University of New Mexico

Utilizing CoCoSo and Interval Neutrosophic MAGDM with SuperHyperSoft for Competitiveness Assessment in Rural Tourism of Surrounding Cities

Aiping Cui, Zhiyao Liu*

Hebei Vocational University of Industry and Technology, Shijiazhuang, 050091, Hebei, China

*Corresponding author, E-mail: 13933152617@163.com; https://orcid.org/0009-0004-2664-061X

Aiping Cui, E-mail: 15032791167@163.com

Abstract: With rising living standards, rural tourism near cities has rapidly developed, playing a key role in the sustainable development of urban economies and societies. Factors like ecological environment, historical and cultural resources, and landscape significantly influence the competitiveness of rural tourism. However, current research on this topic is still in its early stages, with a focus on tourism benefits to cities, often overlooking other impacts. Rural tourism boosts employment, promotes rural industries, and increases farmers' incomes, accelerating rural urbanization and economic growth. Therefore, evaluating the competitiveness of rural tourism near cities is essential for its development. The evaluation of rural tourism competitiveness in the vicinity of cities is multiple-attribute group decision-making (MAGDM) problem. Recently, the Combined Compromise Solution (CoCoSo) approach has been used to address MAGDM. Interval neutrosophic sets (INSs) are employed as approach to characterize uncertain data in the evaluation of rural tourism competitiveness in areas surrounding cities. In this research, the CoCoSo approach is structured for MAGDM with INSs. Then, the interval neutrosophic numbers CoCoSo with SuperHyperSoft (INN-SHS-CoCoSo) approach, based on Hamming distance with the SuperHyperSoft, is developed for MAGDM. SuperHyperSoft is used to teat a set of criteria and sub criteria. Finally, a practical numerical example for the evaluation of rural tourism competitiveness in areas surrounding cities is developed to demonstrate the INN-SHS-CoCoSo approach.

Keywords: MAGDM; INSs; Combined Compromise Solution (CoCoSo); rural tourism competitiveness evaluation; SuperHyperSoft.

---

1. Introduction

The traditional attraction tourism model, with the ticket economy as the link, majorly by the tourism authorities planning and management of single attractions (scenic spots) construction and operation, in general, has a closed and self-circulating characteristics and the development of tourism industry is highly dependent on the attractions (scenic spots) of the ticket revenue, the lack of " tourism+"[1]. The development of tourism industry is highly dependent on the ticket income of attractions (scenic spots), lacking the idea of "tourism+" integrated development, failing to coordinate the construction of tourism infrastructure and public services, and having a single mechanism for tourism growth. Promoting "regional tourism" is a far-reaching change in thinking and strategic adjustment for the modernization and development of China's tourism[2]. Earlier, "regional tourism" appeared in the local tourism sector in the work of planning and summarizing the report, just a conceptual term, but has attracted the attention of the academic community [3]. The so-called regional tourism can be understood as a new concept and mode of integrating natural resources and social resources in a specific geographic space, developing regional characteristic industries with tourism industry as a tractor, and promoting sustainable and coordinated economic and social development of the region with the support of relevant policies and institutional mechanisms[4]. The idea of regional tourism helps to give full play to the economic and social development advantages of a specific geographic space, realizing the cross-border integration of regional industries, especially the optimization of the whole region in the development of natural resources, common construction of transportation and communication, ecological environmental protection, the construction of a unified market, and the sharing of public services, etc., which can enhance the effectiveness of the integration of the tourism industry as a regional characteristic industry[5]. With the socio-economic development, local economic restructuring, and the promotion of metropolitan areas and regional integration development strategies, the formation and development of regional tourism has a natural resource base and socio-economic conditions. It is an innovative model to implement the five development concepts, fully reflecting the strategic position and social value of tourism. Some commentators have suggested that the key issue for the development of regional tourism lies in the deeper integration of industrial development, new urbanization construction, business development, cultural tourism development, etc., so as to realize the integration of "industry, city, business, tourism and culture". Therefore, regional culture has a multiplier effect, which can significantly enhance the value of the tourism industry chain. "Regional Culture + Regional Tourism" is a new business model for the development of the tourism industry, whose core winning element is regional culture, the platform for the operation of the model is regional tourism, and the products sold are tourism service products with additional cultural connotations, which participate in the competition in the tourism market.

Fuzzy decision-making is a prominent area of research, significantly impacting both production and daily life [6-8]. Despite its relatively recent emergence, fuzzy MAGDM has garnered substantial interest from scholars globally, resulting in numerous research achievements. Evaluating rural tourism competitiveness in nearby cities exemplifies MAGDM [9]. Recently, the CoCoSo approach [10-14] and information entropy approach [15] have been employed to address MAGDM challenges. Interval neutrosophic sets (INSs) [16] serve as a means to characterize uncertain information in evaluating rural tourism competitiveness in adjacent cities. To date, few techniques have applied the CoCoSo approach using Hamming distance within the context of INSs. Consequently, an interval neutrosophic numbers CoCoSo (INN-SHS-CoCoSo) approach, Hamming distance, has been developed for MAGDM under INSs. An example illustrating rural tourism competitiveness evaluation in nearby cities, underscores the effectiveness and reliability of the INN-SHS-CoCoSo technique. This paper introduces the INN-SHS-CoCoSo approach, utilizing Hamming distance to tackle MAGDM under SVNSs. Ultimately, a numerical case study focused on rural tourism competitiveness evaluation in nearby cities is presented to validate the proposed approach.

The main objectives of this paper are constructed:

(1) Development of a novel MAGDM approach: The paper aims to introduce a new Multiple Attribute Group Decision-Making (MAGDM) method by integrating the Combined Compromise Solution (CoCoSo) approach with Interval Neutrosophic Sets (INSs). This novel approach is designed to manage complex decision-making scenarios where uncertainty and imprecision play a significant role.

(2) Application of the INN-SHS-CoCoSo method in rural tourism evaluation: The paper introduces a new MAGDM model using the INN-SHS-CoCoSo technique with SuperHyperSoft to evaluate the competitiveness of rural tourism in nearby cities. This approach allows for a comprehensive assessment of various tourism attributes, providing a more robust and accurate analysis of competitiveness in the rural tourism sector.

