sustainable development [12], [13], [14]. At present, China's tourism industry is relatively traditional in terms of economic growth mode and has enormous potential for carbon reduction. However, due to a lack of strategy, there is a lack of research, development, and action in various aspects, which is quite different from the requirements of low-carbon tourism [15], [16]. To clarify and achieve the "two carbon" goals in the tourism industry, it faces various challenges. Cities are important spatial carriers for the tourism industry to achieve the "dual carbon" goals [17], [18], [19]. The tourist destinations in cities are the foundation of tourist activities and an important prerequisite for the sustainable development of tourist destinations. Therefore, combining carbon constraint policies with tourism environment development to study the sustainable carrying potential of urban tourism environment from the perspective of system "state" and system "development" has practical reference significance for achieving the dual carbon goal and creating a green and low-carbon tourism environment for other regions to achieve effective carbon reduction [20], [21], [22].

Atanassov [23] introduced hesitancy into Zadeh's fuzzy set theory [24] and put forward an intuitionistic fuzzy sets (IFSs) that comprehensively considers three aspects of information. Compared with traditional fuzzy sets, IFSs are more practical in handling fuzziness and uncertainty problems by considering three aspects of information, and are therefore widely used [25], [26], [27], [28], [29], [30], [31]. The ordered weighted average (OWA) operator put forward by Yager [32] has become an important technique for solving MADM problems and has been applied in many fields [33], [34], [35], [36], [37], [38], [39]. Roszkowska et al. [40] put forward a mixed MADM method based on TOPSIS on the basis of intuitionistic fuzzy entropy. Ghaffar, et al. [41] put forward a new intuitionistic fuzzy MADM method from the perspective of scheme preference. Feng et al. [42] put forward a corresponding MADM method by improving the Minkowski function based on the concept of hesitant fuzzy sets. Karacan et al. [43] put forward the intuitionistic fuzzy analytical hierarchy process and goal programming. Li and Chen [44] introduced the concept of D intuitionistic fuzzy hesitancy set, which refers to the trust of decision makers in expert opinions. Atalik et al. [45] introduced the hesitation of experts into the model and put forward a new hypothesis testing method for intuitionistic fuzzy parameter population mean statistics. Kizielewicz et al. [46] put forward to improve the score function from the perspective of equal number of supporters and opponents, and put forward a new intuitionistic fuzzy ensemble operator. Rahimi et al. [47] put forward an intuitionistic fuzzy entropy measure for supplier attribute selection and ranking. Thao [48] established entropy and knowledge measures for intuitionistic fuzzy sets based on divergence testing. Zhang et al. [49] put forward the generalized intuitionistic fuzzy normalized weighted optimized geometric bonferroni mean technique. There have been many research results on the improved score function for dealing with the problem of option ranking in multi-attribute decision-making [50], [51], [52], [53], [54], [55], [56], but the score function put forward by the above scholars ignores the problem of heterogeneous consumers having different perceptions and expectations of homogeneous products in the transaction decision-making process. In application, it is difficult to sort special fuzzy numbers and objectively determine parameters. For example, Xu [57] ignored the influence of abstention groups on decision results, and the calculated score function may not match the actual results; Although Zhang et al. [58] and Lin et al. [59] improved the score function to consider the impact of abstention groups on decision results, the parameters of the score function are difficult to objectively provide in practical applications and are difficult to practice.

The sustainable potential bearing capacity evaluation of tourism environment is MAGDM. The IFSs [23], [60], [61], [62] are utilized as the technique for portraying uncertain information during the sustainable potential bearing capacity evaluation of tourism environment. Furthermore, many existing techniques conducted the typical EDAS technique [63], [64] separately to obtain the most optimal decision choice.

Until now, no or few techniques were conducted on the CRITIC technique [65] and EDAS technique [63], [64] based on Hamming distance and Logarithmic distance under IFSs. Therefore, an integrated intuitionistic fuzzy number EDAS (IFN-EDAS) technique is conducted to manage MAGDM based on Hamming distance and Logarithmic distance under IFSs. A numerical example for sustainable potential bearing capacity evaluation of tourism environment and some comparative studies is conducted to verify the validity of IFN-EDAS technique. The main research goal and motivation of this paper is conducted: (1) the EDAS technique was expanded to IFSs based on Hamming distance and Logarithmic distance; (2) the CRITIC technique is utilized to put forward the weight values based on Hamming distance and Logarithmic distance under IFSs. (3) the IFN-EDAS technique based on Hamming distance and Logarithmic distance is founded to manage the MAGDM under IFSs; (4) a numerical case study for sustainable potential bearing capacity evaluation of tourism environment and some comparative analysis is conducted to verify the proposed IFN-EDAS technique.

The framework of this paper is founded below. In Section II, the IFSs is conducted. In Section III, IFN-EDAS technique is conducted under IFSs with CRITIC technique based on Hamming distance and Logarithmic distance. Section IV conducted an illustrative case for sustainable potential bearing capacity evaluation of tourism environment and some comparative analysis. Some remarks are conducted in Section V.

II. PRELIMINARIES

Atanassov [66] conducted the IFSs.

Definition 1 [66]: The IFSs on Θ is:

$$O = \{\langle \theta, u_O(\theta), v_O(\theta)\rangle \mid \theta \in \Theta\} \tag{1}$$

where $\mu_O(\theta) \in [0, 1]$ is membership and $\nu_O(\theta) \in [0, 1]$ is non-membership with information condition: $0 \le \mu_O(\theta) + \nu_O(\theta) \le 1, \forall\ \theta \in \Theta$. Then, $o\theta = (ou, ov)$ is conducted as the IFN.

