NSS
Neutrosophic Sets and Systems, Vol. 75, 2025
University of New Mexico

Enhancing DVNN-WCSM Technique for Double-Valued Neutrosophic Multiple-Attribute Decision-Making in Digital Economy: A Case Study on Enhancing the Quality of Development of Henan's Cultural and Tourism Industry

Yourong Guo*

School of Cultural Heritage and Communication, Luoyang Polytechnic, Luoyang 471000, Henan, China
Corresponding author, e-mail: 202352001@lypt.edu.cn
https://orcid.org/0009-0000-7798-4851

Abstract: Henan Province is the core area of the Yellow River Basin and an important area for inheritance of Yellow River culture. Promoting the development of the cultural and tourism industry in Henan Province essentially involves integrating the cultural resources of the Yellow River in Henan Province, creating cultural tourism products and projects with the cultural characteristics of the Yellow River region, thereby enriching the content of Henan's tourism industry and promoting its economic development. In the future development of the cultural and tourism industry, Henan Province not only needs to solve current problems of insufficient industrial competitiveness, lack of product innovation, and incomplete brand shaping, but also needs to pay attention to the economic and social benefits of the cultural and tourism industry. Only in this way could we truly achieve the high-quality development goals of the cultural and tourism industry. The high-quality development quality evaluation of Henan's cultural and tourism industry driven by digital economy is multiple-attribute decision-making (MADM). The cosine similarity measure (CSM) has been put forward MADM. The double-valued neutrosophic sets (DVNSs) are put forward characterizing fuzzy information during the high-quality development quality evaluation of Henan's cultural and tourism industry driven by digital economy. In this study, the double-valued neutrosophic number CSM (DVNN-CSM) technique and double-valued neutrosophic number weighted CSM (DVNN-WCSM) technique are put forward the MADM along with DVNSs. Finally, a numerical study for high-quality development quality evaluation of Henan's cultural and tourism industry driven by digital economy is put forward validating the DVNNN-WCSM.

Keywords: Multiple-attribute decision-making (MADM); double-valued neutrosophic sets (DVNSs); cosine similarity measure (CSM); high-quality development quality evaluation

1. Introduction

The 20th National Congress of the Communist Party of China's report underscores the initiative to establish a digital China by accelerating the digital economy's growth and fostering its integration with the real economy. In response, the Ministry of Culture and Tourism in 2020 released a directive to enhance the digital cultural industry's quality development. It aims to merge cultural and tourism sectors within the digital economy framework and to expand superior digital cultural and tourism initiatives. Zhengzhou, recognized for its unique cultural and tourism assets labeled as "the soul of the Yellow River, the root of China, the center of heaven and earth, the capital of kung fu, and the source of civilization," stands out in this context. Consequently, the Henan Provincial Government unveiled the 14th Five Year Plan for Cultural Tourism Integration Development of Henan Province. This plan is set to deepen the synergy and

innovation between the "Internet plus tourism" and the digital cultural industry, aiding Henan's ambition to become a global cultural tourism nexus and a national beacon for cultural innovation. Furthermore, the Henan Province Cultural and Tourism Industry Development Work Conference emphasized a commitment to innovation-driven growth, leveraging digital technology to cultivate new cultural and tourism formats. Seizing this momentum, various departments within Henan Province have issued strategic documents advocating for a robust cultural and tourism city. These include positioning the Yellow River as a historic and cultural landmark and setting long-term objectives to establish a formidable cultural and tourism city [1-3]. Therefore, by advancing the high-quality development of the cultural and tourism industry in Henan Province through the digital economy, crafting a compelling narrative about the "Mountains and Rivers of the Motherland," and establishing the brand "Walking in Henan Province, Understanding the Earliest China," Henan can effectively integrate into the "Three Cities, Three Hundred Miles, Three Thousand Years" cultural belt of Zhengzhou and Bianluo. This integration will support Zhengzhou's efforts to become a nationally recognized historical and cultural landmark city and a central city at the national level. Located in the Yellow River Basin, Henan Province's cultural and tourism sector is deeply rooted in the culture of the Yellow River Basin [4]. To fully leverage the advantages of Henan's cultural and tourism natural resources, it is necessary to focus on ecological environment of Yellow River Basin, strengthen environmental governance, and create a green cultural and tourism industry. Henan Province aims to promote the green concept and encourage industrial entities to consciously comply with environmental protection requirements, develop cultural and tourism routes, and develop innovative cultural and tourism products based on not damaging the ecological environment and not affecting ecological balance[5-7]. Only in this way can we achieve good economic benefits while enhancing the social benefits of Henan's cultural and tourism industry, and achieve healthy and sustainable industry development. In the actual development process, cultural and tourism routes can be developed with themes such as "protecting the environment", "Yellow River governance", and "wetland protection"[8-10]. While promoting Yellow River culture, the process of environmental changes in Yellow River Basin can be explained, and tourists can be supported to contribute to ecological environment governance of Yellow River Basin through methods such as "crowdfunding", "small donations", and "collective tree planting". Relevant departments can also collaborate with new media platforms such as WeChat and Xiaohongshu to design activities such as "Henan Cultural and Tourism Steps Exchange for Tree Planting Points" and "Scenic Area Check in Records Exchange for Geopark Maintenance Points", in order to stimulate the enthusiasm of tourists and guide them to make their own contributions to the improvement of the ecological environment in Yellow River Basin. Compared to other inland provinces, Henan Province has certain advantages in the development of cultural and tourism industries[11-13]. This is because Henan is located on a transportation hub: cities such as Zhengzhou and Luoyang have been important hubs for the circulation of goods and economic exchanges since ancient times, and Kaifeng has a long history of cultural, economic, and social development. In addition, many cities in Henan are distributed along the Yellow River Basin and have rich cultural resources in the Yellow River Basin[14-16]. These are the unique conditions for Henan's cultural and tourism industry to create distinctive brands. Therefore, it is necessary to strengthen brand building, based on the Yellow River culture, to create the "Greater Yellow River Provincial Cultural and Tourism" brand, and based on this, to strengthen cooperation and exchange

among cities in Henan Province, and to create tourism routes between cities. If we can take advantage of the flow of people in Luoyang and attract tourists with its popularity, we can transport tourists from Luoyang to unknown urban attractions in the surrounding area, which can play a driving role[17, 18]. Afterwards, relevant departments of various cities can build sub-brands based on the "Greater Yellow River Provincial Cultural and Tourism" brand. For instance, in Kaifeng City, leveraging the historical significance of the "Bianjing Ancient City" in conjunction with the Sui and Tang dynasties can create a powerful brand effect. To enable high-quality development of Henan's cultural and tourism industry from an integration perspective, it is essential for the province to blend modern and historical cultures. This includes merging traditional culture with high-tech, and integrating the cultural and creative industries with tourism, catering, hotel industries, and other sectors.

