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A Single Valued Neutrosophic Extension of the Simple WISP Method

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Abstract. An extension of the Integrated Simple Weighted Sum Product (WISP) method is presented in this article, customized for the application of single-valued neutrosophic numbers. The extension is suggested to take advantage that the application of neutrosophic sets provides in terms of solving complex decision-making problems, as well as decision-making problems associated with assessments, prediction uncertainty, imprecision, and so on. In addition, an adapted questionnaire and appropriate linguistic variables are also proposed in the article to enable a simpler and more precise collection of respondents' attitudes using single-valued neutrosophic numbers. An approach for deneutrosophication, i.e. the transformation of a single-valued neutrosophic number into a crisp number is also proposed in the article. Detailed use and characteristics of the presented improvement are shown on an example of the evaluation of rural tourist tours.

Key words: neutrosophic set, single-valued neutrosophic number, Simple WISP, deneutrosophication, MCDM.

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1. Introduction

According to numerous similar definitions, multiple criteria decision-making (MCDM) is a process of evaluating or ranking alternatives based on a set of mutually conflicting criteria (Levy, 2005; Gebrezgabher *et al.*, 2014; Qin *et al.*, 2020; Ardil *et al.*, 2021). Similar definitions of MCDM can be found in Özdağoğlu *et al.* (2021) and Popovic (2021).

Since the end of the last century, MCDM has been used for solving many decision-making problems, and as a result, numerous MCDM methods have been proposed, such as SAW (MacCrimon, 1968), ELECTRE (Roy, 1968), AHP (Saaty, 1977), TOPSIS (Hwang and Yoon, 1981), PROMEHTEE (Brans, 1982).

In addition to the mentioned MCDM methods, a significant emergence of newly proposed MCDM methods can also be observed, such as ARAS (Zavadskas and Turskis, 2010), WASPAS (Zavadskas *et al.*, 2012), EDAS (Keshavarz Ghorabaee *et al.*, 2015), ARCAS method (Stanujkic *et al.*, 2017b), CoCoSo Yazdani *et al.* (2018), and so on.

However, it should be noted that the emergence of fuzzy sets, introduced by Zadeh (1965), had a significant impact on the use of the MCDM method. The fuzzy set theory enabled the use of a membership function $\mu_A(x)$, whose value lies in the interval [0, 1], that is $\mu_A(x) \in [0, 1]$.

In order to solve the decision-making problems associated with uncertainties and predictions, many MCDM methods have been extended to allow the use of fuzzy numbers. However, the use of only one membership function did not allow solving some types of complex decision-making problems, which is why certain extensions of the fuzzy set theory were proposed, as, for example, interval-valued fuzzy sets (Turksen, 1986), intuitionistic fuzzy sets (Atanassov, 1986) and so on.

In intuitionistic fuzzy set theory, Atanassov (1986) originated the non-membership function $\nu_A(x)$, $\nu_A(x) \in [0, 1]$, with the following restriction $0 \leqslant \mu_A(x)+\upsilon_A(x) \leqslant 1$. As a logical sequence of the membership function in fuzzy sets, a non-membership function discloses non-membership to a set, thus having initiated a fundament for deal with a wider class of decision-making problems. Usage of two functions, the membership and the non-membership function, enabled solving more complex decision-making problems, which also caused the development of appropriate extensions of some MCDM methods.

The membership and non-membership functions in relation to an intuitionistic fuzzy set are also known as truth-membership and falsity-membership functions.

In 1998, Smarandache (1998) further extended fuzzy and intuitionistic fuzzy set theory by introducing the indeterminacy-membership function. Consequently, in neutrosophic set theory (Smarandache, 1998, 1999), each element of a set is defined by three independent membership functions: the truth-membership $T_A(x)$, the indeterminacy-membership $I_A(x)$, and the falsity-membership $F_A(x)$ functions, where the values of the mentioned functions are not limited to the interval [0, 1], and there is also no restriction regarding their sum ${}^-0 \leqslant T_A(x) + I_A(x) + F_A(x) \leqslant 3^+$, as in intuitionistic fuzzy sets. Compared to fuzzy and intuitionistic fuzzy sets, neutrosophic sets are much more flexible and applicable for forming mathematical models designed for solving problems related to uncertainty, vagueness, ambiguity, imprecision, incompleteness, inconsistency, and so on (Smarandache, 1999; Ansari *et al.*, 2011).

