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Intelligent Ranking System for Sustainability Factors in Case of Community-based Tourism

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Abstract

This work proposes a soft computing-based ranking information system to assess the ranking order of the four pillars of sustainability, i.e. (Economic Sustainability, Environmental Sustainability, Social Sustainability, Cultural Sustainability) regarding community-based tourism. In this work, two groups of experts were involved in assessing linguistic inputs. Further, these linguistic inputs were converted to trapezoidal fuzzy numbers; after that, two soft computing techniques, i.e., F-AHP and F-TOPSIS, were applied to obtain the ranking order of all four pillars of sustainability. Community-based tourism (CBT) promotes local community contribution based on celebrating local cultures to holistic development. As per the CBT objective, it aims to maximize investors' profits and maximize the benefits for community stakeholders. The rankings obtained by the suggested system will be helpful for the government, administrative bodies, and different tour operators for making policies according to the rank of each pillar. The contribution of the research is in the tourism industry. The suggested information system has ranked sustainability factors with the intention that policymakers will make policies to improve the poorly ranked factors.

Disciplinary: Artificial Intelligence, Sustainable Tourism Management, Applied Mathematics (Fuzzy), Market Research.

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1 Introduction

India is a land known for its rich and varied ancient culture and its traditions. Its geographical locations, diverse religions, and ancient civilizations made it a prominent hot spot for the tourism industries. India contributed 269.29 billion US dollars in its GDP in 2018, which accounts for 9.2% of India's total GDP. According to the survey conducted by Statista, India has a vast scope for extending its GDP twice in 2029 compared to 2019. According to The Travel and Tourism Competitiveness Report 2019, the ranking of India is 34 out of 140 countries. In this report, the ranking of price affordability of the Indian tourism sector stood at 13 out of 140 countries. India's economy depends heavily on tourism. According to these estimates, the tourism industry contributes significantly to the country's economic development. However, because of the rapid spread of Covid-19 in India, this critical industry has been shut down. When the pandemic is under control, the government must prioritize the recovery of the tourism industry. The most urgent steps will be to rekindle people's enthusiasm for tourism and rebuild job prospects for local communities by encouraging community-based tourism, which is also a key component of the government's recent 'vocal for local' initiative.

Understanding community development theory becomes more relevant in India and other developing countries when talking about community-based tourism. The process of generating economic and social growth for the entire community with their involvement is known as community development. The tourism industry has been shown to offer a variety of profits to communities that lack the financial capital and knowledge to enable them to participate in tourism development without the need for outside help. New sustainable development principles are often adopted to empower and encourage people. (Srivastava et al., 2021). Because of the key function of CBT, the involvement of the local population with tourism is often observed. CBT will also help local communities meet their social, economic, environmental, and cultural needs(Han et al., 2019). Sustainability is an important factor in CBT's development because it aids in policymaking and strategic management. In the tourism industry, sustainable tourism is becoming more common. Many studies have been conducted to assess the value of several features of sustainability in different sectors, such as economic, social, cultural, and environmental sustainability (Beekaroo et al., 2019; Butnariu et al., 2015; Lee et al., 2012). Many articles on multicriteria-based recommendation systems can be found in the literature (Farokhi et al., 2016; Okfalisa et al., 2020).

Recently (Srivastava et al., 2020), A tourist destination recommendation framework based on soft computing has been proposed. In the current work, an intelligent framework is being developed to rank the four pillars of sustainability in community-based tourism.

2 Materials and Methods

For the development of the ranking system, the tools we have used are, Fuzzy sets(Klir et al., 1995; Zadeh, 1965), Fuzzy AHP (F-AHP) (van Laarhoven et al., 1983), Fuzzy TOPSIS(Chen, 2000), and In the case of CBT, attempting to configure the position of the four main sustainability factors.

2.1 Definitions

2.1.1 Fuzzy Sets

In a universe of discourse $\boldsymbol{R}$**,** a fuzzy set $\tilde{P}$ is characterized by its membership grade $\tilde{\mu}_P(x)$ such that

$$\tilde{\mu}_P(x) \rightarrow [0\ 1], \forall\ x \in \boldsymbol{R} \quad (1),$$

then

$$\tilde{P} = \{(x,\ \tilde{\mu}_P(x): x \in \boldsymbol{R}\} \quad (2).$$

2.1.2 Fuzzy Numbers

In the universe of discourse $\boldsymbol{R}$, a fuzzy number is a fuzzy subset that is both convex and normalized (Klir et al., 1995).

2.1.3 Trapezoidal Fuzzy Numbers

A fuzzy number $\tilde{P} = (p, q, r, s)$**,** with its membership function, is given by

$$\tilde{\mu}_A(x) = \begin{cases} \frac{x-p}{q-p}, & p \leq x \leq q \\ 1 & , q \leq x \leq r \\ \frac{s-x}{s-r} & r \leq x \leq s \\ 0 & elsewhere \end{cases} \quad (3),$$

which terms a trapezoidal fuzzy number.