From this perspective of fusion, a strategic step could be to establish a "Yellow River Cultural Landmark" to foster the cohesion of urban cultural and tourism resources within Henan Province. Echoing the insights shared by Secretary Xu Liyi at the "Cultural Tourism Enterprise Symposium," there is a critical need to capitalize on the strengths of historical cities, align with industrial trends, and effectively develop the cultural tourism industry [19-21]. In the process of developing the cultural and tourism industry, it is necessary to fully leverage Zhengzhou's geographical advantages, Kaifeng's historical advantages, and Luoyang's climate advantages, highlight urban characteristics, and build a Yellow River cultural landmark that integrates multiple urban features[22-24]. Secondly, we need to strengthen industrial integration and enrich the content of cultural and tourism integration system. It is recommended to rely on the infrastructure of the cultural and tourism industry to further carry out the construction of projects such as Henan Film and Television City, Republican style streets, and movie towns, achieving the integration of multiple industries such as film and television industry, construction industry, retail industry, and cultural and tourism industry[25-27].

The high-quality development quality evaluation of Henan’s cultural and tourism industry driven by the digital economy is MADM [28, 29]. The CSM approach was put forward by the MADM. The DVNSs [30] are put forward managing fuzzy information during the high-quality development quality evaluation of Henan’s cultural and tourism industry driven by the digital economy. However, it’s known that the existing studies about the CSM approach along with DVNSs do not exist. Hence, it’s very necessary to take the CSM approach along with DVNSs into account. Thus, in this study, the double-valued neutrosophic number CSM (DVNN-CSM) technique and double-valued neutrosophic number weighted CSM (DVNN-WCSM) technique are put forward the MADM along with DVNSs. Finally, a numerical study for high-quality development quality evaluation of Henan’s cultural and tourism industry driven by the digital economy is put forward validating the DVNNN-WCSM. The major contributions of this study are administrated: (1) the CSM approach was enhanced along with DVNSs; (2) the entropy put forward the weight values along with DVNSs; (3) the DVNN-WCSM approach put forward the MAGDM along with DVNSs; (4) numerical example for high-quality development quality evaluation of Henan’s cultural and tourism industry driven by digital economy is administrated to show the DVNN-WCSM approach. (5) the DVNN-WCSM approach is validated through different comparative studies.

The study structure of this work is administrated. In Sect. 2, the DVNSs is administrated. In Sect. 3, the DVNN-CSM and DVNN-WCSM model is put forward along with DVNSs. In Sect. 4, the DVNN-

WCSM model is put forward the MADM along with DVNSs. Sect. 5 administrates numerical examples for high-quality development quality evaluation of Henan's cultural and tourism industry driven by the digital economy and different comparative techniques. Comparative analysis is administrated in Sect. 6. Remarks are administrated in Sect. 7.

2. Preliminaries

Kandasamy [30] administrated the DVNSs.

Definition 1 [30]. The DVNSs DA in Θ is administrated:

$$DA=\left\{\left(\theta,DT_A(\theta),DIT_A(\theta),DIF_A(\theta),DF_A(\theta)\right)\middle|\theta\in\Theta\right\}. \tag{1}$$

where $DT_A(\theta)$ is truth-membership, $DIT_A(\theta)$ is indeterminacy leaning towards $DT_A(\theta)$, $DIF_A(\theta)$ is indeterminacy leaning towards $DF_A(\theta)$, $DF_A(\theta)$ is falsity-membership, $DT_A(\theta),DIT_A(\theta),DIF_A(\theta),DF_A(\theta)\in[0,1]$, $0\le DT_A(\theta)+DIT_A(\theta)+DIF_A(\theta)+DF_A(\theta)\le 4$.

The DVNN is administrated as: $DA=\left(DT_A,DIT_A,DIF_A,DF_A\right)$, $DT_A,DIT_A,DIF_A,DF_A\in[0,1]$, $0\le DT_A+DIT_A+DIF_A+DF_A\le 4$.

Definition 2[30]. Let $DA=\left(DT_A,DIT_A,DIF_A,DF_A\right)$ be DVNN, the score value is administrated:

$$SV(DA)=\frac{\left(2+DT_A+DIT_A-DIF_A-DF_A\right)}{4},\ SV(DA)\in[0,1]. \tag{2}$$

Definition 3[30]. Let $DA=\left(DT_A,DIT_A,DIF_A,DF_A\right)$ be DVNN, the accuracy value is administrated:

$$AV(DA)=\frac{\left(DT_A+DIT_A+DIF_A+DF_A\right)}{4},\ AV(DA)\in[0,1]\ . \tag{3}$$

The order relation for DVNNs is administrated.

Definition 4[30]. Let $DA=\left(DT_A,DIT_A,DIF_A,DF_A\right)$ and $DB=\left(DT_B,DIT_B,DIF_B,DF_B\right)$,

$SV(DA)=\frac{\left(2+DT_A+DIT_A-DIF_A-DF_A\right)}{4}$, $SV(DB)=\frac{\left(2+DT_B+DIT_B-DIF_B-DF_B\right)}{4}$,

$AV(DA)=\frac{\left(DT_A+DIT_A+DIF_A+DF_A\right)}{4}$, $AV(DB)=\frac{\left(DT_B+DIT_B+DIF_B+DF_B\right)}{4}$, if

$SV\left(DA\right)<SV\left(DB\right)$, $DA<DB$; if $SV\left(DA\right)=SV\left(DB\right)$, (1)if $AV\left(DA\right)=AV\left(DB\right)$, $DA=DB$; (2) if $AV\left(DA\right)<AV\left(DB\right)$, $DA<DB$.