The framework of the paper is structured as follows:

Section 2: Introduction to INSs: This section introduces INSs as a mathematical tool for handling uncertain and imprecise information, which is key to evaluating rural tourism competitiveness and other decision-making scenarios.

Section 3: Construction of INN-SHS-CoCoSo approach under **INSs:** Here, the authors detail the development of INN-SHS-CoCoSo approach, which integrates the Hamming distance. This approach is designed to solve MAGDM in environments with uncertainty.

Section 4: Illustrative Case for User Experience Evaluation of Virtual Reality Products: This section provides a real-world example to demonstrate how the INN-SHS-CoCoSo approach can be applied beyond rural tourism. Specifically, it applies the method to evaluate user experiences with virtual reality products, showcasing the method's versatility.

Section 5: Final Remarks: Concluding observations about the method's performance, strengths, and potential improvements are discussed in this section.

Section 6: Research Limitations and Future Directions: This section outlines the limitations of the current research, acknowledging areas for improvement, and suggests potential avenues for future research, such as refining the method or applying it to other domains.

This structured framework ensures that the paper provides a comprehensive and detailed examination of the INN-SHS-CoCoSo method, from its theoretical underpinnings to practical applications and future considerations.

2. Basic knowledge

Wang et al. [17] assembled the SVNSs

Definition 1 [17]. The SVNSs WA in Φ is assembled:

$$WA=\{(\phi,WT_A(\phi),WI_A(\phi),WF_A(\phi))|\phi\in\Phi\} \tag{1}$$

where $WT_A(\phi),WI_A(\phi),WF_A(\phi)\in[0,1]$ is truth-membership (TM), indeterminacy-membership (IM) and falsity-membership (FM), $WT_A(\phi),WI_A(\phi),WF_A(\phi)\in[0,1]$ and satisfies $0\le WT_A(\phi)+WI_A(\phi)+WF_A(\phi)\le 3$.

Wang et al.[16] assembled the INSs.

Definition 2[16]. The INSs A in Φ is assembled:

$$W\tilde{A}=\{(\phi,WT_{\tilde{A}}(\phi),WI_{\tilde{A}}(\phi),WF_{\tilde{A}}(\phi))|\phi\in\Phi\} \tag{2}$$

where the $WT_{\tilde{A}}(\phi),WI_{\tilde{A}}(\phi),WF_{\tilde{A}}(\phi)$ depicts the TM, IM and FM, $WT_{\tilde{A}}(\phi),WI_{\tilde{A}}(\phi),WF_{\tilde{A}}(\phi)\subseteq[0,1]$ and satisfies $0\le \sup WT_{\tilde{A}}(\phi)+\sup WI_{\tilde{A}}(\phi)+\sup WF_{\tilde{A}}(\phi)\le 3$.

The (INN) is expressed as $W\tilde{A}=(WT_{\tilde{A}},WI_{\tilde{A}},WF_{\tilde{A}})=([WTL_{\tilde{A}},WTR_{\tilde{A}}],[WIL_{\tilde{A}},WIR_{\tilde{A}}],[WFL_{\tilde{A}},WFR_{\tilde{A}}])$, where $WT_{\tilde{A}},WI_{\tilde{A}},WF_{\tilde{A}}\subseteq[0,1]$, and $0\le WTR_{\tilde{A}}+WIR_{\tilde{A}}+WFR_{\tilde{A}}\le 3$.

Definition 3 [18]. Let $W\tilde{A}=([WTL_{\tilde{A}},WTR_{\tilde{A}}],[WIL_{\tilde{A}},WIR_{\tilde{A}}],[WFL_{\tilde{A}},WFR_{\tilde{A}}])$ be INN, a score value is assembled:

$$SV(W\tilde{A})=\frac{(2+WTL_{\tilde{A}}-WIL_{\tilde{A}}-WFL_{\tilde{A}})+(2+WTR_{\tilde{A}}-WIR_{\tilde{A}}-WFR_{\tilde{A}})}{6},\ S(W\tilde{A})\in[0,1]. \tag{3}$$

Definition 4[18]. Let $W\tilde{A}=([WTL_{\tilde{A}},WTR_{\tilde{A}}],[WIL_{\tilde{A}},WIR_{\tilde{A}}],[WFL_{\tilde{A}},WFR_{\tilde{A}}])$ be an INN, an accuracy value is assembled:

$$AV(W\tilde{A})=\frac{(WTL_{\tilde{A}}+WTR_{\tilde{A}})-(WFL_{\tilde{A}}+WFR_{\tilde{A}})}{2},\ AV(W\tilde{A})\in[-1,1]\ . \tag{4}$$

Huang et al. [19] assembled the order between INNs.

Definition 5[18]. Let $W\tilde{A}=([WTL_{\tilde{A}},WTR_{\tilde{A}}],[WIL_{\tilde{A}},WIR_{\tilde{A}}],[WFL_{\tilde{A}},WFR_{\tilde{A}}])$ and $W\tilde{B}=([WTL_{\tilde{B}},WTR_{\tilde{B}}],[WIL_{\tilde{B}},WIR_{\tilde{B}}],[WFL_{\tilde{B}},WFR_{\tilde{B}}])$ be two INNs,

$SV\left(W\tilde{A}\right)=\frac{\left(2+WTL_{\tilde{A}}-WIL_{\tilde{A}}-WFL_{\tilde{A}}\right)+\left(2+WTR_{\tilde{A}}-WIR_{\tilde{A}}-WFR_{\tilde{A}}\right)}{6}$ and

$SV\left(W\tilde{B}\right)=\frac{\left(2+WTL_{\tilde{B}}-WIL_{\tilde{B}}-WFL_{\tilde{B}}\right)+\left(2+WTR_{\tilde{B}}-WIR_{\tilde{B}}-WFR_{\tilde{B}}\right)}{6}$, and

$AV\left(W\tilde{A}\right)=\frac{\left(WTL_{\tilde{A}}+WTR_{\tilde{A}}\right)-\left(WFL_{\tilde{A}}+WFR_{\tilde{A}}\right)}{2}$ and

$AV\left(W\tilde{B}\right)=\frac{\left(WTL_{\tilde{B}}+WTR_{\tilde{B}}\right)-\left(WFL_{\tilde{B}}+WFR_{\tilde{B}}\right)}{2}$, if $SV\left(W\tilde{A}\right)<SV\left(W\tilde{B}\right)$, $W\tilde{A}<W\tilde{B}$; if $SV\left(W\tilde{A}\right)=SV\left(W\tilde{B}\right)$, (1) if $AV\left(W\tilde{A}\right)=AV\left(W\tilde{B}\right)$, $W\tilde{A}=W\tilde{B}$; (2) if $SV\left(W\tilde{A}\right)<SV\left(W\tilde{B}\right)$, $W\tilde{A}<W\tilde{B}$.