Definition 2 [67], [68]: Let $o\theta_1 = (ou_1, ov_1)$ and $o\theta_2 = (ou_2, ov_2)$ be IFNs, the score functions (SF) and accuracy functions (AF) of $o\theta_1 = (ou_1, ov_1)$ and $o\theta_2 = (ou_2, ov_2)$ is conducted:

$$SF(o\theta_1) = ou_1 - ov_1, SF(o\theta_2) = ou_2 - ov_2 \tag{2}$$
$$AF(o\theta_1) = ou_1 + ov_1, AF(o\theta_2) = ou_2 + ov_2 \tag{3}$$

For IFNs $o\theta_1 = (ou_1, ov_1)$ and $o\theta_2 = (ou_2, ov_2)$, then [69]

$$\begin{aligned} &(1)\ if\ SF(o\theta_1) < SF(o\theta_2),\quad o\theta_1 < o\theta_2;\\ &(2)\ if\ SF(o\theta_1) = SF(o\theta_2),\\ &\qquad AF(o\theta_1) < AF(o\theta_2),\quad o\theta_1 < o\theta_2;\\ &(3)\ if\ SF(o\theta_1) = SF(o\theta_2),\\ &\qquad AF(o\theta_1) = AF(o\theta_2),\quad o\theta_1 = o\theta_2. \end{aligned}$$

Definition 3 [70]: Let $o\theta_1 = (ou_1, ov_1)$ and $o\theta_2 = (ou_2, ov_2)$ be IFNs, the IFN Hamming distance (IFNHD) is conducted:

$$IFNHD(o\theta_1, o\theta_2) = \frac{1}{2}\left(|ou_1 - ou_2| + |ov_1 - ov_2| + |o\pi_1 - o\pi_2|\right) \tag{4}$$

where $o\pi_1 = 1 - ou_1 - ov_1, o\pi_2 = 1 - ou_2 - ov_2$.

Definition 4 [71]: Let $o\theta_1 = (ou_1, ov_1)$ and $o\theta_2 = (ou_2, ov_2)$ be IFNs, the IFN Logarithmic distance (IFNLD) is conducted:

$$IFNLD(o\theta_1, o\theta_2) = \frac{1}{2}\left(\begin{array}{l} ou_1 \log \frac{2ou_1}{ou_1+ou_2} + ou_2 \log \frac{2ou_2}{ou_1+ou_2}\\ +ov_1 \log \frac{2ov_1}{ov_1+ov_2} + ov_2 \log \frac{2ov_2}{ov_1+ov_2}\\ +o\pi_1 \log \frac{2o\pi_1}{o\pi_1+o\pi_2} + o\pi_2 \log \frac{2o\pi_2}{o\pi_1+o\pi_2} \end{array}\right) \tag{5}$$

where $o\pi_1 = 1 - ou_1 - ov_1, o\pi_2 = 1 - ou_2 - ov_2$.

Definition 5 [69]: Let $o\theta_1 = (ou_1, ov_1)$ and $o\theta_2 = (ou_2, ov_2)$ be IFNs, the operation is conducted:

$$o\theta_1 \oplus o\theta_2 = (ou_1 + ou_2 - ou_1ou_2, ov_1ov_2) \tag{6}$$
$$o\theta_1 \otimes o\theta_2 = (ou_1ou_2, ov_1 + ov_2 - ov_1ov_2) \tag{7}$$
$$\xi o\theta_1 = \left(1 - (1 - ou_1)^{\xi}, (ov_1)^{\xi}\right),\quad \xi > 0 \tag{8}$$
$$(o\theta_1)^{\xi} = \left((ou_1)^{\xi}, 1 - (1 - ov_1)^{\xi}\right),\quad \xi > 0 \tag{9}$$

From Definition 2, the operation laws are done.

The IFWA and IFWG technique is conducted.

Definition 6 [72]: Let $o\theta_j = (ou_j, ov_j)$ be IFNs, the IFWA technique is conducted:

$$IFWA_{ow}(o\theta_1, o\theta_2, \ldots, o\theta_n) = \mathop{\oplus}_{j=1}^{n} (ow_j o\theta_j) = \left(1 - \prod_{j=1}^{n} (1 - ou_j)^{ow_j}, \prod_{j=1}^{n} (ov_j)^{ow_j}\right) \tag{10}$$

where $ow = (ow_1, ow_2, \ldots, ow_n)^T$ be weight of $o\theta_j$, $ow_j > 0$, $\sum_{j=1}^{n} ow_j = 1$.

Definition 7 [73]: Let $o\theta_j = (ou_j, ov_j)$ be IFNs, the IFWG technique is conducted:

$$IFWG_{ow}(o\theta_1, o\theta_2, \ldots, o\theta_n) = \mathop{\otimes}_{j=1}^{n} (o\theta_j)^{ow_j} = \left(\prod_{j=1}^{n} (ou_j)^{ow_j}, 1 - \prod_{j=1}^{n} (1 - ov_j)^{ow_j}\right) \tag{11}$$

where $ow = (ow_1, ow_2, \ldots, ow_n)^T$ be weight of $o\theta_j$, $ow_j > 0$, $\sum_{j=1}^{n} ow_j = 1$.