Definition 5[30]. Let $DA=\left(DT_A,DIT_A,DIF_A,DF_A\right)$ and $DB=\left(DT_B,DIT_B,DIF_B,DF_B\right)$ be two DVNNs, the operations are administrated:

(1) $DA\oplus DB=\left(DT_A+DT_B-DT_ADT_B,DIT_A+DIT_B-DIT_ADIT_B,DIF_ADIF_B,DF_ADF_B\right)$;

(2) $DA\otimes DB=\left(DT_ADT_B,DIT_ADIT_B,DIF_A+DIF_B-DIF_ADIF_B,DF_A+DF_B-DF_ADF_B\right)$;

(3) $\lambda DA=\left(1-\left(1-DT_A\right)^{\lambda},1-\left(1-DIT_A\right)^{\lambda},\left(DIF_A\right)^{\lambda},\left(DF_A\right)^{\lambda}\right),\lambda>0$;

(4) $\left(DA\right)^{\lambda}=\left(\left(DT_A\right)^{\lambda},\left(DIT_A\right)^{\lambda},1-\left(1-DIF_A\right)^{\lambda},1-\left(1-DF_A\right)^{\lambda}\right),\lambda>0.$

3. Some CSM approaches for DVNSs based on cosine function

In light with the idea of CSM [31-37], DVNN-CSM and DVNN-WCSM are administrated.

Definition 6. Let $DA=\left\{\left\langle\xi_j,\left(DT_A\left(\xi_j\right),DIT_A\left(\xi_j\right),DIF_A\left(\xi_j\right),DF_A\left(\xi_j\right)\right)\right\rangle\middle|\xi_j\in\xi\right\}$ and $DB=\left\{\left\langle\xi_j,\left(DT_B\left(\xi_j\right),DIT_B\left(\xi_j\right),DIF_B\left(\xi_j\right),DF_B\left(\xi_j\right)\right)\right\rangle\middle|\xi_j\in\xi\right\}$ be DVNSs in $\xi=\left\{\xi_1,\xi_2,\cdots,\xi_n\right\}$. Then, DVNN-CSM and DVNN-WCSM are administrated between DA and DB:

$$DVNN\text{-}CSM\left(DA,DB\right)=\frac{1}{n}\sum_{j=1}^{n}\cos\left[\frac{\pi}{4}\begin{pmatrix}\left|DT_A\left(\xi_j\right)-DT_B\left(\xi_j\right)\right|\vee\\ \left|DIT_A\left(\xi_j\right)-DIT_B\left(\xi_j\right)\right|\vee\\ \left|DIF_A\left(\xi_j\right)-DIF_B\left(\xi_j\right)\right|\vee\\ \left|DF_A\left(\xi_j\right)-DF_B\left(\xi_j\right)\right|\end{pmatrix}+\frac{\pi}{16}\begin{pmatrix}\left|DT_A\left(\xi_j\right)-DT_B\left(\xi_j\right)\right|+\\ \left|DIT_A\left(\xi_j\right)-DIT_B\left(\xi_j\right)\right|+\\ \left|DIF_A\left(\xi_j\right)-DIF_B\left(\xi_j\right)\right|+\\ \left|DF_A\left(\xi_j\right)-DF_B\left(\xi_j\right)\right|\end{pmatrix}\right] \tag{4}$$

Proposition 1. For DA and DB in $\xi=\left\{\xi_1,\xi_2,\cdots,\xi_n\right\}$, the $DVNN\text{-}CSM\left(DA,DB\right)$ meet the properties (1)-(4):

(1) $0\le DVNN\text{-}CSM\left(DA,DB\right)\le 1$;

(2) $DVNN\text{-}CSM\left(DA,DB\right)=1$, if and only if $DA=DB$;

(3) $DVNN\text{-}CSM\left(DA,DB\right)=DVNN\text{-}CSM\left(DB,DA\right)$;

(4) If DC is DVNS in $\xi=\left\{\xi_1,\xi_2,\cdots,\xi_n\right\}$, $DA\subseteq DB\subseteq DC$, then

$$DVNN\text{-}CSM\left(DA,DC\right)\le DVNN\text{-}CSM\left(DA,DB\right),$$

$$DVNN\text{-}CSM\left(DA,DC\right)\le DVNN\text{-}CSM\left(DB,DC\right).$$

Proof:

(1) Since cosine value is [0,1], $0\le DVNN\text{-}CSM\left(DA,DB\right)\le 1$.

(2) For DVNSs DA and DB in $\xi=\{\xi_1,\xi_2,\cdots,\xi_n\}$, if $DA=DB$, then

$$DT_A\left(\xi_j\right)=DT_B\left(\xi_j\right),DIT_A\left(\xi_j\right)=DIT_B\left(\xi_j\right),DIF_A\left(\xi_j\right)=DIF_B\left(\xi_j\right),DF_A\left(\xi_j\right)=DF_B\left(\xi_j\right).$$

Thus, $\left|DT_A\left(\xi_j\right)-DT_B\left(\xi_j\right)\right|=0$, $\left|DIT_A\left(\xi_j\right)-DIT_B\left(\xi_j\right)\right|=0$, $\left|DIF_A\left(\xi_j\right)-DIF_B\left(\xi_j\right)\right|=0$, $\left|DF_A\left(\xi_j\right)-DF_B\left(\xi_j\right)\right|=0$. Thus, $DVNN\text{-}CSM\left(DA,DB\right)=1$.

If $DVNN\text{-}CSM\left(DA,DB\right)=1$, then $\left|DT_A\left(\xi_j\right)-DT_B\left(\xi_j\right)\right|=0$, $\left|DIT_A\left(\xi_j\right)-DIT_B\left(\xi_j\right)\right|=0$, $\left|DIF_A\left(\xi_j\right)-DIF_B\left(\xi_j\right)\right|=0$, $\left|DF_A\left(xx_j\right)-DF_B\left(xx_j\right)\right|=0$. Since $\cos(0)=1$. Then, $DT_A\left(\xi_j\right)=DT_B\left(\xi_j\right),DIT_A\left(\xi_j\right)=DIT_B\left(\xi_j\right),\ DIF_A\left(\xi_j\right)=DIF_B\left(\xi_j\right),DF_A\left(\xi_j\right)=DF_B\left(\xi_j\right)$ Hence $DA=DB$.

(3) Proof is apparent.