To facilitate usage of neutrosophic sets for solving scientific and engineering problems, Wang *et al.* (2010) proposed a Single-Valued Neutrosophic (SVN) set, by introducing significantly stricter restrictions on the set of values that membership functions can have $T_A(x), I_A(x), F_A(x) : X \to [0, 1]$, as well as the sum of their values $0 \leqslant T_A(x)+I_A(x)+F_A(x) \leqslant 3$.

So far, numerous studies have been conducted to apply SVN sets for solving decision-making problems (Garg, 2020a, 2020b, 2020c, 2022), and as a result, they have been used to solve various problems in a number of decision-making areas such as the economy (Meng *et al.*, 2020), medicine (Zhang *et al.*, 2018; Abdel-Basset *et al.*, 2020), air quality evaluation (Li *et al.*, 2016; Bera and Mahapatra, 2021), and so on. Appropriate extensions that allow the use of SVN sets have also been proposed for a number of MCDM methods, such as TOPSIS (Biswas *et al.*, 2016), PROMETHEE (Xu *et al.*, 2020), AHP (Kahraman *et al.*, 2020), WASPAS (Zavadskas *et al.*, 2015), MULTIMOORA (Stanujkic *et al.*, 2017c), CoCoSo (Rani *et al.*, 2021), and so on.

Stanujkic *et al.* (2021) proposed a new MCDM method entitled the Integrated Simple Weighted Sum Product (WISP) method. Since there is no extension for this method that allows its use with SVN sets, an appropriate extension is provided in this research.

Therefore, the remaining sections are subject to the subsequent organization. In Section 2, some pivotal facts of the SVN sets, as well as some contents relevant to the development of a new improvement and extension of the WISP method are given. The single-valued neutrosophic extension of the WISP technique is presented in Section 3, while Section 4 presents the detailed use of the suggested extension on the example of selecting a rural tourist tour in Romania. Conclusions, limitations of the proposed extension and directions of further development are presented in the final section.

2. Introductory Observations

Some fundamental elements about neutrosophic sets, important for the development of the proposed extension, are presented in this section. In addition, some other contents that are also important for the development of the proposed extension are also discussed in this section.

2.1. *The Basis of the Single-Valued Neutrosophic Sets*

Definition 1. Let X be the universe of discourse. A neutrosophic set A in X is an object with entries of the form (Smarandache, 1999)

$$A = \{x\langle T_A(x), I_A(x), F_A(x)\rangle \mid x \in X\}, \tag{1}$$

where: $T_A(x)$ denotes the truth-membership function, $I_A(x)$ denotes the indeterminacy-membership function, and $F_A(x)$ denotes the falsity-membership function, $T_A(x)$, $I_A(x)$, $F_A(x) : X \to]^-0, 1^+[$, and $^-0 \leqslant T_A(x) + I_A(x) + F_A(x) \leqslant 3^+$.

Definition 2 (Wang *et al.*, 2010; Smarandache, 2005). If X is the universe of discourse, then the SVN set A in X is an object possessing the form

$$A = \left\{x\left\langle T_A(x), I_A(x), F_A(x)\right\rangle \,\middle|\, x \in X\right\}, \tag{2}$$

where: $T_A(x), I_A(x), F_A(x) : X \to [0, 1]$, and $0 \leqslant T_A(x) + I_A(x) + F_A(x) \leqslant 3$.

Definition 3. For an SVN set A in X, the triple $\langle t_A, i_A, f_A\rangle$ is called the SVN number (Smarandache, 1999).