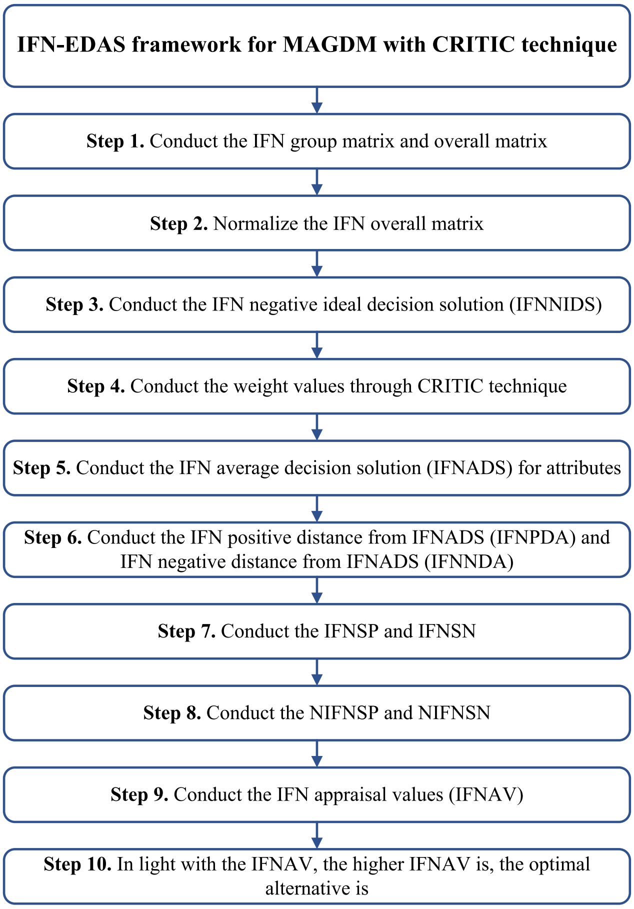

FIGURE 1. IFN-EDAS framework for MAGDM with CRITIC technique.

III. IFN-EDAS FRAMEWORK FOR MAGDM WITH CRITIC TECHNIQUE

Then, IFN-EDAS technique is conducted for MAGDM. Let $OA = \{OA_1, OA_2, \cdots, OA_m\}$ be alternatives, and attributes $OG = \{OG_1, OG_2, \cdots, OG_n\}$ with weight $ow = (ow_1, ow_2, \ldots, ow_n)^T$, where $ow_j \in [0,1]$, $\sum_{j=1}^{n} ow_j = 1$ and invited experts $OE = \{OE_1, OE_2, \cdots, OE_q\}$ with weight be $o\omega = (o\omega_1, o\omega_2, \ldots, o\omega_n)^T$, where $o\omega_j \in [0,1]$, $\sum_{j=1}^{n} o\omega_j = 1$.

Then, IFN-EDAS technique is conducted for MAGDM (See Figure 1).

Step 1: Conduct the IFN decision matrix $IFNDM^{(t)} = \left[IFNDM_{ij}^{(t)}\right]_{m\times n} = \left(ou_{ij}^{(t)}, ov_{ij}^{(t)}\right)_{m\times n}$ and conduct the overall matrix $IFNDM = \left[IFNDM_{ij}\right]_{m\times n}$: (12) and (13), as shown at the bottom of the next page.

Based on IFWA technique, the $IFNDM = \left[IFNDM_{ij}\right]_{m\times n} = \left(ou_{ij}, ov_{ij}\right)_{m\times n}$ is:

$$IFNDM_{ij} = \begin{pmatrix} o\omega_1 IFNDM_{ij}^{(1)} \oplus o\omega_2 IFNDM_{ij}^{(2)} \\ \oplus \cdots \oplus o\omega_q IFNDM_{ij}^{(q)} \end{pmatrix}$$

$$= \left(1 - \prod_{t=1}^{q}\left(1 - ou_{ij}^{(t)}\right)^{o\omega_t}, \prod_{t=1}^{q}\left(ov_{ij}^{(t)}\right)^{o\omega_t}\right) \quad (14)$$

Step 2: Normalize the $IFNDM = \left[IFNDM_{ij}\right]_{m\times n} = \left(ou_{ij}, ov_{ij}\right)_{m\times n}$ into $NIFNDM = \left[NIFNDM_{ij}\right]_{m\times n} = \left(nou_{ij}, nov_{ij}\right)_{m\times n}$.

For benefit attributes:

$$NIFNDM_{ij} = \left(nou_{ij}, nov_{ij}\right) = \left(ou_{ij}, ov_{ij}\right) \quad (15)$$

For cost attributes:

$$NIFNDM_{ij} = \left(nou_{ij}, nov_{ij}\right) = \left(ov_{ij}, ou_{ij}\right) \quad (16)$$

Step 3: Conduct the IFN negative ideal decision solution (IFNNIDS):

$$IFNNIDS_j = \left(nou_j, nov_j\right) \quad (17)$$

$$SF\left(IFNNIDS_j\right) = \min_i SF\left(nou_{ij}, nov_{ij}\right) \quad (18)$$

Step 4: Conduct the weight values with CRITIC technique.

The CRITIC technique [65] is utilized to obtain the weight values.