(4) If $DA\subseteq DB\subseteq DC$, then $DT_A\left(\xi_j\right)\le DT_B\left(\xi_j\right)\le DT_C\left(\xi_j\right)$, $DIT_A\left(\xi_j\right)\le DIT_B\left(\xi_j\right)\le DIT_C\left(\xi_j\right)$, $DIF_A\left(\xi_j\right)\ge DIF_B\left(\xi_j\right)\le DIF_C\left(\xi_j\right)$, $DF_A\left(\xi_j\right)\ge DF_B\left(\xi_j\right)\le DF_C\left(\xi_j\right)$ for $j=1,2,\cdots,n$. Then, we have

$$\left|DT_A\left(\xi_j\right)-DT_B\left(\xi_j\right)\right|\le\left|DT_A\left(\xi_j\right)-DT_C\left(\xi_j\right)\right|,$$

$$\left|DT_B\left(\xi_j\right)-DT_C\left(\xi_j\right)\right|\le\left|DT_A\left(\xi_j\right)-DT_C\left(\xi_j\right)\right|,$$

$$\left|DIT_A\left(\xi_j\right)-DIT_B\left(\xi_j\right)\right|\le\left|DIT_A\left(\xi_j\right)-DIT_C\left(\xi_j\right)\right|,$$

$$\left|DIT_B\left(\xi_j\right)-DIT_C\left(\xi_j\right)\right|\le\left|DIT_A\left(\xi_j\right)-DIT_C\left(\xi_j\right)\right|$$

$$\left|DIF_A\left(\xi_j\right)-DIF_B\left(\xi\right)\right|\le\left|DIF_A\left(\xi_j\right)-DIF_C\left(\xi_j\right)\right|,$$

$$\left|DIF_B\left(\xi_j\right)-DIF_C\left(\xi_j\right)\right|\le\left|DIF_A\left(\xi_j\right)-DIF_C\left(\xi_j\right)\right|,$$

$$\left|DF_A\left(\xi_j\right)-DF_B\left(\xi_j\right)\right|\le\left|DF_A\left(\xi_j\right)-DF_C\left(\xi_j\right)\right|,$$

$$\left|DF_B\left(\xi_j\right)-DF_C\left(\xi_j\right)\right|\le\left|DF_A\left(\xi_j\right)-DF_C\left(\xi_j\right)\right|,$$

Hence, $DVNN\text{-}CSM\left(DA,DC\right)\le DVNN\text{-}CSM\left(DA,DB\right)$,

$DVNN\text{-}CSM\left(DA,DC\right)\le DVNN\text{-}CSM\left(DB,DC\right)$, for $k=1,2$, as cosine function is decreasing for $\left[0,\frac{\pi}{2}\right]$.

In more and more MADM settings, the weight values for $\xi_j\in\xi$ need be considered. Then, the DVNN-WCSM is administrated:

$$DVNN\text{-}WCSM\left(DA,DB\right)$$
$$=\sum_{j=1}^{n}dw_j\cos\left[\frac{\pi}{4}\begin{pmatrix}\left|DT_A\left(\xi_j\right)-DT_B\left(\xi_j\right)\right|\vee\\ \left|DIT_A\left(\xi_j\right)-DIT_B\left(\xi_j\right)\right|\vee\\ \left|DIF_A\left(\xi_j\right)-DIF_B\left(\xi_j\right)\right|\vee\\ \left|DF_A\left(\xi_j\right)-DF_B\left(\xi_j\right)\right|\end{pmatrix}+\frac{\pi}{16}\begin{pmatrix}\left|DT_A\left(\xi_j\right)-DT_B\left(\xi_j\right)\right|+\\ \left|DIT_A\left(\xi_j\right)-DIT_B\left(\xi_j\right)\right|+\\ \left|DIF_A\left(\xi_j\right)-DIF_B\left(\xi_j\right)\right|+\\ \left|DF_A\left(\xi_j\right)-DF_B\left(\xi_j\right)\right|\end{pmatrix}\right] \tag{5}$$

where $dw=\left(dw_1,dw_2,\cdots,dw_n\right)^T$ is weight values of ξ_j, $dw_j\in[0,1]$, $\sum_{j=1}^{n}dw_j=1$ and the symbol "$\vee$ "is maximum operation. If $dw=\left(1/n,1/n,\cdots,1/n\right)^T$, then $DVNN\text{-}WCSM\left(DA,DB\right)=DVNN\text{-}CSM\left(DA,DB\right)$.

The $DVNN\text{-}WCSM\left(DA,DB\right)$ meet the Proposition 2.

Proposition 2. For DVNSs DA and DB in $\xi=\left\{\xi_1,\xi_2,\cdots,\xi_n\right\}$, $DVNN\text{-}WCSM\left(DA,DB\right)$ meet properties (1-4):

(5) $0\le DVNN\text{-}WCSM\left(DA,DB\right)\le 1$;

(6) $DVNN\text{-}WCSM\left(DA,DB\right)=1$, then $DA=DB$;

(7) $DVNN\text{-}WCSM\left(DA,DB\right)=DVNN\text{-}WCSM\left(DB,DA\right)$;

(8) If DC is the DVNS in XX, $DA\subseteq DB\subseteq DC$, we have: $DVNN\text{-}WCSM\left(DA,DC\right)\le DVNN\text{-}WCSM\left(DA,DB\right)$ and $DVNN\text{-}WCSM\left(DA,DC\right)\le DVNN\text{-}WCSM\left(DB,DC\right)$.

4. Proposed DVNN-WCSM technique for MADM

The DVNN-WCSM technique is administrated for MADM. Let $DA=\left\{DA_1,DA_2,\cdots,DA_m\right\}$ be alternatives, $DG=\left\{DG_1,DG_2,\cdots,DG_n\right\}$ be attributes with weight dw, where $dw_j\in\left[0,1\right]$, $\sum_{j=1}^{n}dw_j=1$. Suppose that assessed values are administrated with DVNNs $DR=\left(DR_{ij}\right)_{m\times n}=\left(DT_{ij},DIT_{ij},DIF_{ij},DF_{ij}\right)_{m\times n}$. Then, DVNN-WCSM technique is administrated for MADM.

Step 1. Administrate the DVNN-matrix $DR=\left(DR_{ij}\right)_{m\times n}=\left(DT_{ij},DIT_{ij},DIF_{ij},DF_{ij}\right)_{m\times n}$.

$$DR=\left[DR_{ij}\right]_{m\times n}=\begin{bmatrix}DR_{11} & DR_{12} & \cdots & DR_{1n}\\ DR_{21} & DR_{22} & \cdots & DR_{2n}\\ \vdots & \vdots & \vdots & \vdots\\ DR_{m1} & DR_{m2} & \cdots & DR_{mn}\end{bmatrix} \tag{6}$$

$$DR_{ij}=\left(DT_{ij},DIT_{ij},DIT_{ij},DF_{ij}\right) \tag{7}$$

Step 2. Normalize the $DR=\left(DR_{ij}\right)_{m\times n}=\left(DT_{ij},DIT_{ij},DIF_{ij},DF_{ij}\right)_{m\times n}$ into $NDR=\left(NDR_{ij}\right)_{m\times n}=\left(NDT_{ij},NDIT_{ij},NDIF_{ij},NDF_{ij}\right)_{m\times n}$.

$$\begin{aligned}NDR_{ij}&=\left(NDT_{ij},NDIT_{ij},NDIF_{ij},NDF_{ij}\right)\\&=\begin{cases}\left(DT_{ij},DIT_{ij},DIF_{ij},DF_{ij}\right), & DG_j\ is\ benefit\ attribute\\ \left(DF_{ij},DIF_{ij},DIT_{ij},DT_{ij}\right), & DG_j\ is\ \cos t\ attribue\end{cases}\end{aligned} \tag{8}$$

Step 3. Administrate the weight numbers through entropy.