2.1.4 Normalized Fuzzy Sets

A fuzzy set $\tilde{P}$, is called a normalized in the universe of discourse $\boldsymbol{R}$, if $\exists\ an\ x\ \in \boldsymbol{R}$ such that

$$\tilde{\mu}_P(x) = 1 \quad (4).$$

2.1.5 Linguistic Variables

Language words are the values of such a variable, and fuzzy numbers can be used to denote linguistic values (Zadeh, 1975). For instance, the linguistic variable "weight" has values such as very low, low, high, very high, Extremely high, and so on.

2.1.6 A Measure for Distance Between Two Trapezoidal Fuzzy Numbers

Let us consider two trapezoidal fuzzy numbers $\tilde{A} = (a_1, a_2, a_3, a_4)$ and $\tilde{B} = (b_1, b_2, b_3, b_4)$ with centroid points (α_A, β_A) and (α_B, β_B), left and right spreads are (L_A, R_A) and (L_B, R_B) respectively. Then, the distance(Ebadi et al., 2013) between the two trapezoidal fuzzy number is given by:

$$d(\tilde{A}, \tilde{B}) = \max\{|\alpha_A - \alpha_B|, |\beta_A - \beta_B|, |L_A - L_B|, |R_A - R_B|\} \quad (5),$$

where

$$\alpha_A = \frac{1}{3}[a_1 + a_2 + a_3 + a_4 - \frac{a_4 a_3 - a_1 a_2}{(a_4 + a_3) - (a_1 + a_2)}] \quad (6),$$

$$\beta_A = \frac{1}{3}[1 - \frac{a_3 - a_2}{(a_4 + a_3) - (a_1 + a_2)}] \quad (7),$$

$$L_A = a_2 - a_1, and\ R_A = a_4 - a_3 \quad (8).$$

3 Methodology

3.1 Fuzzy AHP (F-AHP)

The procedure of Fuzzy AHP is as follows in terms of developing an intelligent ranking structure.

· **Step-1**

Table 1 gives the fuzzy scales if we are making a comparison matrix of given criteria and then for pairwise comparisons if criteria C_1 has High Dominance to criteria C_3, a decision-maker may rate it as (3, 5, 7,9) on the other hand, the criteria C_3 will be less critical to C_1 hence it will be assessed as (1/9, 1/7, 1/5, 1/3).

Table 1: **A** fuzzified scale to perform the pairwise comparison.

Linguistic Variables	Symbolic Codes	Fuzzy Scale
Equal Importance	E I	(1.0, 1.0, 1.0,1.0)
Very Less Important	V L I	(0,0.50,1.50,2.0)
Less Important	L I	(1.0, 1.50, 2.50, 3.0)
Important	I	(2.0, 2.50, 3.50, 4.0)
Very Important	V I	(3.0, 3.50, 4.50, 5.0)
Extremely Important	Ex.I	(4.0, 4.50, 5.50, 6.0)

Suppose there are (k) decision-makers, (p) criteria, and (q) alternatives, then the comparison matrix for the kth decision maker is

$$\widetilde{M}^k = \begin{bmatrix} \tilde{c}_{11}^k & \tilde{c}_{12}^k & \dots \tilde{c}_{1p}^k \\ \tilde{c}_{21}^k & \tilde{c}_{22}^k & \dots \tilde{c}_{2p}^k \\ \dots & \dots & \dots \\ \tilde{c}_{p1}^k & \tilde{c}_{p2}^k & \dots \tilde{c}_{pp}^k \end{bmatrix} \quad (9),$$

where $\tilde{c}_{ij}^k$ is a trapezoidal fuzzy number.

· **Step-2**

After step (1), the average preference comparison matrix will be

$$\widetilde{M} = \begin{bmatrix} \tilde{c}_{11} & \tilde{c}_{12} & \dots \tilde{c}_{1p} \\ \tilde{c}_{21} & \tilde{c}_{22} & \dots \tilde{c}_{2p} \\ \dots & \dots & \dots \\ \tilde{c}_{p1} & \tilde{c}_{p2} & \dots \tilde{c}_{pp} \end{bmatrix} \quad (10),$$

where

$$\tilde{c}_{ij} = \frac{\sum_{k=1}^{k} \tilde{c}_{ij}^k}{k} \quad (11).$$

· **Step-3**

Calculation of geometric mean for each criterion-

$$\tilde{r}_i = \left(\prod_{j=1}^{p} \widetilde{c_{ij}}\right)^{\left(\frac{1}{p}\right)} \qquad , i = 1, 2, 3, \cdots p \quad (12),$$

where $\tilde{r}_i = (\alpha_i, \beta_i, \gamma_i, \delta_i)$.