(1) The IFN correlation decision coefficient (IFNCDC) is conducted. (19), as shown at the bottom of the next page, where

$$f\left(IFNHDLD_j\right) = \frac{1}{2m}\sum_{i=1}^{m}\begin{pmatrix} IFNHD\left(NIFNDM_{ij}, IFNNIDS_j\right) \\ +IFNLD\left(NIFNDM_{ij}, IFNNIDS_j\right) \end{pmatrix},$$

$$f\left(IFNHDLD_t\right) = \frac{1}{2m}\sum_{i=1}^{m}\begin{pmatrix} IFNHD\left(NIFNDM_{it}, IFNNIDS_t\right) \\ +IFNLD\left(NIFNDM_{it}, IFNNIDS_t\right) \end{pmatrix},$$

$$f\left(IFNHDLD_{ij}\right) = \frac{1}{2}\begin{pmatrix} IFNHD\left(NIFNDM_{ij}, IFNNIDS_j\right) \\ +IFNLD\left(NIFNDM_{ij}, IFNNIDS_j\right) \end{pmatrix},$$

$$f\left(IFNHDLD_{it}\right) = \frac{1}{2}\begin{pmatrix} IFNHD\left(NIFNDM_{it}, IFNNIDS_t\right) \\ +IFNLD\left(NIFNDM_{it}, IFNNIDS_t\right) \end{pmatrix}.$$

(2) Conduct the IFN standard deviation (IFNSD).

$$IFNSD_j = \sqrt{\frac{1}{m-1}\sum_{i=1}^{m}\begin{pmatrix} f\left(IFNHDLD_{ij}\right) \\ -f\left(IFNHDLD_j\right) \end{pmatrix}^2} \quad (20)$$

(3) Conduct the attribute weight.

$$ow_j = \frac{IFNSD_j \sum_{t=1}^{n}\left(1 - IFNCDC_{jt}\right)}{\sum_{j=1}^{n}\left(IFNSD_j \sum_{t=1}^{n}\left(1 - IFNCDC_{jt}\right)\right)} \quad (21)$$

Step 5: Conduct the IFN average decision solution (IFNADS) for attributes.

$$IFNADS = \left[IFNADS_j\right]_{1\times n} = \left[\frac{\underset{j=1}{\overset{n}{\oplus}}\left(NIFNDM_{ij}\right)}{m}\right]_{1\times n} \quad (22)$$

$$\begin{aligned} IFNADS_j &= \frac{1}{m}\underset{i=1}{\overset{m}{\oplus}} NIFNDM_{ij} \\ &= \left(nou_j, nov_j\right) \\ &= \left(1-\prod_{i=1}^{m}\left(1-nou_{ij}\right)^{\frac{1}{m}}, \prod_{i=1}^{m}\left(nov_{ij}\right)^{\frac{1}{m}}\right) \end{aligned} \quad (23)$$

Step 6: Conduct the IFN positive distance from IFNADS (IFNPDA) and IFN negative distance from IFNADS (IFNNDA):

For the positive attributes, (24) and (25), as shown at the bottom of the next page.

For the negative attributes, (26) and (27), as shown at the bottom of the next page.

Step 7: Conduct the $IFNSP_i$ and $IFNSN_i$.

$$IFNSP_i = \sum_{j=1}^{n} ow_j \cdot IFNPDA_{ij}, \quad (28)$$

$$IFNSN_i = \sum_{j=1}^{n} ow_j \cdot IFNNDA_{ij}, \quad (29)$$

Step 8: Conduct the normalized $IFNSP_i$ and $IFNSN_i$:

$$NIFNSP_i = \frac{IFNSP_i}{\max_i \left(IFNSP_i\right)}, \quad (30)$$

$$NIFNSN_i = 1 - \frac{IFNSN_i}{\max_i \left(IFNSN_i\right)} \quad (31)$$

Step 9: Conduct the IFN appraisal values (IFNAV).

$$IFNAV_i = \frac{1}{2}\left(NIFNSP + NIFNSN_i\right) \quad (32)$$

Step 10: In light with the IFNAV, the higher IFNAV is, the optimal alternative is.

IV. NUMERICAL EXAMPLE AND COMPARATIVE ANALYSIS

A. NUMERICAL EXAMPLE FOR SUSTAINABLE POTENTIAL BEARING CAPACITY EVALUATION OF TOURISM ENVIRONMENT

In the context of the dual carbon goals, optimizing the energy structure has become the only way to reduce carbon emissions in the tourism environment. The tourism industry should focus on and address the high energy consumption in tourism activities, as well as the resulting carbon emissions in the

$$\begin{aligned} &(1)\ o\theta_1 \oplus o\theta_2 = o\theta_2 \oplus o\theta_1,\ o\theta_1 \otimes o\theta_2 = o\theta_2 \otimes o\theta_1,\ \left(\left(o\theta_1\right)^{\xi_1}\right)^{\xi_2} = \left(o\theta_1\right)^{\xi_1\xi_2};\\ &(2)\ \xi\left(o\theta_1 \oplus o\theta_2\right) = \xi o\theta_1 \oplus \xi o\theta_2,\ \left(o\theta_1 \otimes o\theta_2\right)^{\xi} = \left(o\theta_1\right)^{\xi} \otimes \left(o\theta_2\right)^{\xi};\\ &(3)\ \xi_1 o\theta_1 \oplus \xi_2 o\theta_1 = \left(\xi_1+\xi_2\right) o\theta_1,\ \left(o\theta_1\right)^{\xi_1} \otimes \left(o\theta_1\right)^{\xi_2} = \left(o\theta_1\right)^{\left(\xi_1+\xi_2\right)}. \end{aligned}$$

$$IFNDM^{(t)} = \left[IFNDM_{ij}^{(t)}\right]_{m\times n} = \begin{matrix} & OG_1 & OG_2 & \cdots & OG_n \\ \begin{matrix} OA_1 \\ OA_2 \\ \vdots \\ OA_m \end{matrix} & \multicolumn{4}{c}{\begin{bmatrix} IFNDM_{11}^{(t)} & IFNDM_{12}^{(t)} & \cdots & IFNDM_{1n}^{(t)} \\ IFNDM_{21}^{(t)} & IFNDM_{22}^{(t)} & \cdots & IFNDM_{2n}^{(t)} \\ \vdots & \vdots & \vdots & \vdots \\ IFNDM_{m1}^{(t)} & IFNDM_{m2}^{(t)} & \cdots & IFNDM_{mn}^{(t)} \end{bmatrix}} \end{matrix} \quad (12)$$