The weight is really important for MADM [38-42]. Entropy [43] is put forward weight along with HFSs [44]. The normalized DVNN-matrix $DVNNM_{ij}$ is administrated:

$$DVNNM_{ij} = \frac{SV\left(NDT_{ij}, NDIT_{ij}, NDIF_{ij}, NDF_{ij}\right)+1}{\sum_{i=1}^{m}\left(SV\left(NDT_{ij}, NDIT_{ij}, NDIF_{ij}, NDF_{ij}\right)+1\right)}, \tag{9}$$

Then, DVNN Shannon information entropy (DVNNSIE) is administrated:

$$DVNNSIE_j = -\frac{1}{\ln m}\sum_{i=1}^{m} DVNNM_{ij} \ln DVNNM_{ij} \tag{10}$$

and $DVNNM_{ij} \ln DVNNM_{ij} = 0$ if $DVNNM_{ij} = 0$.

Then, the weight numbers are administrated:

$$dw_j = \frac{1 - DVNNSIE_j}{\sum_{j=1}^{n}\left(1 - DVNNSIE_j\right)} \tag{11}$$

Step 4. Administrate the DVNN positive ideal alternative (DVNNPIA):

$$DVNNPIA = \left(DVNNPIA_1, DVNNPIA_2, \cdots, DVNNPIA_n\right) \tag{12}$$

$$DVNNPIA_j = \left(NDT_j, NDIT_j, NDIF_j, NDF_j\right) \tag{13}$$

$$\begin{aligned} &SV\left(NDT_j, NDIT_j, NDIF_j, NDF_j\right) \\ &= \max_i SV\left(NDT_{ij}, NDIT_{ij}, NDIF_{ij}, NDF_{ij}\right) \end{aligned} \tag{14}$$

Step 5. Administrate the $DVNN\text{-}WCSM\left(DA_i, DVNNPIA\right)$:

$$\begin{aligned} &DVNN\text{-}WCSM\left(DA_i, DVNNPIA\right) \\ &= \sum_{j=1}^{n} ow_j \cos\left[\frac{\pi}{4}\begin{pmatrix} \left|NDT_j - NDT_{ij}\right| \vee \\ \left|NDIT_j - NDIT_{ij}\right| \vee \\ \left|NDIF_j - NDIF_{ij}\right| \vee \\ \left|NDF_j - NDF_{ij}\right| \end{pmatrix} + \frac{\pi}{16}\begin{pmatrix} \left|NDT_j - NDT_{ij}\right| + \\ \left|NDIT_j - NDIT_{ij}\right| + \\ \left|NDIF_j - NDIF_{ij}\right| + \\ \left|NDF_j - NDF_{ij}\right| \end{pmatrix}\right] \end{aligned} \tag{15}$$

Step 6. In line with $DVNN\text{-}WCSM\left(DA_i, DVNNPIA\right)$, the order is obtained. The largest $DVNN\text{-}WCSM\left(DA_i, DVNNPIA\right)$ is optimal one.

5. Application on double-valued Neutrosophic set

Guided by documents like the "2020 Key Points for Ecological Protection and High-Quality Development of the Yellow River Basin in Henan Province" and the "Henan Tourism Regulations," there is a pressing

need for relevant departments to enhance the development of cultural and tourism industry resources in Henan Province. The focus is on expanding the cultural and tourism sectors while also considering the ecological environment and regional economic growth, aiming to significantly boost the economic and social benefits of these industries. There are, however, existing challenges within Henan's cultural and tourism sector that demand attention. Addressing these challenges requires the formulation of high-quality development strategies tailored to the region's unique characteristics, thereby fostering continuous progress in this sector. The current state of Henan's cultural and tourism industry, based on the statistical bulletin, presents mixed developments across different cities: (1) Zhengzhou and Luoyang showcase supply advantages in the cultural and tourism sectors, with numerous enterprises in Zhengzhou and robust public service capabilities in Luoyang. Despite this, Luoyang has fewer cultural and tourism enterprises compared to Zhengzhou. (2) Both cities are noted for their strong industrial innovation capabilities. Luoyang, in particular, excels in developing smart scenic spots, while Zhengzhou leads in cultural and creative development. (3) The industrial structure in Zhengzhou and Luoyang is relatively balanced, contrasting with other cities that face geographic limitations and reduced market influence, leading to notable imbalances. To support and enhance the cultural and tourism industry in Henan, several strategic initiatives are necessary: (1) Government Support: Increased backing for leading cultural and tourism enterprises is crucial. This includes leveraging national industrial parks and cultural industry bases within Henan to consolidate resources, boost investment in leading companies, and initiate projects like the Yellow River National Cultural Park and the Yellow River Ecological Cultural Tourism Corridor. These efforts aim to create large-scale, branded cultural and tourism projects. (2) Utilization of Public Resources: It's vital to maximize the use of public cultural and tourism resources, integrating the infrastructure of libraries, museums, and cultural centers across Henan. This approach should foster collaborations across multiple venues, developing comprehensive cultural and tourism projects, renowned tourism routes, and distinctive cultural products, thereby enriching the industry ecosystem and enhancing Henan's overall competitiveness in these sectors. The ongoing evaluation of Henan's cultural and tourism industry's quality development, driven by the digital economy, is a MADM process. Seven Henan's cultural and tourism industries are assessed with different attributes: DG_1 is thinking on the digital development of the cultural and tourism industry. DG_2 is the input of production factors required for the digital development of the

cultural and tourism industry. DG_3 is the supply of digital development in the cultural and tourism industry. DG_4 is a digital management service for the cultural and tourism industry. The DVNN-WCSM approach is putting forward the high-quality development quality evaluation of Henan's cultural and tourism industry driven by the digital economy.