· **Step-4**

Evaluation of fuzzy weights for each criterion

$$S = \sum_{i=1}^{p} \tilde{r}_i \qquad (13),$$

where

$$\tilde{r}_1 \oplus \tilde{r}_2 \oplus \ldots \oplus \tilde{r}_p = (\alpha_1, \beta_1, \gamma_1, \delta_1) \oplus (\alpha_2, \beta_2, \gamma_2, \delta_2) \ldots (\alpha_p, \beta_p, \gamma_p, \delta_p)$$

$$= (\alpha_1 + \alpha_2 \ldots + \alpha_p, \beta_1 + \beta_2 + \cdots + \beta_p, \gamma_1 + \gamma_2 \ldots + \gamma_p, \delta_1 + \delta_2 \ldots + \delta_p)$$

$$= \left(\sum_{i=1}^{p} \alpha_i, \sum_{i=1}^{p} \beta_i, \sum_{i=1}^{p} \gamma_i, \sum_{i=1}^{p} \delta_i\right)$$

$$S^{-1} = \left(\frac{1}{\sum_{i=1}^{p} \delta_i}, \frac{1}{\sum_{i=1}^{p} \gamma_i}, \frac{1}{\sum_{i=1}^{p} \beta_i}, \frac{1}{\sum_{i=1}^{p} \alpha_i}\right) \qquad (14).$$

Now for each criteria C_i, the fuzzy weight is given by

$$\widetilde{w}_i = (\tilde{r}_i \otimes S^{-1}) \qquad (15).$$

where $\widetilde{w}_i = (w_{i1}, w_{i2}, w_{i3}, w_{i4})$.

· **Step-5**

Defuzzification of $\widetilde{w}_i$ to obtain crisp value by MATLAB (center of the area) method.

· **Step-6**

By process of normalization, we will obtain a normalized weight value for each criterion

$$N_i = \frac{W_i}{\sum_{i=1}^{p} W_i} \qquad (16).$$

· **Step-7**

Apply the above steps corresponding to each criterion and for each alternative, say normalized weight vector for criteria is $w^c = (w_1^c, w_2^c, w_3^c \ldots w_p^c)^T$ where w_i^c is the normalized weight for i^{th} criteria and normalized weight matrix for q alternatives are $W^a = [a_{ij}]$, for 1(i)q, 1(j) p, where a_{ij} is the normalized weight for i^{th} alternative and the concerning j^{th} criteria, each a_{ij} and w_i^c are evaluated with the help of step 12, which is given by the term

$$W^a = \begin{bmatrix} a_{11} & a_{12} & \ldots a_{1p} \\ a_{21} & a_{22} & \ldots a_{2p} \\ \ldots & \ldots & \ldots \\ a_{q1} & a_{q2} & \ldots a_{qp} \end{bmatrix} \qquad (17).$$

We will obtain the scores for each alternative by

$$A = W^a w^c \qquad (18),$$

$$A = \begin{bmatrix} A_1 \\ A_2 \\ \ldots \\ A_q \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & \ldots a_{1p} \\ a_{21} & a_{22} & \ldots a_{2p} \\ \ldots & \ldots & \ldots \\ a_{q1} & a_{q2} & \ldots a_{qp} \end{bmatrix} \begin{bmatrix} w_1^c \\ w_2^c \\ \ldots \\ w_p^c \end{bmatrix} \qquad (19).$$

Here the alternative with the highest score will be suggested as the first preference.

3.2 Fuzzy TOPSIS

The Fuzzy TOPSIS is based upon the principle of distance to a positive and negative ideal solution, with the basic method being as follows.

· **Step 1:**

Consider, if we have k experts (decision-makers), and the k[th] decision maker's inputs for i^{th} alternative regarding j^{th} criteria are $\tilde{x}_{ij}{}^{k} = \left(a_{ij}{}^{k},\ b_{ij}{}^{k}, c_{ij}{}^{k}, d_{ij}{}^{k}\right)$ and inputs for weight are $\widetilde{w}_j{}^{k} = \left(w_{j1}{}^{k},\ w_{j2}{}^{k},\ w_{j3}{}^{k}, w_{j4}{}^{k}\right)$ respectively, where $1 \le i \le m;\ i \in \boldsymbol{N}$ and $1 \le j \le n;\ j \in \boldsymbol{N}$

· **Step 2:**

Aggregated fuzzy inputs of i^{th} alternative regarding j^{th} criteria are $\tilde{x}_{ij}=(a_{ij}, b_{ij}, c_{ij}, d_{ij})$ such that

$$a_{ij} = \min_k\{a_{ij}{}^{k}\},\ b_{ij} = \min_k\{b_{ij}{}^{k}\},\ c_{ij} = \max_k\{c_{ij}{}^{k}\},\ d_{ij} = \max_k\{d_{ij}{}^{k}\} \quad (20).$$

And the aggregated values of fuzzy importance weights are $\widetilde{w}_j = (w_{j1}, w_{j2}, w_{j3}, w_{j4})$

$$w_{j1} = \min_k\{w_{j1}{}^{k}\},\ w_{j2} = \min_k\{w_{j2}{}^{k}\},\ w_{j3} = \max_k\{w_{j3}{}^{k}\},\ w_{j4} = \max_k\{w_{j4}{}^{k}\}$$

· **Step 3:**

The matrix $\widetilde{D}$ denotes the fuzzy decision matrix, which contains aggregate values of all fuzzy inputs which are taken from experts,

$$\widetilde{D} = \begin{array}{c} \\ A_1 \\ A_2 \\ \dots \\ A_m \end{array} \begin{array}{c} \begin{array}{ccc} C_1 & C_2 & \dots C_n \end{array} \\ \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots \tilde{x}_{2n} \\ \dots & \dots & \dots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots \tilde{x}_{mn} \end{bmatrix} \end{array} \quad (21).$$