Definition 6[20]. Let $W\tilde{A}=\left(\left[WTL_{\tilde{A}},WTR_{\tilde{A}}\right],\left[WIL_{\tilde{A}},WIR_{\tilde{A}}\right],\left[WFL_{\tilde{A}},WFR_{\tilde{A}}\right]\right)$ and $W\tilde{B}=\left(\left[WTL_{\tilde{B}},WTR_{\tilde{B}}\right],\left[WIL_{\tilde{B}},WIR_{\tilde{B}}\right],\left[WFL_{\tilde{B}},WFR_{\tilde{B}}\right]\right)$ be two INNs, the operations are presented:

$$(1) W\tilde{A}\oplus W\tilde{B}=\begin{pmatrix}\left(WTL_{\tilde{A}}+WTL_{\tilde{B}}-WTL_{\tilde{A}}WTL_{\tilde{B}},WTR_{\tilde{A}}+WTR_{\tilde{B}}-WTR_{\tilde{A}}WTR_{\tilde{B}}\right),\\ \left[VIL_{\tilde{A}}VIL_{\tilde{B}},VIR_{\tilde{A}}VIR_{\tilde{B}}\right],\left[VFL_{\tilde{A}}VFL_{\tilde{B}},VFR_{\tilde{A}}VFR_{\tilde{B}}\right]\end{pmatrix};$$

$$(2) W\tilde{A}\otimes W\tilde{B}=\begin{pmatrix}\left[WTL_{\tilde{A}}WTL_{\tilde{B}},WTR_{\tilde{A}}WTR_{\tilde{B}}\right],\\ \left[WIL_{\tilde{A}}+WIL_{\tilde{B}}-WIL_{\tilde{A}}WIL_{\tilde{B}},WIR_{\tilde{A}}+WIR_{\tilde{B}}-WIR_{\tilde{A}}WIR_{\tilde{B}}\right],\\ \left[WFL_{\tilde{A}}+WFL_{\tilde{B}}-WFL_{\tilde{A}}WFL_{\tilde{B}},WFR_{\tilde{A}}+WFR_{\tilde{B}}-WFR_{\tilde{A}}WFR_{\tilde{B}}\right]\end{pmatrix};$$

$$(3) \lambda W\tilde{A}=\begin{pmatrix}\left[1-\left(1-WTL_{\tilde{A}}\right)^{\lambda},1-\left(1-WTR_{\tilde{A}}\right)^{\lambda}\right],\\ \left[\left(WIL_{\tilde{A}}\right)^{\lambda},\left(WIR_{\tilde{A}}\right)^{\lambda}\right],\left[\left(WFL_{\tilde{A}}\right)^{\lambda},\left(WFR_{\tilde{A}}\right)^{\lambda}\right]\end{pmatrix},\lambda>0;$$

$$(4) \left(V\tilde{A}\right)^{\lambda}=\begin{pmatrix}\left[\left(WTL_{\tilde{A}}\right)^{\lambda},\left(WTR_{\tilde{A}}\right)^{\lambda}\right],\left[\left(WIL_{\tilde{A}}\right)^{\lambda},\left(WIR_{\tilde{A}}\right)^{\lambda}\right],\\ \left[1-\left(1-WFL_{\tilde{A}}\right)^{\lambda},1-\left(1-WFR_{\tilde{A}}\right)^{\lambda}\right]\end{pmatrix},\lambda>0.$$

Definition 7[21]**.** Let $W\tilde{A}=\left(\left[WTL_{\tilde{A}},WTR_{\tilde{A}}\right],\left[WIL_{\tilde{A}},WIR_{\tilde{A}}\right],\left[WFL_{\tilde{A}},WFR_{\tilde{A}}\right]\right)$ and $W\tilde{B}=\left(\left[WTL_{\tilde{B}},WTR_{\tilde{B}}\right],\left[WIL_{\tilde{B}},WIR_{\tilde{B}}\right],\left[WFL_{\tilde{B}},WFR_{\tilde{B}}\right]\right)$, then INN Hamming distance (INNHD) is assembled:

$$INNHD\left(W\tilde{A},W\tilde{B}\right)=\frac{1}{6}\begin{pmatrix}\left|WTL_{\tilde{A}}-WTL_{\tilde{B}}\right|+\left|WTR_{\tilde{A}}-WTR_{\tilde{B}}\right|+\left|WIL_{\tilde{A}}-WIL_{\tilde{B}}\right|+\\ \left|WIR_{\tilde{A}}-WIR_{\tilde{B}}\right|+\left|WFL_{\tilde{A}}-WFL_{\tilde{B}}\right|+\left|WFR_{\tilde{A}}-WFR_{\tilde{B}}\right|\end{pmatrix} \quad (5)$$

The INNWA operator [20] are assembled:

Definition 8[20]. Let $V\tilde{A}_j=\left(\left[VTL_j,VTR_j\right],\left[VIL_j,VIR_j\right],\left[VFL_j,VFR_j\right]\right)$ be INNs, the INNWG operator is assembled:

$$\begin{aligned}&\text{INNWG}\left(W\tilde{A}_1,W\tilde{A}_2,\ldots,W\tilde{A}_n\right)\\&=\left(W\tilde{A}_1\right)^{w_1}\otimes\left(W\tilde{A}_2\right)^{w_2},\ldots\otimes\left(W\tilde{A}_n\right)^{w_n}=\overset{n}{\underset{j=1}{\otimes}}\left(W\tilde{A}_j\right)^{w_j}\\&=\begin{pmatrix}\left[\prod_{j=1}^{n}\left(WTL_{ij}\right)^{w_j},\prod_{j=1}^{n}\left(WTR_{ij}\right)^{w_j}\right],\\ \left[1-\prod_{k=1}^{l}\left(1-WFL_{ij}^{k}\right)^{w_j},1-\prod_{k=1}^{l}\left(1-WFR_{ij}^{k}\right)^{w_j}\right],\\ \left[1-\prod_{k=1}^{l}\left(1-WTL_{ij}^{k}\right)^{w_j},1-\prod_{k=1}^{l}\left(1-WTR_{ij}^{k}\right)^{w_j}\right]\end{pmatrix}\end{aligned} \quad (6)$$

where $w=\left(w_1,w_2,...,w_n\right)^T$ be weight of $W\tilde{A}_j$, $w_j>0,\sum_{j=1}^{n}w_j=1.$

3. Method

INN-SHS-CoCoSo approach is assembled for MAGDM. Let $WA=\left\{WA_1,WA_2,\cdots,WA_m\right\}$ be alternatives, and attributes $WG=\left\{WG_1,WG_2,\cdots,WG_n\right\}$ with weight ω, where $\omega_j\in\left[0,1\right]$, $\sum_{j=1}^{n}\omega_j=1$ and experts $WE=\left\{WE_1,WE_2,\cdots,WE_q\right\}$ with weight be $\left\{w_1,w_2,\cdots,w_t\right\}$.

Suppose the universe set $D=\{C_1,C_2,\ldots,C_n\}$ and the $P(D)$ is the power set of D. As well $Y_1,Y_2,\ldots,Y_n$ are criteria. $P(Y_1),P(Y_2), and\ P(Y_3)$ are the power sets of $Y_1,Y_2,\ldots,Y_n$.
Let $F: P(Y_1)\times P(Y_2)\times P(Y_3)\to P(D)$ and this is called SuperHyperSoft.

$$\begin{aligned}&P(Y_1)\times P(Y_2)\times P(Y_3)\\&=\{\{Y_{11}\},\{Y_{12}\},\{Y_{11},Y_{12}\}\}\times\{\{Y_{21}\},\{Y_{22}\},\{Y_{21},Y_{22}\}\}\\&\times\{\{Y_{31}\},\{Y_{32}\},\{Y_{33}\},\{Y_{31},Y_{32}\},\{Y_{31},Y_{33}\},\{Y_{32},Y_{33}\},\{Y_{31},Y_{32},Y_{33}\}\}\end{aligned}$$

The INN-SHS-CoCoSo approach is assembled for MAGDM:

Step 1. Build the INN-matrix $WR^t=\left[WR_{ij}^t\right]_{m\times n}=\left(\left[WTL_{ij}^t,WTR_{ij}^t\right],\left[WIL_{ij}^t,WIR_{ij}^t\right],\left[WFL_{ij}^t,WFR_{ij}^t\right]\right)_{m\times n}$ and average matrix $WR=\left[WR_{ij}\right]_{m\times n}$:

$$WR^t = \left[WR_{ij}^t\right]_{m\times n} = \begin{matrix} & WG_1 & WG_2 & \dots & WG_n \\ WA_1 & WR_{11}^t & WR_{12}^t & \dots & WR_{1n}^t \\ WA_2 & WR_{21}^t & WR_{22}^t & \dots & WR_{2n}^t \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ WA_m & WR_{m1}^t & WR_{m2}^t & \dots & WR_{mn}^t \end{matrix} \quad (7)$$

$$WR = \left[WR_{ij}\right]_{m\times n} = \begin{matrix} & WG_1 & WG_2 & \dots & WG_n \\ WA_1 & WR_{11} & WR_{12} & \dots & WR_{1n} \\ WA_2 & WR_{21} & WR_{22} & \dots & WR_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ WA_m & WR_{m1} & WR_{m2} & \dots & WR_{mn} \end{matrix} \quad (8)$$

Based on INNWG, the

$WR = \left[WR_{ij}\right]_{m\times n} = \left(\left[WTL_{ij}, WTR_{ij}\right], \left[WIL_{ij}, WIR_{ij}\right], \left[WFL_{ij}, WFR_{ij}\right]\right)_{m\times n}$ is:

$$WR_{ij} = \left(WR_{ij}^1\right)^{w_1} \otimes \left(WR_{ij}^2\right)^{w_2}, \dots \otimes \left(WR_{ij}^t\right)^{w_t}$$

$$= \begin{pmatrix} \left[\prod_{k=1}^{t}\left(WTL_{ij}^t\right)^{w_j}, \prod_{k=1}^{t}\left(WTR_{ij}^t\right)^{w_j}\right], \\ \left[1-\prod_{k=1}^{t}\left(WIL_{ij}^t\right)^{w_j}, 1-\prod_{k=1}^{t}\left(WIR_{ij}^t\right)^{w_j}\right], \\ \left[1-\prod_{k=1}^{t}\left(WFL_{ij}^t\right)^{w_j}, 1-\prod_{k=1}^{t}\left(WFR_{ij}^t\right)^{w_j}\right] \end{pmatrix} \quad (9)$$

Step 2. Then we obtained the crisp values.

Step 3. Combined the decision matrix.

Step 4. Normalized the decision matrix.

Step 5. Normalize the decision matrix

$$Y_{ij} = \frac{WR_{ij} - \min WR_{ij}}{\max WR_{ij} - \min WR_{ij}} \text{ for beneficial criteria.} \quad (10)$$

$$Y_{ij} = \frac{\max WR_{ij} - WR_{ij}}{\max WR_{ij} - \min WR_{ij}} \text{ for cost criteria.} \quad (11)$$

Step 6. Compute the criteria weights by using the mean method.