Step 1. Administrate the DVNN-matrix $DR = \left(DR_{ij}\right)_{7\times4}$ (Table 1).

Table 1. $DR = \left(DR_{ij}\right)_{7\times4}$

	DG_1	DG_2
DA_1	(0.44, 0.56,0.07, 0.48)	(0.44, 0.67,0.39, 0.48)
DA_2	(0.43, 0.67,0.44, 0.44)	(0.44, 0.56,0.44, 0.46)
DA_3	(0.49, 0.49,0.44, 0.49)	(0.43, 0.76,0.44, 0.44)
DA_4	(0.46, 0.45,0.44, 0.40)	(0.44, 0.44, 0.25,0.44)
DA_5	(0.43, 0.54,0.07, 0.49)	(0.42, 0.45,0.34, 0.49)
DA_6	(0.26, 0.43, 0.34,0.47)	(0.43, 0.52,0.58, 0.57)
DA_7	(0.22, 0.39, 0.31,0.43)	(0.39, 0.48,0.54, 0.53)
	DG_3	DG_4
DA_1	(0.44, 0.48,0.07, 0.47)	(0.44, 0.65,0.43, 0.48)
DA_2	(0.43, 0.47,0.28, 0.44)	(0.43,0.28,0.63, 0.48)
DA_3	(0.45, 0.65,0.09, 0.44)	(0.43, 0.42,0.05, 0.39)
DA_4	(0.44,0.45,0.45, 0.47)	(0.36, 0.24,0.35, 0.34)
DA_5	(0.44, 0.46,0.35, 0.48)	(0.48,0.47,0.44, 0.39)
DA_6	(0.37,0.31,0.43, 0.35)	(0.31, 0.25,0.37, 0.38)
DA_7	(0.24, 0.32,0.37, 0.41)	(0.36,0.35,0.32, 0.28)

Step 2. Normalize the $DR = \left(DR_{ij}\right)_{7\times4}$ into $NDR = \left(NDR_{ij}\right)_{7\times4}$ (See Table 2).

Table 2. $NDR = \left(NDR_{ij}\right)_{7\times4}$

	DG_1	DG_2
DA_1	(0.44, 0.56,0.07, 0.48)	(0.44, 0.67,0.39, 0.48)
DA_2	(0.43, 0.67,0.44, 0.44)	(0.44, 0.56,0.44, 0.46)
DA_3	(0.49, 0.49,0.44, 0.49)	(0.43, 0.76,0.44, 0.44)
DA_4	(0.46, 0.45,0.44, 0.40)	(0.44, 0.44, 0.25,0.44)
DA_5	(0.43, 0.54,0.07, 0.49)	(0.42, 0.45,0.34, 0.49)
DA_6	(0.26, 0.43, 0.34,0.47)	(0.43, 0.52,0.58, 0.57)
DA_7	(0.22, 0.39, 0.31,0.43)	(0.39, 0.48,0.54, 0.53)
	DG_3	DG_4
DA_1	(0.44, 0.48,0.07, 0.47)	(0.44, 0.65,0.43, 0.48)

DA_2	(0.43, 0.47,0.28, 0.44)	(0.43,0.28,0.63, 0.48)
DA_3	(0.45, 0.65,0.09, 0.44)	(0.43, 0.42,0.05, 0.39)
DA_4	(0.44,0.45,0.45, 0.47)	(0.36, 0.24,0.35, 0.34)
DA_5	(0.44, 0.46,0.35, 0.48)	(0.48,0.47,0.44, 0.39)
DA_6	(0.37,0.31,0.43, 0.35)	(0.31, 0.25,0.37, 0.38)
DA_7	(0.24, 0.32,0.37, 0.41)	(0.36,0.35,0.32, 0.28)

Step 3. Administrate the weight numbers (Table 3).

Table 3. The weight numbers

	DG_1	DG_2	DG_3	DG_4
Weight	0.2356	0.3177	0.2355	0.2112

Step 4. Administrate the DVNNPIA (Table 4):

Table 4. The DVNNPIA

	DG_1	**DG_2**
DVNNPIA	(0.49, 0.49,0.44, 0.49)	(0.44, 0.67,0.39, 0.48)

	DG_3	**DG_4**
DVNNPIA	(0.45, 0.65,0.09, 0.44)	(0.48,0.47,0.44, 0.39)

Step 5. Administrate the $DVNN\text{-}WCSM\left(DA_i, DVNNPIA\right)$ (Table 5):

Table 5. The $DVNN\text{-}WCSM\left(DA_i, DVNNPIA\right)$

Similarity measures	$DVNN\text{-}WCSM\left(DA_i, DVNNPIA\right)$	Order
$\left(DA_1, DVNNPIA\right)$	0.5252	4
$\left(DA_2, DVNNPIA\right)$	0.8238	1
$\left(DA_3, DVNNPIA\right)$	0.4449	5
$\left(DA_4, DVNNPIA\right)$	0.7267	2
$\left(DA_5, DVNNPIA\right)$	0.6563	3

$\left(DA_6, DVNNPIA\right)$	0.4216	6
$\left(DA_7, DVNNPIA\right)$	0.4097	7

Step 6. In line with $DVNN\text{-}WCSM\left(DA_i, DVNNPIA\right)$, the order is $DA_2 > DA_4 > DA_5 > DA_1 > DA_3 > DA_6 > DA_7$, and the optimal Henan's cultural and tourism industry is DA_2.

6. Comparative analysis

Then, $DVNSWCSM\left(DA_i, DVNNPIA\right)$ is compared with weighted Dice similarity measures $WD_{\mathrm{DVNS}_1}\left(DA_i, DVNNPIA\right)$, $WD_{\mathrm{DVNS}_2}\left(DA_i, DVNNPIA\right)$ and weighted generalized Dice similarity measures $WGD_{\mathrm{DVNS}_1}\left(DA_i, DVNNPIA\right)$, $WGD_{\mathrm{DVNS}_2}\left(DA_i, DVNNPIA\right)$ [45] (See Table 6).