And the aggregate values of fuzzy importance of weights are given by the row matrix $\widetilde{W}$.

$$\widetilde{W} = [\widetilde{w}_1 \quad \widetilde{w}_2 \quad \widetilde{w}_3 \quad \dots \quad \widetilde{w}_n] \quad (22),$$

where each $\tilde{x}_{ij}$, $\widetilde{w}_j$ $\forall$ $1 \le i \le m;\ i \in \boldsymbol{N}$ and $1 \le j \le n;\ j \in \boldsymbol{N}$, are linguistic inputs, that are exchanged with any trapezoidal fuzzy inputs such as $\tilde{x}_{ij}=(a_{ij}, b_{ij}, c_{ij}, d_{ij})$, and $\widetilde{w}_j = (w_{j1}, w_{j2}, w_{j3}, w_{j4})$.

· **Step 4:**

In this step, the normalization process of the fuzzy decision matrix has been performed:

$$\tilde{R} = [\tilde{r}_{ij}]_{m\times n}, \text{ where } 1 \le i \le m;\ i \in \boldsymbol{N} \text{ and } 1 \le j \le n;\ j \in \boldsymbol{N} \quad (23),$$

where

$$\left.\begin{array}{ll} \tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^+}, \frac{b_{ij}}{c_j^+}, \frac{c_{ij}}{c_j^+}, \frac{d_{ij}}{c_j^+}\right) & And \\ c_j^+ = \max_i\left(d_{ij}\right) & (benifit\ criteria) \\ \tilde{r}_{ij} = \left(\frac{a_j^-}{d_{ij}}, \frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right) & And \\ a_j^- = \min_i\left(a_{ij}\right) & (cost\ \ criteria) \end{array}\right\} \quad (24).$$

It can be observed that the values of normalized trapezoidal fuzzy numbers lie in the interval [0, 1]

· **Step 5:**

This step interprets the process to obtain a weighted normalized fuzzy matrix $\tilde{V}$,

$$\tilde{V} = [\tilde{v}_{ij}] = [\tilde{r}_{ij} * \tilde{w}_j]_{m\times n}, \text{ where } 1 \le i \le m;\ i \in \boldsymbol{N} \text{ and } 1 \le j \le n;\ j \in \boldsymbol{N} \quad (25).$$

· **Step 6:**

The fuzzy positive and negative ideal solutions, i.e., FPIS, and FNIS respectively, are obtained in this step:

$$\begin{aligned} & A^{+} = (\tilde{v}_1^{+}, \tilde{v}_2^{+}, \dots \tilde{v}_n^{+}) \quad And \\ \tilde{v}_j^{+} = \max_i (v_{ij4}) \quad & \text{where } 1 \le i \le m;\ i \in \boldsymbol{N} \text{ and } 1 \le j \le n;\ j \in \boldsymbol{N} \\ & A^{-} = (\tilde{v}_1^{-}, \tilde{v}_2^{-}, \dots \tilde{v}_n^{-}) \quad And \\ \tilde{v}_j^{-} = \min_i (v_{ij1}) \quad & \text{where } 1 \le i \le m;\ i \in \boldsymbol{N} \text{ and } 1 \le j \le n;\ j \in \boldsymbol{N} \end{aligned} \quad (26).$$

· **Step 7:**

The following equations can be used to calculate the distances d_i^{+} *and* d_i^{-} of each weighted alternative from (FPIS) and (FNIS):

$$d_i^{+} = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^{+}) \quad \text{where } 1 \le i \le m;\ i \in \boldsymbol{N} \quad (27),$$

$$d_i^{-} = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^{-}) \quad \text{where } 1 \le i \le m;\ i \in \boldsymbol{N} \quad (28),$$

where $d_v(\tilde{a}, \tilde{b})$ denotes the distance between two trapezoidal fuzzy numbers $\tilde{a}$ *and* $\tilde{b}$

· **Step 8:**

This step provides the closeness coefficient CCi; this shows the simultaneous distance from (FPIS A^{+}) and (FNIS A^{-}) which is defined as-

$$CCi = \frac{d_i^{-}}{d_i^{-} + d_i^{+}}, \text{ where } 1 \le i \le m;\ i \in \boldsymbol{N} \quad (29).$$

The closeness coefficient CCi with the highest value reflects the best option, and it indicates that the best option is closest to the FPIS and farthest from the FNIS

· **Step 9:**

Use the closeness coefficient CCi to rank the alternatives.

4 Design of the Model

4.1 Application of F-AHP

The sustainability considerations for community-based tourism (CBT) are configured through a case study. A_1 -Economic Sustainability (ES), A_2 -Social Sustainability (SS), A_3 -Environmental Sustainability (EnS), and A_4 -Cultural Sustainability (CS) are the four dimensions of sustainability; and the criteria were taken as, Human Capital Development (HC), Innovation (IN), Tourism Activities and Products (TAP), Attitude and Belief towards CBT (AB), Tourism Resources Management (TRM), CBT Management (CBTM), Values to Tourists (VT), Tourism Resource (TR), Market Demand Identification and Marketing Strategy Development (MDIMSD).