$$IFNDM = \left[IFNDM_{ij}\right]_{m\times n} = \begin{matrix} & OG_1 & OG_2 & \cdots & OG_n \\ \begin{matrix} OA_1 \\ OA_2 \\ \vdots \\ OA_m \end{matrix} & \multicolumn{4}{c}{\begin{bmatrix} IFNDM_{11} & IFNDM_{12} & \cdots & IFNDM_{1n} \\ IFNDM_{21} & IFNDM_{22} & \cdots & IFNDM_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ IFNDM_{m1} & IFNDM_{m2} & \cdots & IFNDM_{mn} \end{bmatrix}} \end{matrix} \quad (13)$$

$$IFNCDC_{jt} = \frac{\sum_{i=1}^{m}\left(f\left(IFNHDLD_{ij}\right) - f\left(IFNHDLD_j\right)\right) f\left(IFNHDLD_{it}\right) - f\left(IFNHDLD_t\right)}{\sqrt{\sum_{i=1}^{m}\left(f\left(IFNHDLD_{ij}\right) - f\left(IFNHDLD_j\right)\right)^2}\sqrt{\sum_{i=1}^{m}\left(f\left(IFNHDLD_{it}\right) - f\left(IFNHDLD_t\right)\right)^2}},$$

$$j, t = 1, 2, \ldots, n, \quad (19)$$

TABLE 1. Linguistic scale and IFNs.

Linguistic Terms	IFNs
Exceedingly Terrible-OET	(0.10,0.80)
Very Terrible-OVT	(0.20,0.70)
Terrible-OT	(0.30,0.60)
Medium-OM	(0.50,0.50)
Well-OW	(0.65,0.30)
Very Well-OVW	(0.75,0.20)
Exceedingly Well-OEW	(1.0,0.0)

TABLE 2. Evaluation values from OE_1.

	OG_1	OG_2	OG_3	OG_4
OA_1	OW	OM	OT	OVW
OA_2	OT	OW	OVW	OVT
OA_3	OM	OM	OW	OT
OA_4	OM	OW	OVW	OT
OA_5	OW	OVT	OVT	OM

tourism industry. The methods to optimize regional energy consumption structure include the government introducing relevant policies in areas such as clothing, food, housing, and transportation to ensure the implementation of optimized energy structure, developing and utilizing environmentally friendly clean or renewable energy, encouraging people to

$$IFNPDA_{ij} = \frac{1}{2}\left(\begin{array}{c}\frac{\max(0, IFNHD(NIFNDM_{ij}, IFNNIDS_j) - IFNHD(IFNADS_j, IFNNIDS_j))}{IFNHD(IFNADS_j, IFNNIDS_j)} \\ + \frac{\max(0, IFNLD(NIFNDM_{ij}, IFNNIDS_j) - IFNLD(IFNADS_j, IFNNIDS_j))}{IFNLD(IFNADS_j, IFNNIDS_j)}\end{array}\right) \tag{24}$$

$$IFNNDA_{ij} = \frac{1}{2}\left(\begin{array}{c}\frac{\max(0, IFNHD(IFNADS_j, IFNNIDS_j) - IFNHD(NIFNDM_{ij}, IFNNIDS_j))}{IFNHD(IFNADS_j, IFNNIDS_j)} \\ + \frac{\max(0, IFNLD(IFNADS_j, IFNNIDS_j) - IFNLD(NIFNDM_{ij}, IFNNIDS_j))}{IFNLD(IFNADS_j, IFNNIDS_j)}\end{array}\right) \tag{25}$$

$$IFNPDA_{ij} = \frac{1}{2}\left(\begin{array}{c}\frac{\max(0, IFNHD(IFNADS_j, IFNNIDS_j) - IFNHD(NIFNDM_{ij}, IFNNIDS_j))}{IFNHD(IFNADS_j, IFNNIDS_j)} \\ + \frac{\max(0, IFNLD(IFNADS_j, IFNNIDS_j) - IFNLD(NIFNDM_{ij}, IFNNIDS_j))}{IFNLD(IFNADS_j, IFNNIDS_j)}\end{array}\right) \tag{26}$$

$$IFNNDA_{ij} = \frac{1}{2}\left(\begin{array}{c}\frac{\max(0, IFNHD(NIFNDM_{ij}, IFNNIDS_j) - IFNHD(IFNADS_j, IFNNIDS_j))}{IFNHD(IFNADS_j, IFNNIDS_j)} \\ + \frac{\max(0, IFNLD(NIFNDM_{ij}, IFNNIDS_j) - IFNLD(IFNADS_j, IFNNIDS_j))}{IFNLD(IFNADS_j, IFNNIDS_j)}\end{array}\right) \tag{27}$$

TABLE 3. Evaluation values from OE_2.

	OG_1	OG_2	OG_3	OG_4
OA_1	OVT	OVW	OM	OVT
OA_2	OVW	OVT	OM	OT
OA_3	OW	OM	OVT	OVW
OA_4	OM	OT	OVW	OW
OA_5	OW	OVW	OVT	OM

TABLE 4. Evaluation values from OE_3.