Table 6. Order for different techniques

Techniques	order
$WD_{\mathrm{DVNS}_1}\left(DA_i, DVNNPIA\right)$	$DA_2 > DA_4 > DA_5 > DA_1 > DA_3 > DA_6 > DA_7$
$WD_{\mathrm{DVNS}_2}\left(DA_i, DVNNPIA\right)$	$DA_2 > DA_4 > DA_5 > DA_1 > DA_3 > DA_6 > DA_7$
$WGD_{\mathrm{DVNS}_1}\left(DA_i, DVNNPIA\right)$	$DA_2 > DA_4 > DA_5 > DA_1 > DA_3 > DA_6 > DA_7$
$WGD_{\mathrm{DVNS}_2}\left(DA_i, DVNNPIA\right)$	$DA_2 > DA_4 > DA_5 > DA_1 > DA_3 > DA_6 > DA_7$
$DVNSWCSM\left(DA_i, DVNNPIA\right)$	$DA_2 > DA_4 > DA_5 > DA_1 > DA_3 > DA_6 > DA_7$

From the comparative analysis, it could be administrated that these techniques have the same optimal Henan's cultural and tourism industry and worst Henan's cultural and tourism industry. This verified the DVNN-WCSM approach is reasonable and effective.

7. Conclusion

Industrial integration is the foundation of the development of cultural and tourism industry. Strengthening the integration of culture and tourism industry, developing cultural tourism integration products and service projects, is the main means of comprehensively developing the cultural tourism

industry. Cultural and tourism brands are an important element in the development of the cultural and tourism industry in Henan Province. A good brand effect can attract more tourists, while also introducing foreign funds and technology to drive the high-quality development of cultural and tourism industry. From the actual situation, although Henan Province has rich cultural resources in the Yellow River Basin and distinct cultural characteristics, there is a lack of integration and utilization of these characteristic resources, and no brand of "Yellow River Basin cultural tourism" has been established. There is insufficient promotion of the ecological environment, historical culture, cultural development, and other aspects of the region, and no brand effect has been formed. The high-quality development quality evaluation of Henan's cultural and tourism industry driven by the digital economy is MADM. In this study, entropy is put forward the weight values along with DVNSs, and the DVNN-CSM technique and DVNN-WCSM technique are put forward along with DVNSs. Then, the DVNN-WCSM approach is put forward the MAGDM along with DVNSs. Finally, a numerical study for high-quality development quality evaluation of Henan's cultural and tourism industry driven by the digital economy is put forward validating the DVNNN-WCSM. The major contributions of this study are administrated: (1) the CSM approach was enhanced along with DVNSs; (2) the entropy put forward the weight values along with DVNSs; (3) the DVNN-WCSM approach put forward the MAGDM along with DVNSs; (4) numerical example for high-quality development quality evaluation of Henan's cultural and tourism industry driven by digital economy is administrated to show the DVNN-WCSM approach. (5) the DVNN-WCSM approach is validated through different comparative studies.

Acknowledgments

This work was supported by the Soft Science Project of the Henan Provincial Department of Science and Technology, Project Number 242400410527.

References

[1] Z. Cao, H. Xu, B.S.X. Teo, Sentiment of chinese tourists towards malaysia cultural heritage based on online travel reviews, Sustainability, 15 (2023) 17.

[2] Y.L. Kong, Real-time processing system and internet of things application in the cultural tourism industry development, Soft Computing, 27 (2023) 10347-10357.

[3] J.Q. Li, T.J. Lee, N. Chen, K.S. Park, Pro-environmental behaviour of the residents in sensitive tourism destinations, Journal of Vacation Marketing, 29 (2023) 291-308.

[4] G.L. Liu, Research on the role of red tourism on the inheritance and development of red culture from the perspective of psychological education, International Journal of Mental Health Nursing, 32 (2023) 30-30.

[5] X. Liu, Tourism development, environmental regulations, and natural resource management: Evidence from

g20 countries, Resources Policy, 86 (2023) 11.

[6] W. Luo, Z.H. Huang, S.Y. Cheng, Z.Q. Gan, Oriental management strategies for urban resilience: Based on the wuli-shili-renli methodology and coupled coordination degree model, Heliyon, 9 (2023) 12.

[7] Z.Y. Mao, K. Ma, Y.S. Li, C.M. Kuang, Y.J. Tang, S.W. Zhu, X.F. Zhang, P. Zhang, Q.P. Qin, Environmental evaluation and regulation method of ancient buildings based on wireless rechargeable sensor network, Ieee Sensors Journal, 23 (2023) 20865-20873.

[8] X.Y. Meng, Application of vr recognition based on image object detection algorithm in urban street landscape art design, Soft Computing, (2023) 9.

[9] P. Munoz, E. Donaque, A. Larranaga, J. Martinez, A. Mejias, Tourism-related placeness feature extraction from social media data using machine learning models, International Journal of Interactive Multimedia and Artificial Intelligence, 8 (2023) 217.

[10] P.F. Wang, X.D. Cao, Z.Y. Gao, X.Y. Su, X. Wei, The influence of leisure patterns on the subjective well-being of the floating population-a social integration perspective, Leisure Studies, (2023) 16.

[11] Y. Wang, Y.L. Gao, R. Faraj, Cross-cultural aspects of tourism and hospitality: A services marketing and management perspective, Journal of Tourism and Cultural Change, 21 (2023) 623-625.

[12] Y.X. Wang, W.W. Hu, K.S. Park, Q. Yuan, N. Chen, Examining residents? Support for night tourism: An application of the social exchange theory and emotional solidarity, Journal of Destination Marketing & Management, 28 (2023) 12.

[13] B.B. Xie, W. Wei, Y.Y. Li, C.Y. Liu, S.L. Ju, Research on spatial distribution characteristics and correlation degree of the historical and cultural towns (villages) in china, Sustainability, 15 (2023) 17.

[14] L. Yang, Y.S. Yang, S.J. Zhang, H.M. Li, H.H. Cao, Y.F. Cui, F.W. Liu, M.M. Ma, Asynchronous transformation of cropping patterns from 5800-2200 cal bp on the southern loess plateau, china, Land, 12 (2023) 18.

[15] Y.Z. Yang, S.J. Liu, X.T. Song, The co-creation of museum experience value from the perspective of visitor motivation, Sage Open, 13 (2023) 19.

[16] Q. Zhang, J. Zhang, S. Lu, Y. Liu, L. Liu, Y.Y. Wang, M.Y. Cao, Multi-resolution feature extraction and fusion for traditional village landscape analysis in remote sensing imagery, Traitement Du Signal, 40 (2023) 1259-1266.

[17] Y.X. Zhang, M.Y. Yang, Z.Y. Li, W.Z. Li, C.C. Lu, Z.G. Li, H.D. Li, F.F. Zhai, Study on the spatial distribution characteristics and influencing factors in the reuse of national industrial heritage sites in china, Sustainability, 15 (2023) 23.