Definition 4. Let $x_1 = \langle t_1, i_1, f_1\rangle$ and $x_2 = \langle t_2, i_2, f_2\rangle$ be two SVN numbers and $\alpha > 0$. The basic operations on SVN numbers are as follows:

$$x_1 + x_2 = \langle t_1 + t_2 - t_1 t_2, i_1 i_2, f_1 f_2\rangle, \tag{3}$$

$$x_1 \cdot x_2 = \langle t_1 t_2, i_1 + i_2 - i_1 i_2, f_1 + f_2 - f_1 f_2\rangle, \tag{4}$$

$$\alpha \cdot x_1 = \left\langle 1 - (1 - t_1)^\alpha, i_1^\alpha, f_1^\alpha\right\rangle, \tag{5}$$

$$x_1^\alpha = \left\langle t_1^\alpha, i_1^\alpha, 1 - (1 - f_1)^\alpha\right\rangle. \tag{6}$$

Definition 5. Let $x = \langle t, i, f\rangle$ be an SVN number. The score function $s_{(x)}$ of x is defined by Smarandache (2020)

$$s_{(x)} = \frac{t + (1 - i) + (1 - f)}{3} = \frac{2 + t - i - f}{3}, \tag{7}$$

where $s_{(x)} \in [0, 1]$.

Definition 6. Let $x = \langle t, i, f\rangle$ be an SVN number. The reliability of the information $r_{(x)}$ included in x is defined by Stanujkic *et al.* (2020):

$$r_{(x)} = \begin{cases} \frac{|t-f|}{t+i+f} & t + i + f \neq 0, \\ 0 & t + i + f = 0, \end{cases} \tag{8}$$

where $r_{(x)} \in [0, 1]$.

Definition 7. Let $A_{ij} = \langle t_{ij}, i_{ij}, f_{ij}\rangle$ be a stream of SVN numbers, $i = 1, 2, \ldots m$; $j = 1, 2, \ldots n$. Then the average reliability of the information $\bar{r}(A_{ij})$ contained in the collection of SVN numbers can be calculated as

$$\bar{r}(A_{ij}) = \sum_{i=1}^{m} \sum_{j=1}^{n} r_{(x)}, \tag{9}$$

where $r_{(x)}$ denotes the reliability of the information contained in an SVN number x.

Definition 8. Let $A_j = \langle t_j, i_j, f_j \rangle$ be a cluster of SVNSs. The SVN Weighted Average (WA_{svn}) function of A_j is defined by Sahin (2014)

$$WA_{svn}(A_j) = \sum_{j=1}^{n} A_j w_j = \left\langle 1 - \prod_{j=1}^{n}(1 - t_j)^{w_j}, \prod_{j=1}^{n} i_j^{w_j}, \prod_{j=1}^{n} f_j^{w_j} \right\rangle, \tag{10}$$

where w_j denotes the weight of element j of the collection A_j, $w_j \in [0, 1]$, and $\sum_{j=1}^{n} w_j = 1$.

Definition 9. Let $A_j = \langle t_j, i_j, f_j \rangle$ be a set of SVNSs. The SVN Weighted Geometric (WG_{svn}) operator of A_j is defined by Sahin (2014)

$$WG_{svn}(A_j) = \prod_{j=1}^{n} A_j^{w_j} = \left\langle \prod_{j=1}^{n} t_j^{w_j}, 1 - \prod_{j=1}^{n}(1 - i_j)^{w_j}, 1 - \prod_{j=1}^{n}(1 - f_j)^{w_j} \right\rangle, \tag{11}$$

where w_j means a weight corresponding to the element j of the collection A_j, $w_j \in [0, 1]$, and $\sum_{j=1}^{n} w_j = 1$.

2.2. *Questionnaire Designed for Using SVN Numbers*

The use of SVN numbers for collecting respondents' attitudes also requires the use of a specially designed questionnaire. It has already been stated that SVN numbers use three membership functions, which allows the use of complex evaluation criteria. Instead of using ordinary questionnaires based on questions prepared for collecting ratings of alternatives concerning the selected criteria, the proposed questionnaire uses affirmative sentences whose truthfulness should be assessed using three membership functions.