	OG_1	OG_2	OG_3	OG_4
OA_1	OM	OVW	OT	OW
OA_2	OVT	OM	OVW	OW
OA_3	OVT	OVW	OM	OW
OA_4	OVW	OW	OM	OT
OA_5	OVW	OT	OVT	OM

TABLE 5. The $IFNDM = \left[IFNDM_{ij}\right]_{5\times 4}$.

	OG_1	OG_2	OG_3	OG_4
OA_1	(0.45，0.23)	(0.56，0.44)	(0.31，0.46)	(0.64，0.36)
OA_2	(0.74，0.11)	(0.69，0.21)	(0.63，0.29)	(0.57，0.23)
OA_3	(0.63，0.31)	(0.48，0.34)	(0.72，0.25)	(0.37，0.34)
OA_4	(0.76，0.23)	(0.63，0.19)	(0.53，0.42)	(0.54，0.45)
OA_5	(0.79，0.16)	(0.82，0.17)	(0.46，0.41)	(0.67，0.21)

travel low-carbon, and suppressing the use of energy with high carbon emission intensity from the source to reduce carbon emissions in the tourism industry. From the perspective of the tourism industry, specific measures can be taken from tourism transportation, tourism accommodation, and specific tourist attractions. As a destination for tourists to engage in tourism activities, the environment and carbon emissions pollution of tourist attractions have an important impact on the sustainable carrying potential of the tourism environment of the entire tourist destination. Therefore, scenic spots should focus on reducing carbon emissions from both tourism carbon sources and carbon sinks. In terms of tourism carbon sources, it is necessary to choose green and clean energy and carbon reduction technologies according to the positioning of the scenic area itself, and actively update the use of high energy consuming facilities and equipment in the park. Scenic area managers need to introduce intelligent and intelligent tourism management systems to understand and observe the behavior of tourists in real time, and use the powerful functions of intelligent systems to provide tourists

TABLE 6. The $NIFNDM = \left[NIFNDM_{ij}\right]_{5\times 4}$.

	OG_1	OG_2	OG_3	OG_4
OA_1	(0.45，0.23)	(0.56，0.44)	(0.31，0.46)	(0.64，0.36)
OA_2	(0.74，0.11)	(0.69，0.21)	(0.63，0.29)	(0.57，0.23)
OA_3	(0.63，0.31)	(0.48，0.34)	(0.72，0.25)	(0.37，0.34)
OA_4	(0.76，0.23)	(0.63，0.19)	(0.53，0.42)	(0.54，0.45)
OA_5	(0.79，0.16)	(0.82，0.17)	(0.46，0.41)	(0.67，0.21)

TABLE 7. The IFINIDS.

	OG_1	OG_2	OG_3	OG_4
IFNNIDS	(0.45，0.23)	(0.48，0.34)	(0.31，0.46)	(0.37，0.34)

TABLE 8. The weight values.

	OG_1	OG_2	OG_3	OG_4
weight	0.2333	0.3355	0.2177	0.2135

TABLE 9. The IFNADS.

	IFNADS
OG_1	(0.28，0.34)
OG_2	(0.37，0.23)
OG_3	(0.26，0.45)
OG_4	(0.32，0.19)

with rich and colorful information about scenic areas and tourism. In this process, it is necessary to convey to tourists that sustainable development of tourism must take the path of low-carbon development through the joint efforts of tourists and other related themes, so that tourists understand their responsibilities and obligations, There is a consensus in the whole society that when the concept of low-carbon and environmental protection travel is formed, it will also bring certain convenience to the management of scenic spots, not only saving tourism management costs, but also saving manpower and material resources. The degree of emphasis placed on greenery in scenic areas is to some extent proportional to the carbon sequestration capacity they can provide. When the forest coverage of the scenic area reaches a certain proportion, the absorbed carbon dioxide can be fixed in the vegetation or soil. Therefore, carbon sequestration should be given more

TABLE 10. The IFNPDA.

	OG_1	OG_2	OG_3	OG_4
OA_1	0.0357	0.0000	0.0000	0.6475
OA_2	0.0000	0.0283	0.4765	0.0000
OA_3	0.6684	0.0000	0.0468	0.0000
OA_4	0.0000	0.0000	0.0000	0.5451
OA_5	0.0000	0.9234	0.6716	0.0000

TABLE 11. The IFNNDA.

	OG_1	OG_2	OG_3	OG_4
OA_1	0.0000	0.7261	0.2997	0.0000
OA_2	0.2492	0.0000	0.0000	0.2508
OA_3	0.0000	0.0983	0.0000	0.4339
OA_4	0.3429	0.2359	0.2554	0.0000
OA_5	0.7056	0.0000	0.0000	0.4254

attention, as it plays a very important and critical role in absorbing carbon. Therefore, high vegetation coverage in scenic areas can be fully utilized, the comparative advantage of abundant forest resources can be enhanced by planting trees and improving vegetation types in suitable areas of the scenic area, thereby enhancing the self-purification ability of the natural ecosystem and enhancing the carbon absorption capacity of the scenic area. The sustainable potential bearing capacity evaluation of tourism environment is a MAGDM. Therefore, the sustainable potential bearing capacity evaluation of tourism environment is presented to show the developed approach in this paper. There are five national ecological tourism demonstration scenic areas OA_i $(i = 1, 2, 3, 4, 5)$ are selected in line with four attributes: ① OG_1 is potential capacity for ecotourism development; ② OG_2 is potential capacity of tourism industry development; ③OG_3 is potential capacity of tourism economic development; ④OG_4 is potential capacity of tourism development. The five national ecological tourism demonstration scenic areas OA_i $(i = 1, 2, 3, 4, 5)$ are assessed through employing the linguistic scales (See Table 1 [74]) based on four attributes through three experts $OE^{(t)}$ $(t = 1, 2, 3)$ with expert's weight values is (0.35, 0.30, 0.35).