Figure 1 shows the hierarchy structure with criteria and alternatives.

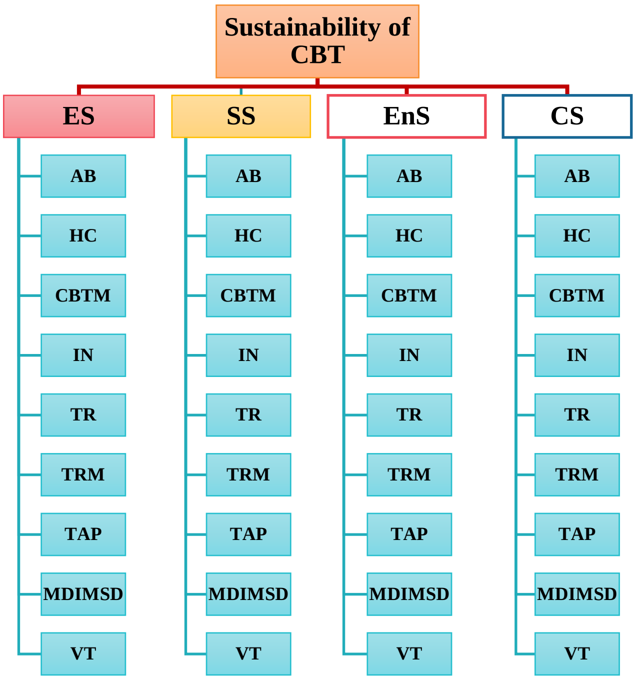

Figure 1: Hierarchy diagram for ranking of sustainability pillars

Concerning the fuzzified scale Table 1, the experts' ratings are given in Table 2. The comparison in all pairs of all alternatives corresponding to the criterion "AB" is given in Table 3.

Table 2: Pairwise Comparison of Ratings by Experts

AB	ES	SS	EnS	CS
ES	EI	VLI	VLI	VLI
SS	*	EI	*	*
EnS	*	LI	EI	*
CS	*	LI	LI	EI

Table 3: Pairwise comparisons regarding the main criteria

Criterion AB	ES	SS	EnS	CS
ES	(1.0,1.0,1.0,1.0)	(0,0.50,1.5,2)	(0,0.50,1.50,2.0)	(0,0.50,1.50,2.0)
SS	(0,0.50,0.667,2)	(1.0,1.0,1.0,1.0)	(0.333,0.4,0.667,1)	(0.333,0.40,0.667,1)
EnS	(0,0.50,0.667,2)	(1.0,1.50,2.50,3.0)	(1.0,1.0,1.0,1.0)	(0.3333,0.40,0.667,1)
CS	(0,0.50,0.667,2)	(1.0,1.50,2.50,3.0)	(1.0,1.50,2.50,3.0)	(1.0,1.0,1.0,1.0)

The calculation of geometric mean of the Alternative' Economic Sustainability (ES)' corresponding to the criterion "AB- Attitude and Belief towards" with the help of step (4) of FAHP methodology is -

$$\tilde{r}_1 = \left(\prod_{j=1}^{p} \tilde{c}_{ij}\right)^{\left(\frac{1}{p}\right)}$$

$$= \left[(1*0*0*0)^{1/4}, (1*0.5*0.5*0.5)^{1/4}, (1*1.5*1.5*1.5)^{1/4}, (1*2*2*2)^{1/4}\right] \quad (30).$$

$= (0, 0.596, 1.355, 1.681)$

Similarly, other values and their normalized weights are obtained using steps (4), step (5), and step (6) and are mentioned in Table 4.

Table 4: Normalized weights evaluation

Alternatives	AB	$w_i = \tilde{r}_i * S^{-1}$	W_i Using MATLAB	$N_i = W_i / SUM$
ES	(0, 0.594, 1.355,1.681)	(0,091,0.297,0.580)	0.250	0.258
SS	(0, 0.532, 0.738,1.189)	(0,0.081,0.162, 0.41)	0.173	0.179
EnS	(0, 0.740, 1.027,1.565)	(0,0.114,0.226, 0.540)	0.231	0.239
CS	(0, 1.029, 1.42872,2.0598)	(0,0,0.033, 0.320)	0.309	0.321
SUM (S)	(0, 2.896, 4.548,6.495)		0.963	
Inverse of S	(0,0.345,0.219,0.153)			
Increasing Order (S^{-1})	(0,0.154,0.219,0.345)			

The normalized weights of alternatives related to each criterion in Table 5 were obtained using a similar procedure. Table 6 shows the fuzzy weights and normalized weight for all criteria.

Table 5: Normalized weights of each alternative related to each criterion.