For example, the first criterion, used in numerical illustration, Destination attractiveness, integrates the natural attractions of a tourist destination, such as natural beauties, mountain ranges, lakes, rivers, landscapes, environmental protection, diversity of flora and fauna, and others. Using the three affiliation functions provided by neutrosophic numbers, the respondent can express the level of his agreement with the confirmatory sentence, the level of his disagreement, and the level of his uncertainty regarding the statements included in the confirmatory sentence. It should be noted that the evaluation based on the use of SVN numbers does not require the mandatory use of all three membership functions for evaluation. Depending on their opinions, respondents can use three, two, or even one membership function. In cases when one or two membership functions are not used in the evaluation the values of unused membership functions are automatically set to value 0.

Finally, using Eq. (9), the average reliability of the information collected from the respondents can be assessed, and based on that a decision can be made on the usability of the questionnaire, i.e. its use for evaluation or its rejection as useless.

Table 1
Linguistic variables for expressing confidence levels.

Linguistic variable	Abbreviation	Crisp numerical value	Permissible value range
Extremely High	EH	9	[8, 10]
Very High	VH	8	[7, 9]
High	H	7	[6, 8]
Moderate High	MH	6	[5, 7]
Moderate	M	5	[4, 6]
Moderate Low	ML	4	[3, 5]
Low	L	3	[2, 4]
Very Low	VL	2	[1, 3]
Extremely Low	EL	1	[0, 2]

2.3. *Linguistic Variables*

Linguistic variables are often used in various extensions of grey, fuzzy, intuitionistic fuzzy, and neutrosophic extensions of MCDM methods to facilitate and enable decision-makers, i.e. respondents, to more accurately evaluate alternatives.

For the purposes of this research, the following nine-point scale, shown in Table 1, was chosen.

In addition to the use of linguistic variables, i.e. their abbreviations, respondents can express their attitudes using the recommended crisp numerical values. However, if they want it or it is necessary, the respondents can express their attitudes more precisely using numbers from the interval [0, 10].

2.4. *Deneutrosophication*

Similar to defuzzification in fuzzy sets, in the neutrosophy, a deneutrosophication is the process of transforming information contained in neutrosophic numbers into crisp values.

The transformation of neutrosophic information into a crisp value can be easily performed using Eq. (7). However, much better results, primarily in terms of analysis of different scenarios, can be achieved by applying the following equation:

$$df_{(x)} = \frac{2 + \alpha t - \beta i - \gamma f}{3}, \tag{12}$$

where: $x = \langle t, i, f \rangle$ is an SVNN, α, β, and γ are coefficients, and $\alpha, \beta, \gamma \in [0, 1]$.

In the case when all three coefficients tend to a value of one, $\alpha, \beta, \gamma \cong 1$, Eq. (12) gives similar values as Eq. (7). In contrast, when all three values of the coefficients tend to zero, $\alpha, \beta, \gamma \cong 0$, all the information contained in the neutrosophic numbers is meaningless.

3. A Single-Valued Neutrosophic Extension of the WISP method

The Simple WISP method was proposed in Stanujkic *et al.* (2021). Based on this method, a procedure for ranking alternatives based on using SVNNs can be presented using the following steps:

Step 1. Construct a single-valued neutrosophic initial decision-making matrix and determine criteria weights. In this step, the single-valued neutrosophic initial decision matrix is formed using linguistic variables proposed in Section 2.3. Criteria weights can be determined using some of several MCDM methods primarily intended for specifying criteria weights such as the AHP method (Saaty, 1980), SWARA method (Kersuliene *et al.*, 2010), Best-Worst method (Rezaei, 2015), or PIPRECIA method (Stanujkic *et al.*, 2017a).