The IFN-EDAS technique is conducted to manage the sustainable potential bearing capacity evaluation of tourism environment.

Step 1: Conduct the $IFNDM^t = \left[IFNDM_{ij}^t\right]_{5\times4}$ (See Table 2-4).

Then in line with IFWA technique, the $IFNDM = \left[IFNDM_{ij}\right]_{5\times4}$ is conducted (Table 5).

Step 2: Normalize the $IFNDM = \left[IFNDM_{ij}\right]_{5\times4}$ into $NIFNDM = \left[NIFNDM_{ij}\right]_{5\times4}$ (See Table 6).

Step 3: Conduct the IFINIDS (See Table 7).

TABLE 12. The IFNSP and IFNSN.

	IFNSP	IFNSN
OA_1	0.1466	0.3088
OA_2	0.1132	0.1117
OA_3	0.1661	0.1256
OA_4	0.1164	0.2147
OA_5	0.4560	0.2554

TABLE 13. The NIFNSP and NIFNSN.

	NIFNSP	NIFNSN
OA_1	0.3215	0.0000
OA_2	0.2483	0.6384
OA_3	0.3643	0.5932
OA_4	0.2552	0.3047
OA_5	1.0000	0.1729

TABLE 14. The IFNAV.

	IFNAV	Order
OA_1	0.1607	5
OA_2	0.4434	3
OA_3	0.4788	2
OA_4	0.2800	4
OA_5	0.5865	1

Step 4: Conduct the weight information (See Table 8):
Step 5: Conduct the IFNADS (Table 9).

Step 6: Conduct the IFNPDA and IFNNDA (See Table 10-11).

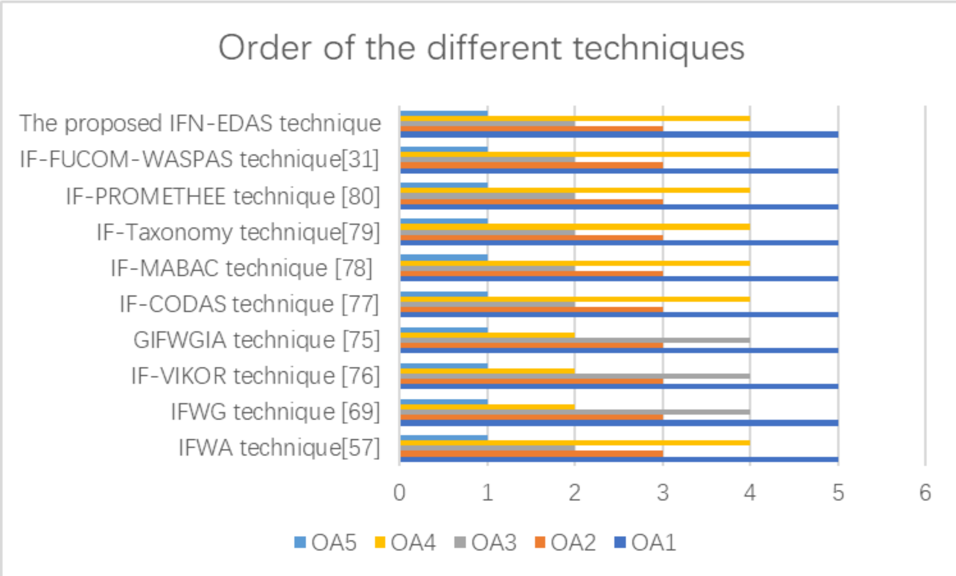

FIGURE 2. Order of the different techniques.

TABLE 15. Order of the different techniques.

	Order
IFWA technique[57]	$OA_5 > OA_3 > OA_2 > OA_4 > OA_1$
IFWG technique [69]	$OA_5 > OA_3 > OA_4 > OA_2 > OA_1$
IF-VIKOR technique [76]	$OA_5 > OA_3 > OA_4 > OA_2 > OA_1$
GIFWGIA technique [75]	$OA_5 > OA_3 > OA_4 > OA_2 > OA_1$
IF-CODAS technique [77]	$OA_5 > OA_3 > OA_2 > OA_4 > OA_1$
IF-MABAC technique [78]	$OA_5 > OA_3 > OA_2 > OA_4 > OA_1$
IF-Taxonomy technique[79]	$OA_5 > OA_3 > OA_2 > OA_4 > OA_1$
IF-PROMETHEE technique [80]	$OA_5 > OA_3 > OA_2 > OA_4 > OA_1$
IF-FUCOM-WASPAS technique[31]	$OA_5 > OA_3 > OA_2 > OA_4 > OA_1$
The proposed IFN-EDAS technique	$OA_5 > OA_3 > OA_2 > OA_4 > OA_1$

Step 7: Conduct the values of IFNSP and IFNSN (See Table 12).

Step 8: Conduct the NIFNSP and NIFNSN (Table 13).

Step 9: Calculate the IFNAV (See Table 14).

TABLE 16. WS coefficient calculation.