Alternatives\Criteria	AB	HC	CBTM	IN	TR	TRM	TAP	MDIMSD	VT
ES	0.259	0.250	0.250	0.250	0.250	0.250	0.247	0.261	0.278
SS	0.179	0.250	0.250	0.250	0.250	0.250	0.203	0.278	0.208
EnS	0.239	0.250	0.250	0.250	0.250	0.250	0.347	0.208	0.261
CS	0.320	0.250	0.250	0.250	0.250	0.250	0.203	0.252	0.252

Table 6: Each criterion's fuzzy weights

AB	(0.033, 0.058, 0.138, 2.319)
HC	(0,0.076, 0.188, 3.482)
CBTM	(0, 0.087, 0.209, 3.585)
IN	(0, 0.079, 0.202, 3.355)
TR	(0,0.091, 0.267, 4.434)
TRM	(0, 0.080, 0.221, 3.661)
TAP	(0, 0.055, 0.133, 3.364)
MDIMSD	(0,0.055, 0.126, 2.978)
VT	(0, 0.045, 0.099, 2.757)

Table 7: Every criterion's normalized weights for each alternative

AB	HC	CBTM	IN	TR	TRM	TAP	MDIMSD	VT
0.088	0.129	0.134	0.008	0.165	0.136	0.124	0.110	0.102

By using step (7) of section (3.1), we found the final scores, which are given below

$$A = \begin{bmatrix} A_1 = ES \\ A_2 = SS \\ A_3 = EnS \\ A_4 = CS \end{bmatrix} = \begin{bmatrix} 0.259 & 0.25 & 0.25 & 0.25 & 0.25 & 0.25 & 0.247 & 0.261 & 0.277 \\ 0.179 & 0.25 & 0.25 & 0.25 & 0.25 & 0.25 & 0.202 & 0.277 & 0.208 \\ 0.239 & 0.25 & 0.25 & 0.25 & 0.25 & 0.25 & 0.347 & 0.208 & 0.261 \\ 0.320 & 0.25 & 0.25 & 0.25 & 0.25 & 0.25 & 0.202 & 0.252 & 0.252 \end{bmatrix} \begin{bmatrix} 0.088 \\ 0.129 \\ 0.134 \\ 0.008 \\ 0.165 \\ 0.136 \\ 0.124 \\ 0.110 \\ 0.102 \end{bmatrix} \quad (31),$$

$$\begin{bmatrix} ES \\ SS \\ EnS \\ CS \end{bmatrix} = \begin{bmatrix} 0.254 \\ 0.236 \\ 0.257 \\ 0.250 \end{bmatrix} \quad (32).$$

4.2 Application of F-TOPSIS

The experts' ratings for each criterion-related alternative are shown in Table 8 and Table 9. D_1 and D_2 are the first and second experts, respectively.

Table 8: Inputs are given by First Decision-Maker.

D_1	AB	HC	CBTM	IN	TR	TRM	TAP	MDIMSD	VT
E S	V I	E I	L I	V I	E I	I	V I	I	V I
S S	L I	E I	L I	E I	V I	E I	V I	E I	I
EN S	E I	V L I	I	I	E I	V I	E I	E I	E I
C S	V L I	L I	V I	V I	I	E I	I	L I	V I

Table 9: Inputs are given by Second Decision-Maker.

D_2	AB	HC	CBTM	IN	TR	TRM	TAP	MDIMSD	VT
E S	E I	E I	E I	E I	E I	E I	E I	E I	E I
S S	E I	V I	E I	I	E I	E I	V I	I	V I
EN S	E I	E I	V I	I	E I	E I	V I	L I	I
C S	E I	V I	E I	I	E I	E I	V I	I	V I

The linguistic inputs given by experts are converted into trapezoidal fuzzy inputs and shown in Tables 10; 11 and 12. We have shown the normalized fuzzy decision matrix and weighted fuzzy decision matrix, which are found in steps 3, 4, 5.

Table 10: Fuzzy conversion of ratings given by experts

D1	AB				HC				CBTM				IN				TR				TRM				TAP				MDIMSD				VT			
ES	3	3.5	4.5	5	4	4.5	5.5	6	1	1.5	2.5	3	3	3.5	4.5	5	4	4.5	5.5	6	2	2.5	3.5	4	3	3.5	4.5	5	2	2.5	3.5	4	3	3.5	4.5	5
SS	1	1.5	2.5	3	4	4.5	5.5	6	1	1.5	2.5	3	4	4.5	5.5	6	3	3.5	4.5	5	4	4.5	5.5	6	3	3.5	4.5	5	4	4.5	5.5	6	2	2.5	3.5	4
ENS	4	4.5	5.5	6	0	0.5	1.5	2	2	2.5	3.5	4	2	2.5	3.5	4	4	4.5	5.5	6	3	3.5	4.5	5	4	4.5	5.5	6	4	4.5	5.5	6	4	4.5	5.5	6
CS	0	0.5	1.5	2	1	1.5	2.5	3	3	3.5	4.5	5	3	3.5	4.5	5	2	2.5	3.5	4	4	4.5	5.5	6	2	2.5	3.5	4	1	1.5	2.5	3	3	3.5	4.5	5
D2	AB				HC				CBTM				IN				TR				TRM				TAP				MDIMSD				VT			
ES	4	4.5	5.5	6	4	4.5	5.5	6	4	4.5	5.5	6	4	4.5	5.5	6	4	4.5	5.5	6	4	4.5	5.5	6	4	4.5	5.5	6	4	4.5	5.5	6	4	4.5	5.5	6
SS	4	4.5	5.5	6	3	3.5	4.5	5	4	4.5	5.5	6	2	2.5	3.5	4	4	4.5	5.5	6	4	4.5	5.5	6	3	3.5	4.5	5	2	2.5	3.5	4	3	3.5	4.5	5
ENS	4	4.5	5.5	6	4	4.5	5.5	6	3	3.5	4.5	5	2	2.5	3.5	4	4	4.5	5.5	6	4	4.5	5.5	6	3	3.5	4.5	5	1	1.5	2.5	3	2	2.5	3.5	4
CS	4	4.5	5.5	6	3	3.5	4.5	5	4	4.5	5.5	6	2	2.5	3.5	4	4	4.5	5.5	6	4	4.5	5.5	6	3	3.5	4.5	5	2	2.5	3.5	4	3	3.5	4.5	5