Step 7. Compute the total of the weighted comparability sequence of each alternative.

$$X_i = \sum_{j=1}^{n} w_j Y_{ij} \quad (12)$$

Step 8. Compute the whole power weight of compatibility sequence of each alternative.

$$Z_i = \sum_{j=1}^{n} \left(Y_{ij}\right)^{w_j} \quad (13)$$

Step 9. Compute the relative weights of the alternatives by using the aggregate strategies.

$$K_{ia} = \frac{Z_i + X_i}{\sum_{i=1}^{m}(Z_i + X_i)} \quad (14)$$

$$K_{ib} = \frac{X_i}{\min X_i} + \frac{Z_i}{\min Z_i} \quad (15)$$

$$K_{ic} = \frac{\gamma(X_i)+(1-\beta)(Z_i)}{\beta \max X_i+(1-\beta) \max Z_i}; \ 0 \leq \gamma \leq 1 \tag{16}$$

Step 10. Compute the assessment value

$$K_i = (K_{ia}K_{ib}K_{ic})^{\frac{1}{3}} + \frac{1}{3}(K_{ia} + K_{ib} + K_{ic}) \tag{17}$$

Step 11. Rank the alternatives.

4. Numerical example for rural tourism competitiveness evaluation

With the development of the social economy and the improvement of living standards, people's demand for leisure activities and connecting with nature is gradually increasing. Rural tourism, which encompasses rural scenery, rural life, and rural culture, has emerged as a popular trend. The impact of rural tourism on rural society and the economy is multifaceted, promoting increased farmers' income, agricultural efficiency, rural cultural construction, and ecological environment improvement. It significantly drives the adjustment of rural industrial structures and the construction of a modern rural economic development system. Therefore, promoting the high-quality development of rural tourism aligns with contemporary needs. Rural tourism attracts urban tourists primarily because rural areas possess primitive cultures and histories that are rapidly disappearing with urban-rural integration. In developing rural tourism, local governments must comprehensively understand and analyze local cultural resources, systematically extract regional characteristic cultural resources with tourism development value, and focus on the systematic development of intangible cultural heritage. This heritage should be organically integrated with the modern tourism industry to enhance the cultural connotation of rural tourism, form a new development model that achieves mutual benefits, and integrate culture and tourism effectively.

The development of rural tourism relies heavily on the active participation of local residents, especially in a competitive environment. Many regions have rich intangible cultural heritage, and effectively integrating this heritage with the rural tourism industry can further enhance its core competitiveness. To continuously strengthen the core competitiveness of the rural tourism industry, it is crucial for local villagers to actively participate, increase the inheritance and protection of intangible cultural heritage, enhance its influence, and promote the development of the rural tourism industry. Evaluating rural tourism competitiveness in surrounding cities involves MAGDM. This process requires a comprehensive assessment of various attributes and factors that contribute to the attractiveness and sustainability of rural tourism destinations. By employing advanced decision-making approaches such as INN-SHS-CoCoSo technique, local governments and stakeholders can make informed decisions to foster the high-quality development of rural tourism, ensuring it meets the evolving needs and preferences of tourists while preserving and enhancing local cultural heritage.

Five rural tourism demonstration zones assessed with six attributes: Ten rural tourism demonstration zones are assessed with INNs under three experts with equal weight. Table 1 shows the list of criteria and weight.

Table 1. List of criteria.

	Criteria	Values	Weights
C_1	Transport Accessibility	<50%, >100%.	0.174973
C_2	Cultural Heritage Sites	<20, >20	0.159406
C_3	Accommodation Capacity	<50, >50 beds	0.176843
C_4	Visitor Satisfaction	High, Moderate, Low	0.158682
C_5	Environmental Conservation Efforts	<50%, >50%	0.164595
C_6	Tourism Revenue	<\$1M, > \$100M.	0.1655

We built the decision matrix as shown in Table 2. Then we compute the criteria weights as shown in Table 1.

Table 2. The decision matrix.

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.5,0.6],[0.5,0.6],[0.4,0.5])
A_2	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.6,0.7],[0.4,0.5],[0.3,0.4])
A_3	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.1,0.2],[0.1,0.2],[0.8,0.9])
A_4	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.2,0.3],[0.3,0.4],[0.7,0.8])
A_5	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.3,0.4],[0.4,0.5],[0.6,0.7])
A_6	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.4,0.5],[0.5,0.6],[0.5,0.6])
A_7	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.5,0.5],[0.6,0.7],[0.4,0.5])
A_8	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.5,0.6],[0.5,0.6],[0.4,0.5])
A_9	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.6,0.7],[0.4,0.5],[0.3,0.4])
A_{10}	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.1,0.2],[0.1,0.2],[0.8,0.9])
	C_1	C_2	C_3	C_4	C_5	C_6
A_1	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.5,0.6],[0.5,0.6],[0.4,0.5])
A_2	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.6,0.7],[0.4,0.5],[0.3,0.4])
A_3	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.1,0.2],[0.1,0.2],[0.8,0.9])
A_4	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.2,0.3],[0.3,0.4],[0.7,0.8])
A_5	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.3,0.4],[0.4,0.5],[0.6,0.7])
A_6	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.5,0.6],[0.5,0.6],[0.4,0.5])
A_7	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.6,0.7],[0.4,0.5],[0.3,0.4])
A_8	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.1,0.2],[0.1,0.2],[0.8,0.9])
A_9	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.2,0.3],[0.3,0.4],[0.7,0.8])
A_{10}	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.3,0.4],[0.4,0.5],[0.6,0.7])
	C_1	C_2	C_3	C_4	C_5	C_6
A_1	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.3,0.4],[0.4,0.5],[0.6,0.7])
A_2	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.2,0.3],[0.3,0.4],[0.7,0.8])
A_3	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.1,0.2],[0.1,0.2],[0.8,0.9])

A_4	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.6,0.7],[0.4,0.5],[0.3,0.4])
A_5	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.3,0.4],[0.4,0.5],[0.6,0.7])
A_6	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.3,0.4],[0.4,0.5],[0.6,0.7])
A_7	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.2,0.3],[0.3,0.4],[0.7,0.8])
A_8	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.1,0.2],[0.1,0.2],[0.8,0.9])
A_9	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.1,0.2],[0.1,0.2],[0.8,0.9])	([0.6,0.7],[0.4,0.5],[0.3,0.4])
A_{10}	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.1,0.2],[0.1,0.2],[0.8,0.9])

Based on SuperHyperSoft we can suggest a set of suggestions for sub criteria to rank the alternatives Let $F: (\{< 50\%, > 100\%\}, \{< 20, > 20\}, \{> 50 \text{ beds}\}, \{\text{High}\}, \{> 50\%\}, \{> \$100\text{M}\})$. There are four suggestions such as:

S_1: <50%, <20, >50 beds, high, >50%, <$100m

S_2: <50%, >20, >50 beds, high, >50%, <$100m

S_3: >50%, <20, >50 beds, high, >50%, <$100m

S_4: >50%, >20, >50 beds, high, >50%, <$100m

Then we applied the proposed method for 4 suggestions.