[18] H. Zhu, Z.C. Chen, Population genetics and pedigree geography of trionychia japonica in the four mountains of henan province and the taihang mountains, Open Geosciences, 15 (2023) 13.

[19] Y. Li, L.Y. Jiao, M. Zhou, How does cultural heritage destination digitalization influence tourists' attitudes? The role of constructive authenticity and technology-destination fit, Journal of Travel & Tourism Marketing, 41 (2024) 221-234.

[20] W. Luo, Q.D. Ran, S.Y. Cheng, What kind of support can promote academic entrepreneurial intention: An analysis of the qualitative comparative analysis configuration effect of multiple support, Managerial and Decision Economics, 45 (2024) 1414-1427.

[21] L.X. Ouyang, S. Zhang, S.C. Zhu, Z. Liu, J. Li, Digital technology in tourism dance performance: Exploring the influence of tourists' flow experience and meaningful experience on revisit intention, Ieee Access, 12 (2024) 46347-46361.

[22] F. Wang, Analysis of the role of psychological occupational therapy in the process of cultural tourism with

tourists, Journal of Intelligent & Fuzzy Systems, 46 (2024) 2775-2788.

[23] J.J. Wang, Z. Chen, T.Z. Chen, W. Wang, B.L. Liu, Empirical analysis of factors influencing industrial eco-efficiency in the yellow river basin from a social embeddedness perspective, Heliyon, 10 (2024) 15.

[24] Z.W. Wu, X.Y. Shang, Q. Hou, J.G. Xu, Z.L. Kang, H.J. Ma, Using ultrasonic-assisted sodium bicarbonate treatment to improve the gel and rheological properties of reduced-salt pork myofibrillar protein, Meat Science, 212 (2024) 7.

[25] Q. Xu, Incorporating cnn-lstm and svm with wavelet transform methods for tourist passenger flow prediction, Soft Computing, 28 (2024) 2719-2736.

[26] X.Y. Zhang, B.F. Peng, L.L. Zhou, C.Y. Lu, Y.L. Wang, R. Liu, H. Xiang, Tourism development potential and obstacle factors of cultural heritage: Evidence from traditional music in xiangxi, Journal of Geographical Sciences, 34 (2024) 309-328.

[27] D.J. Zhong, Q.Y. He, Y.Y. Li, Y.B. Wang, J. Chen, Cultural values and homestead retention: Insights from rural tourism residents, Current Psychology, (2024) 21.

[28] S. Bhuvaneshwari, C.A.C. Sweety, A. Singh, S. Broumi, M. Talea, P.K. Raut, A novel and an efficient codas technique to solve real-life magdm problems in fermatean neutrosophic environment, Neutrosophic Sets and Systems, 72 (2024) 41-59.

[29] M. Abouhawwash, M. Jameel, Evaluation factors of solar power plants to reduce cost under neutrosophic multi-criteria decision making model, Sustainable Machine Intelligence Journal, 2 (2023) 1-11.

[30] I. Kandasamy, Double-valued neutrosophic sets, their minimum spanning trees, and clustering algorithm, Journal of Intelligent Systems, 27 (2018) 163-182.

[31] J. Ye, Cosine similarity measures for intuitionistic fuzzy sets and their applications, Mathematical and Computer Modelling, 53 (2011) 91-97.

[32] K.C. Hung, K.P. Lin, Ieee, A new intuitionistic fuzzy cosine similarity measures and its application, in: 2012 ieee international conference on industrial engineering and engineering management, 2012, pp. 2194-2198.

[33] J. Ye, Interval-valued intuitionistic fuzzy cosine similarity measures for multiple attribute decision-making, International Journal of General Systems, 42 (2013) 883-891.

[34] J. Ye, Improved cosine similarity measures of simplified neutrosophic sets for medical diagnoses, Artificial Intelligence in Medicine, 63 (2015) 171-179.

[35] S. Jimenez, F.A. Gonzalez, A. Gelbukh, Mathematical properties of soft cardinality: Enhancing jaccard, dice and cosine similarity measures with element-wise distance, Information Sciences, 367 (2016) 373-389.

[36] W. Qiu, G.C. Zhang, L. Zhu, Cosine similarity measures for dual hesitant fuzzy sets, in: J. Zhu, G. Yao (Eds.) Proceedings of the 2016 4th international conference on machinery, materials and computing technology, 2016, pp. 511-514.

[37] J. Ye, Similarity measures of intuitionistic fuzzy sets based on cosine function for the decision making of mechanical design schemes, Journal of Intelligent & Fuzzy Systems, 30 (2016) 151-158.

[38] Tehreem, A. Hussain, A. Alsanad, M.A.A. Mosleh, Spherical cubic fuzzy extended topsis method and its application in multicriteria decision-making, Mathematical Problems in Engineering, 2021 (2021) 14.

[39] R.P. Tan, W.D. Zhang, S.Q. Chen, Decision-making method based on grey relation analysis and trapezoidal fuzzy neutrosophic numbers under double incomplete information and its application in typhoon disaster assessment, Ieee Access, 8 (2020) 3606-3628.

[40] J.H. Kim, B.S. Ahn, The hierarchical vikor method with incomplete information: Supplier selection problem, Sustainability, 12 (2020) 15.

[41] M.S.A. Khan, F. Khan, J. Lemley, S. Abdullah, F. Hussain, Extended topsis method based on pythagorean cubic fuzzy multi-criteria decision making with incomplete weight information, Journal of Intelligent & Fuzzy Systems, 38 (2020) 2285-2296.

[42] P.D. Liu, W.Q. Liu, Multiple-attribute group decision-making method of linguistic q-rung orthopair fuzzy power muirhead mean operators based on entropy weight, International Journal of Intelligent Systems, 34 (2019) 1755-1794.

[43] C.E. Shannon, A mathematical theory of communication, Bell System Technical Journal, 27 (1948) 379-423.

[44] R. Wang, X. Rong, Extended group decision making method for quality evaluation of mental health education of college students with hesitant triangular fuzzy information, Journal of Intelligent & Fuzzy Systems, (2023) https://doi.org/10.3233/JIFS-231719.

[45] Q. Khan, P. Liu, T. Mahmood, Some generalized dice measures for double-valued neutrosophic sets and their applications, Mathematics, 6 (2018) 121.

Received: June 21, 2024. Accepted: Oct 12, 2024