Table 11: Normalized Fuzzy Weights

	AB				HC				CBTM				IN				TR				TRM				TAP				MDIMSD				VT			
ES	0.5	0.58	0.9	1	0.7	0.75	0.92	1	0.2	0.25	0.92	1	0.5	0.58	0.92	1	0.67	0.8	0.92	1	0.33	0.42	0.92	1	0.5	0.58	0.92	1	0.33	0.42	0.92	1	0.5	1	0.92	1
SS	0.17	0.25	0.9	1	0.5	0.58	0.92	1	0.2	0.25	0.92	1	0.3	0.42	0.92	1	0.5	0.6	0.92	1	0.67	0.75	0.92	1	0.5	0.58	0.75	0.83	0.33	0.42	0.92	1	0.3	0	0.75	0.8
ENS	0.67	0.75	0.9	1	0	0.08	0.92	1	0.3	0.42	0.75	0.83	0.3	0.42	0.58	0.7	0.67	0.8	0.92	1	0.5	0.58	0.92	1	0.5	0.58	0.92	1	0.17	0.25	0.92	1	0.3	0	0.92	1
CUL	0	0.08	0.9	1	0.2	0.25	0.75	0.8	0.5	0.58	0.92	1	0.3	0.42	0.75	0.8	0.33	0.4	0.92	1	0.67	0.75	0.92	1	0.33	0.42	0.75	0.83	0.17	0.25	0.58	0.67	0.5	1	0.75	0.8

Table 12: Weighted Normalized Fuzzy Weights

	AB				HC				CBTM				IN				TR				TRM				TAP				MDIMSD				VT			
ES	0.02	0.03	0.1	2.3	0	0.06	0.17	3.5	0	0.02	0.19	3.58	0	0.05	0.19	3.4	0	0.1	0.25	4.4	0	0.03	0.2	3.66	0	0.03	0.12	3.36	0	0.02	0.12	2.98	0	0	0.09	2.8
SS	0.01	0.01	0.1	2.3	0	0.04	0.17	3.5	0	0.02	0.19	3.58	0	0.03	0.19	3.4	0	0.1	0.25	4.4	0	0.06	0.2	3.66	0	0.03	0.1	2.8	0	0.02	0.12	2.98	0	0	0.07	2.3
ENS	0.02	0.04	0.1	2.3	0	0.01	0.17	3.5	0	0.04	0.16	2.99	0	0.03	0.12	2.2	0	0.1	0.25	4.4	0	0.05	0.2	3.66	0	0.03	0.12	3.36	0	0.01	0.12	2.98	0	0	0.09	2.8
CUL	0	0	0.1	2.3	0	0.02	0.14	2.9	0	0.05	0.19	3.58	0	0.03	0.15	2.8	0	0	0.25	4.4	0	0.06	0.2	3.66	0	0.02	0.1	2.8	0	0.01	0.07	1.99	0	0	0.07	2.3

Further, we evaluated FPIS and FNIS by using step 6, the distances from FPIS and FNIS evaluated with the help of step 7, and by using step 8, we evaluated the closeness coefficient CCi that represents the simultaneous distance from FPIS and FNIS. Table 13 shows the obtained values of FPIS, FNIS. We used the methodology proposed by Ebadi et al. (2013) and Hamming distance (Grzegorzewski, 2004) to calculate the fuzzy distances from FPIS and FNIS distance, and closeness coefficient are calculated for two trapezoidal fuzzy numbers and shown in Table 14.

Table 13: The values of FNIS and FPIS for each criterion

	FNIS	FPIS
AB	(0, 0, 0, 0)	(2.310,2.310,2.310, 2.310)
HC	(0, 0, 0, 0)	(3.480,3.480,3.480,3.480)
CBTM	(0, 0, 0, 0)	(3.60,3.60,3.60,3.60)
IN	(0, 0, 0, 0)	(3.40,3.40,3.40,3.40)
TR	(0, 0, 0, 0)	(4.40,4.40,4.40,4.40)
TRM	(0, 0, 0, 0)	(3.70,3.70,3.70,3.70)
TAP	(0, 0, 0, 0)	(3.40,3.40,3.40,3.40)
MDIMSD	(0, 0, 0, 0)	(3.0,3.0,3.0,3.0)
VT	(0, 0, 0, 0)	(2.80,2.80,2.80,2.80)

Table 14: The final output obtained by F-TOPSIS.