Suggestion 1

We normalized the decision matrix as shown in Table 3.

Then we computed the total of the weighted comparability sequence for each alternative as shown in Table 4.

Then we computed the power weight.

Then we computed the relative weights of the alternatives.

Then we computed assessment values.

Then we ranked the alternatives as shown in Figure 1.

Table 3. The normalized decision matrix.

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	0.43	0.31068	0.606796	0.755208	0.730539	0.843318
A_2	0.96	0.349515	0.587379	0.536458	0.742515	1
A_3	0.235	0.694175	0.81068	0	0.107784	0
A_4	1	0.621359	0.742718	0.760417	0.197605	0.672811
A_5	0.885	0.514563	0.723301	0.78125	1	0.539171
A_6	0.625	0.446602	0.121359	0.979167	0.047904	0.75576
A_7	0.675	0.121359	0	0.427083	0.57485	0.820276
A_8	0	0	1	0.505208	0	0.331797
A_9	0.48	1	0.927184	1	0.083832	1
A_{10}	0.91	0.708738	0.650485	0.609375	0.57485	0.179724

Table 4. The weighted comparability sequence.

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	0.075238	0.049524	0.107308	0.119838	0.120243	0.139569
A_2	0.167974	0.055715	0.103874	0.085126	0.122214	0.1655
A_3	0.041119	0.110656	0.143363	0	0.017741	0
A_4	0.174973	0.099049	0.131345	0.120665	0.032525	0.11135
A_5	0.154851	0.082025	0.127911	0.123971	0.164595	0.089233
A_6	0.109358	0.071191	0.021462	0.155376	0.007885	0.125078
A_7	0.118107	0.019345	0	0.067771	0.094618	0.135756
A_8	0	0	0.176843	0.080168	0	0.054913
A_9	0.083987	0.159406	0.163966	0.158682	0.013798	0.1655
A_{10}	0.159225	0.112977	0.115034	0.096697	0.094618	0.029744

Suggestion 2

We normalized the decision matrix as shown in Table 5.

Then we computed the total of the weighted comparability sequence for each alternative as shown in Table 6.

Then we computed the power weight.

Then we computed the relative weights of the alternatives.

Then we computed The assessment values.

Then we ranked the alternatives as shown in Figure 1.

Table 5. The normalized decision matrix.

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	0.43	0.626728	0.606796	0.755208	0.730539	0.843318
A_2	0.96	0.557604	0.587379	0.536458	0.742515	1
A_3	0.235	0.331797	0.81068	0	0.107784	0
A_4	1	0.820276	0.742718	0.760417	0.197605	0.672811
A_5	0.885	0.603687	0.723301	0.78125	1	0.539171
A_6	0.625	0.691244	0.121359	0.979167	0.047904	0.75576
A_7	0.675	0.672811	0	0.427083	0.57485	0.820276
A_8	0	0	1	0.505208	0	0.331797
A_9	0.48	1	0.927184	1	0.083832	1
A_{10}	0.91	0.442396	0.650485	0.609375	0.57485	0.179724

Table 6. The weighted comparability sequence.

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	0.075238	0.099904	0.107308	0.119838	0.120243	0.139569
A_2	0.167974	0.088886	0.103874	0.085126	0.122214	0.1655
A_3	0.041119	0.052891	0.143363	0	0.017741	0
A_4	0.174973	0.130757	0.131345	0.120665	0.032525	0.11135
A_5	0.154851	0.096231	0.127911	0.123971	0.164595	0.089233

A_6	0.109358	0.110189	0.021462	0.155376	0.007885	0.125078
A_7	0.118107	0.10725	0	0.067771	0.094618	0.135756
A_8	0	0	0.176843	0.080168	0	0.054913
A_9	0.083987	0.159406	0.163966	0.158682	0.013798	0.1655
A_{10}	0.159225	0.070521	0.115034	0.096697	0.094618	0.029744

Suggestion 3

We normalized the decision matrix as shown in Table 7.

Then we computed the total of the weighted comparability sequence for each alternative as shown in Table 8.

Then we computed the power weight.

Then we computed the relative weights of the alternatives.

Then we computed The assessment values.

Then we ranked the alternatives as shown in Figure 1.

Table 7. The normalized decision matrix.

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	0.43	0.31068	0.606796	0.755208	0.730539	0.843318
A_2	0.96	0.349515	0.587379	0.536458	0.742515	1
A_3	0.235	0.694175	0.81068	0	0.107784	0
A_4	1	0.621359	0.742718	0.760417	0.197605	0.672811
A_5	0.885	0.514563	0.723301	0.78125	1	0.539171
A_6	0.625	0.446602	0.121359	0.979167	0.047904	0.75576
A_7	0.675	0.121359	0	0.427083	0.57485	0.820276
A_8	0	0	1	0.505208	0	0.331797
A_9	0.48	1	0.927184	1	0.083832	1
A_{10}	0.91	0.708738	0.650485	0.609375	0.57485	0.179724

Table 8. The weighted comparability sequence.

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	0.075238	0.049524	0.107308	0.119838	0.120243	0.139569
A_2	0.167974	0.055715	0.103874	0.085126	0.122214	0.1655
A_3	0.041119	0.110656	0.143363	0	0.017741	0
A_4	0.174973	0.099049	0.131345	0.120665	0.032525	0.11135
A_5	0.154851	0.082025	0.127911	0.123971	0.164595	0.089233
A_6	0.109358	0.071191	0.021462	0.155376	0.007885	0.125078
A_7	0.118107	0.019345	0	0.067771	0.094618	0.135756
A_8	0	0	0.176843	0.080168	0	0.054913
A_9	0.083987	0.159406	0.163966	0.158682	0.013798	0.1655
A_{10}	0.159225	0.112977	0.115034	0.096697	0.094618	0.029744

Suggestion 4

We normalized the decision matrix as shown in Table 9.