	IFN-EDAS technique	IFWA technique	IFWG technique	IF-VIKOR technique
OA_1	5	5	5	5
OA_2	3	3	3	3
OA_3	2	2	4	4
OA_4	4	4	2	2
OA_5	1	1	1	1
Coefficients	WS	1.0000	0.7917	0.7917

	IFN-EDAS technique	GIFWGIA technique	IF-CODAS technique	IF-MABAC technique
OA_1	5	5	5	5
OA_2	3	3	3	3
OA_3	2	4	2	2
OA_4	4	2	4	4
OA_5	1	1	1	1
Coefficients	WS	0.7917	1.0000	1.0000

	IFN-EDAS technique	IF-Taxonomy technique	IF-PROMETHEE technique	IF-FUCOM-WASPAS technique
OA_1	5	5	5	5
OA_2	3	3	3	3
OA_3	2	2	2	2
OA_4	4	4	4	4
OA_5	1	1	1	1
Coefficients	WS	1.0000	1.0000	1.0000

Step 10: In line with the IFNAV, the order is: $OA_5 > OA_3 > OA_2 > OA_4 > OA_1$ and OA_5 is the optimal national ecological tourism demonstration scenic area.

B. COMPARATIVE ANALYSIS

Then, the IFN-EDAS technique is compared with IFWA technique [57] and IFWG technique [69], generalized intuitionistic fuzzy weighted geometric interaction averaging (GIFWGIA) technique [75], IF-VIKOR technique [76], IF-CODAS technique [77], IF-MABAC technique [78], IF-Taxonomy technique [79], IF-PROMETHEE technique [80] and intuitionistic fuzzy FUCOM-WASPAS(IF-FUCOM-WASPAS) technique [31]. The comparative information results are conducted in Table 15 and Figure 2.

Furthermore, the order similarity degree between the IFWA technique [57] and IFWG technique [69], GIFWGIA technique [75], IF-VIKOR technique [76], IF-CODAS technique [77], IF-MABAC technique [78], IF-Taxonomy technique [79], IF-PROMETHEE technique [80], IF-FUCOM-WASPAS technique [31]. and the proposed IFN-EDAS technique was conducted in line with the WS coefficients [81], the calculating results are conducted in Table 16.

The WS coefficient conducted the order results of the proposed IFN-EDAS technique is same to the order results of the IFWA technique [57], IF-CODAS technique [77], IF-MABAC technique [78], IF-Taxonomy technique [79], IF-PROMETHEE technique [80] and IF-FUCOM-WASPAS technique [31]; the WS coefficient shows the order results of the proposed IFN-EDAS is slightly different to the order results of the IFWG technique [69], GIFWGIA technique [75] and IF-VIKOR technique [76]. Furthermore, the reason for this subtle order difference is that IFWG technique [69] and GIFWGIA technique [75] emphasize the individual's influence for decision result; while IF-VIKOR technique [76]focused on maximizing group benefits and minimizing individual regrets of opposing opinions. This verifies the IFN-EDAS model is reasonable and effective.

V. CONCLUSION

The tourism environment system does not refer to a single natural system, but a composite environmental system that includes social, economic, natural and other subsystems established within a specific research period, based on the tourism resources of the tourism destination and with the interests of multiple stakeholders as the core. Compared to general environmental systems, tourism environmental systems are more complex and mainly include the following points: firstly, the smooth development of tourism activities not only relies on the tourism resources of the destination, but also on the participation of multiple parties to complete the entire tourism activity. Secondly, the tourism environment system has aggregation and scale, and the tourism industry extends upstream and downstream to drive larger scale development. Finally, the tourism environment system is a closely connected circular development system. Any situation in any part of the system will provide feedback to promote or inhibit the normal operation of other parts, coordinate the normal operation of various parts of the tourism environment, and pay attention to the sustainable improvement of the tourism environment system, promoting harmonious coexistence between people and the environment. The sustainable potential bearing capacity evaluation of tourism environment is MAGDM. Recently, the EDAS technique was utilized to solve the MAGDM. The IFSs are utilized as a technique for portraying uncertain information during the sustainable potential bearing capacity evaluation of tourism environment. In this paper, the IFN-EDAS technique is conducted to manage MAGDM under IFSs. Finally, a numerical case study for sustainable potential bearing capacity evaluation of tourism environment is supplied to validate the proposed technique.

There may be some possible limitations for sustainable potential bearing capacity evaluation of tourism environment, which can be further conducted in future research: (1) It is a worthwhile research topic to apply multi-agent systems to sustainable potential bearing capacity evaluation of tourism environment under IFSs environment [82], [83], [84]; (2) It is also worthwhile to apply regret theory to the study of sustainable potential bearing capacity evaluation of tourism environment under IFSs environment [85], [86], [87]; (3) In subsequent studies, the application of IFSs needs to be conducted with consensus measures for sustainable potential bearing capacity evaluation of tourism environment [88], [89], [90], [91], [92].

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RONG YAN was born in Hubei, in 1985. She received the master's degree from Hainan Tropical Ocean University. She is currently a Teacher with the Chongqing City Vocational College. Her research interests include tourism planning and business administration.

YONGGUANG HAN was born in Shandong, in 1982. He received the master's degree from Chongqing Normal University. He is currently a Teacher with the Chongqing City Vocational College. His research interests include scenic spot planning and project management.

FANG LI was born in Handan, Hebei, China, in 1983. She received the master's degree from Nanchang University, China. She is currently pursuing the degree with the University of Perpetual Help System DALTA, Philippines. Her research interests include operation management, information security, and big data analysis.

PENGFEI LI was born in Taiyuan, Shanxi, China, in 1985. He received the master's degree from the University of Western Australia. He is currently pursuing the degree with the University of Perpetual Help System DALTA, Philippines. His research interests include operation management, educational psychology, and big data analysis.