By Ebadi et al. (2013) Distance Method			By Hamming Distance Method		
	Distance from FPIS	Distance from FNIS		Distance from FPIS	Distance from FNIS
ES	28.482	28.482	ES	21.999	7.938
SS	28.0141	27.501	SS	22.277	7.660
ENS	28.169	26.869	ENS	66.272	7.474
CS	27.451	25.476	CS	22.847	7.091

5 Results and Discussion

The rankings obtained using the F-AHP methodology are mentioned in Table 15; in the results, Alternative (A_3) has the highest score. That means environmental sustainability is the most important factor, and in the results, we can see that the social sustainability factor has the fourth rank.

Table 15: The final ranking of alternatives as per the score evaluated by the model designed

Alternatives	Score	Rank
Economic Sustainability (A1)	0.254	2
Social Sustainability (A2)	0.236	4
Environmental Sustainability (A3)	0.257	1
Cultural Sustainability (A4)	0.250	3

The ranking shown in Table 16 is obtained by Fuzzy TOPSIS; in this methodology, we applied two different distance methods to compare the results regarding the sustainability features. Here we can see a little fluctuation in the results; in both results, economic and social sustainability features have ranked first and second while the fluctuation occurs in environmental and cultural sustainability.

Table 16: The final output obtained by F-TOPSIS

Ebadi et al.'s Distance Method			Hamming Distance Method		
Alternatives	Closeness Coefficient	Ranks	Alternatives	Closeness Coefficient	Ranks
ES	0.5	1	ES	0.265	1
SS	0.495	2	SS	0.255	2
ENS	0.488	3	ENS	0.101	4
CS	0.481	4	CS	0.236	3

Table 17 shows the comparison between results obtained by both soft computing techniques, i.e., F-AHP and F-TOPSIS.

Table 17: A comparison of the findings from F-AHP and F-TOPSIS

Alternatives	F-AHP	By F-TOPSIS (Ebadi et al.'s Distance Method)	By F-TOPSIS (Hamming Distance Method)
ES	2	1	1
SS	4	2	2
ENS	1	3	4
CS	3	4	3

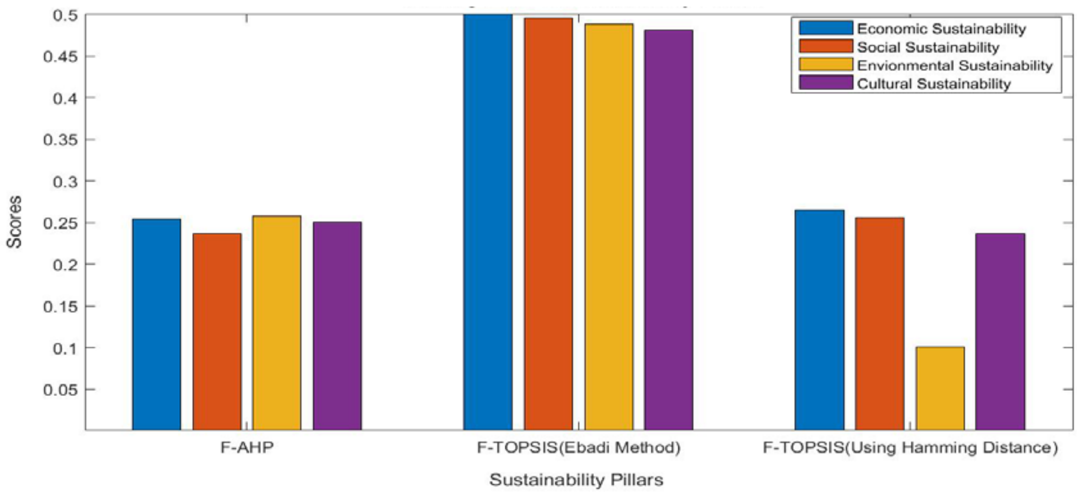

Figure 2: Ranking Order of Sustainability Pillars

As we can see, Figure 2 compares the results obtained from both methodologies with little difference. This happens because of uncertainty and difference in the thinking of different experts. The main motive behind the study is to suggest the intelligent ranking information system, and the rankings suggested by the information system will be helpful for policymakers. The proposed ranking system would serve as a tool for government bodies and tourism-related administrative officials to establish strategies for the long-term growth of community-based tourism.

6 Conclusion

This study develops an intelligent sustainability ranking information system that ranks the four pillars of sustainable community-based tourism growth in the most likely order (economic, social, environmental, and cultural sustainability). We proposed the ranking information system and compared the rankings of all four variables with the support of expert opinions and soft computing methodologies. The results of the proposed information system's rankings can be used to strengthen the alternatives with low rankings.

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