Then we computed the total of the weighted comparability sequence for each alternative as shown in Table 10.

Then we computed the power weight.

Then we computed the relative weights of the alternatives.

Then we computed The assessment values.

Then we ranked the alternatives as shown in Figure 1. We show the alternative 5 is the best.

Table 9. The normalized decision matrix.

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	0.43	0.626728	0.606796	0.755208	0.730539	0.843318
A_2	0.96	0.557604	0.587379	0.536458	0.742515	1
A_3	0.235	0.331797	0.81068	0	0.107784	0
A_4	1	0.820276	0.742718	0.760417	0.197605	0.672811
A_5	0.885	0.603687	0.723301	0.78125	1	0.539171
A_6	0.625	0.691244	0.121359	0.979167	0.047904	0.75576
A_7	0.675	0.672811	0	0.427083	0.57485	0.820276
A_8	0	0	1	0.505208	0	0.331797
A_9	0.48	1	0.927184	1	0.083832	1
A_{10}	0.91	0.442396	0.650485	0.609375	0.57485	0.179724

Table 10. The weighted comparability sequence.

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	0.075238	0.099904	0.107308	0.119838	0.120243	0.139569
A_2	0.167974	0.088886	0.103874	0.085126	0.122214	0.1655
A_3	0.041119	0.052891	0.143363	0	0.017741	0
A_4	0.174973	0.130757	0.131345	0.120665	0.032525	0.11135
A_5	0.154851	0.096231	0.127911	0.123971	0.164595	0.089233
A_6	0.109358	0.110189	0.021462	0.155376	0.007885	0.125078
A_7	0.118107	0.10725	0	0.067771	0.094618	0.135756
A_8	0	0	0.176843	0.080168	0	0.054913
A_9	0.083987	0.159406	0.163966	0.158682	0.013798	0.1655
A_{10}	0.159225	0.070521	0.115034	0.096697	0.094618	0.029744

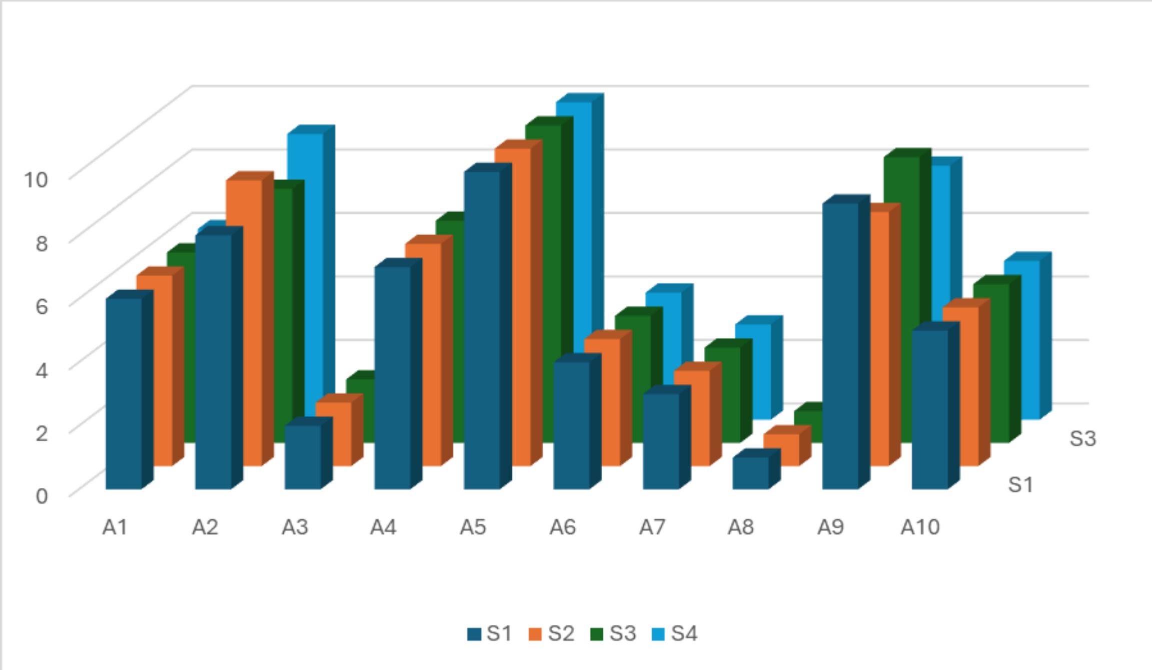

Figure 1. The rank of alternatives.

5. Conclusion and contributions

The evaluation of rural tourism competitiveness around cities aims to analyze and assess the overall performance and attractiveness of rural tourism destinations in the market. With the acceleration of urbanization, more and more urban residents are choosing rural areas as short-term vacation and leisure destinations, making the evaluation of rural tourism competitiveness particularly important. By comprehensively analyzing the resource advantages, visitor experience, market performance, and development potential of rural tourism, stakeholders and operators can better understand their market position and identify potential areas for improvement. At the same time, such evaluations provide a basis for policymakers to optimize rural tourism development strategies, improve the quality of tourism services, and promote the sustainable growth of rural economies. Ultimately, the competitiveness of rural tourism not only affects the number of visitors and their satisfaction but also determines its long-term development prospects in the tourism market. The evaluation of rural tourism competitiveness in surrounding cities involves MAGDM. Recently, the CoCoSo approach has been effectively applied to address MAGDM challenges. In this context, INSs serve as a tool for handling uncertain information during the evaluation process. The proposed INN-SHS-CoCoSo approach utilizes the Hamming distance to address MAGDM under INSs.

This approach integrates the following components:

(1) INSs with SuperHyperSoft for Uncertainty: INSs with SuperHyperSoft effectively manage the uncertainty and vagueness inherent in the evaluation process, allowing for more nuanced decision-making.

(2) Hamming Distance: The Hamming distance is employed to measure the difference between interval neutrosophic numbers.

A numerical case study is provided to validate the effectiveness of the proposed INN-SHS-CoCoSo approach. This case study demonstrates how the approach can be applied to assess rural tourism competitiveness, thereby offering a robust framework for decision-makers to prioritize and optimize rural tourism development strategies.

6. Research limitations and future research works

Although this paper proposes an effective evaluation method for the competitiveness of rural tourism around cities, there are still some shortcomings. First, the neglect of external factors is a major issue. The paper focuses on internal factors (such as resources and facilities) for evaluation but overlooks the potential impact of external factors like policy support, market demand changes, and technological advancements. These external factors could play a crucial role in real-world operations. Second, the complexity of the model's application limits its practicality. While the use of Interval Neutrosophic Sets (INSs) effectively handles uncertainty, the calculations are complex and highly specialized, making it challenging for ordinary rural tourism managers or decision-makers to apply these methods efficiently. Lastly, the lack of consideration for dynamic changes is another deficiency. The evaluation in this paper is based on static data, without accounting for the dynamic nature of factors such as the rural tourism market over time, which may result in a lack of forward-looking competitiveness assessment.

For future research directions, the following three aspects can be considered:

(1) Incorporating external factors: Future studies should integrate external factors such as policy support, changes in market demand, and technological innovations into the evaluation model of rural tourism competitiveness to improve the comprehensiveness and realism of the assessment. This would not only more accurately reflect competitiveness but also provide stronger references for policymakers.

(2) Simplifying the model and developing practical tools: Further research should consider how to simplify complex evaluation models or develop user-friendly decision-support tools, enabling rural tourism managers to more easily apply these models. This would help improve the operability and applicability of the evaluation methods.

(3) Introducing dynamic evaluation models: Future research could explore how to introduce a time dimension into competitiveness evaluations, developing dynamic models that track changes in rural tourism competitiveness over time. This would help decision-makers adjust strategies in response to changes in the market and environment, ensuring the sustainable development of rural tourism.

References

[1] Lebe SS, Milfelner B. Innovative organisation approach to sustainable tourism development in rural areas. Kybernetes. 2006;35(7-8):1136-46.

[2] Zasada I, Piorr A. The role of local framework conditions for the adoption of rural development policy: An example of diversification, tourism development and village renewal in brandenburg, germany. Ecological Indicators. 2015;59:82-93.

[3] Pejanovic R, Demirovic D, Glavas-Trbic D, Maksimovic G, Tomas-Simin M. Clusters as a factor of competitiveness of rural tourism destinations in the danube region of the republic of serbia. Tourism Economics. 2017;23(2):475-82.

[4] Feng NP, Wei FF, Zhang KH, Gu DX. Innovating rural tourism targeting poverty alleviation through a multi-industries integration network: The case of zhuanshui village, anhui province, china. Sustainability. 2018;10(7):18.

[5] Long NT, Nguyen TL. Sustainable development of rural tourism in an giang province, vietnam. Sustainability. 2018;10(4):20.

[6] Nabeeh N. Assessment and contrast the sustainable growth of various road transport systems using intelligent neutrosophic multi-criteria decision-making model. Sustainable Machine Intelligence Journal. 2023;2:(2):1-12.

[7] Mohamed R, Ismail MM. Leveraging an uncertainty methodology to appraise risk factors threatening sustainability of food supply chain. Neutrosophic Systems with Applications. 2024;19:30-52.

[8] A. Nabeeh N, M. Sallam K. A combined compromise solution (cocoso) of mcdm problems for selection of medical best bearing ring. Neutrosophic Optimization and Intelligent Systems. 2024;1:1-13.

[9] Lei F, Cai Q, Liao NN, Wei GW, He Y, Wu J, et al. Todim-vikor method based on hybrid weighted distance under probabilistic uncertain linguistic information and its application in medical logistics center site selection. Soft Computing. 2023;27(13):8541-59.

[10] Yazdani M, Zarate P, Zavadskas EK, Turskis Z. A combined compromise solution (cocoso) method for multi-criteria decision-making problems. Management Decision. 2018;57(9):2501-19.

[11] Badi I, Jibril M, Bakır M. A composite approach for site optimization of fire stations. Journal of Intelligent Management Decision. 2022;1(1):28-35.

[12] Badi I, Bouraima MB. Development of mcdm-based frameworks for proactively managing the most critical risk factors for transport accidents: A case study in libya. Spectrum of engineering and management sciences. 2023;1(1):38-47.

[13] Badi I, Stević Ž, Bouraima MB. Evaluating free zone industrial plant proposals using a combined full consistency method-grey-cocoso model. Journal of Industrial Intelligence. 2023;1(2):101-09.

[14] Tešić D, Božanić D, Radovanović M, Petrovski A. Optimising assault boat selection for military operations: An application of the dibr ii-bm-cocoso mcdm model. Journal of Intelligent Management Decision. 2023;2(4):160-71.

[15] Shannon CE. A mathematical theory of communication. Bell System Technical Journal. 1948;27(4):379-423.

[16] Wang H, Smarandache F, Zhang YQ, Sunderraman R. Interval neutrosophic sets and logic: Theory

and applications in computing. Hexis: Phoenix, AZ, USA. 2005.

[17] Wang H, Smarandache F, Zhang YQ, Sunderraman R. Single valued neutrosophic sets. Multispace Multistruct. 2010(4):410-13.

[18] Peng JJ, Wang JQ, Wang J, Zhang HY, Chen XH. Simplified neutrosophic sets and their applications in multi-criteria group decision-making problems. International Journal of Systems Science. 2016;47(10):2342-58.

[19] Huang YH, Wei GW, Wei C. Vikor method for interval neutrosophic multiple attribute group decision-making. Information. 2017;8(4):144.

[20] Zhang HY, Wang JQ, Chen XH. Interval neutrosophic sets and their application in multicriteria decision making problems. Scientific World Journal. 2014;2014:645953.

[21] Ye J. Similarity measures between interval neutrosophic sets and their applications in multicriteria decision-making. Journal of Intelligent & Fuzzy Systems. 2014;26(1):165-72.

Received: Aug 28, 2024. Accepted: Nov 24, 2024