Step 2. Generate a normalized intuitionistic decision-making matrix as

$$r_{ij} = \langle t_{ij}, i_{ij}, f_{ij} \rangle = \left\langle \frac{xt_{ij}}{10}, \frac{xi_{ij}}{10}, \frac{xf_{ij}}{10} \right\rangle, \tag{13}$$

where: xt_{ij}, xi_{ij} and xf_{ij} denote the affiliation level of alternative i regarding criterion j expressed using three membership functions, respectively.

Denominators used in Eq. (13) were chosen according to the 9-point linguistic scale proposed in Table 1.

Step 3. Compute the sum and product of the weight-normalized neutrosophic performance of each alternative, for the beneficial and non-beneficial criteria, using Eqs. (10) and (11), as follows:

$$S_i^{\max} = \left\langle 1 - \prod_{j \in \phi_{\max}} (1 - t_j)^{w_j}, \prod_{j \in \phi_{\max}} i_j^{w_j}, \prod_{j \in \phi_{\max}} f_j^{w_j} \right\rangle, \tag{14}$$

$$S_i^{\min} = \left\langle 1 - \prod_{j \in \phi_{\min}} (1 - t_j)^{w_j}, \prod_{j \in \phi_{\min}} i_j^{w_j}, \prod_{j \in \phi_{\min}} f_j^{w_j} \right\rangle, \tag{15}$$

$$P_i^{\max} = \left\langle \prod_{j \in \phi_{\max}} t_j^{w_j}, 1 - \prod_{j \in \phi_{\max}} (1 - i_j)^{w_j}, 1 - \prod_{j \in \phi_{\max}} (1 - f_j)^{w_j} \right\rangle, \tag{16}$$

$$P_i^{\min} = \left\langle \prod_{j \in \phi_{\min}} t_j^{w_j}, 1 - \prod_{j \in \phi_{\min}} (1 - i_j)^{w_j}, 1 - \prod_{j \in \phi_{\min}} (1 - f_j)^{w_j} \right\rangle, \tag{17}$$

where: $S_i^{\max} = \langle t_i, i_i, f_i \rangle$ and $S_i^{\min} = \langle t_i, i_i, f_i \rangle$ denote the sum of the weight-normalized neutrosophic performances of alternative i, achieved based on beneficial and non-beneficial criteria, respectively, and $P_i^{\max} = \langle t_i, i_i, f_i \rangle$ and $P_i^{\min} = \langle t_i, i_i, f_i \rangle$ denote the product of the weight-normalized neutrosophic performances of alternative i, achieved based on beneficial and non-beneficial criteria, respectively, $\phi_{\max}$ and $\phi_{\min}$ denote sets of beneficial and nonbeneficial criteria, respectively.

Step 4. Calculate the values of four utility measures u_i^{sd}, u_i^{pd}, u_i^{sr}, and u_i^{pr}. The subtraction and division operations required for determining the four utility measures used in the WISP method are not primarily defined for SVNNs. Therefore, values of $S_i^{\max}$, $S_i^{\min}$, $P_i^{\max}$, and $P_i^{\min}$, should be transformed into crisp values before calculating the four utility measures.

Deneutrosophication can be performed using Eq. (7) or Eq. (12), after which the values of the four utility measures can be calculated as follows:

$$u_i^{sd} = S_i^{\max} - S_i^{\min}, \tag{18}$$

$$u_i^{pd} = P_i^{\max} - P_i^{\min}, \tag{19}$$

$$u_i^{sr} = \frac{S_i^{\max}}{S_i^{\min}}, \quad \text{and} \tag{20}$$

$$u_i^{pr} = \frac{P_i^{\max}}{P_i^{\min}}. \tag{21}$$

Step 5. Recalculate values of four utility measures, as follows:

$$\vartheta_i^{sd} = \frac{1 + u_i^{sd}}{1 + \max_i u_i^{sd}}, \tag{22}$$

$$\vartheta_i^{pd} = \frac{1 + u_i^{pd}}{1 + \max_i u_i^{pd}}, \tag{23}$$

$$\vartheta_i^{sr} = \frac{1 + u_i^{sr}}{1 + \max_i u_i^{sr}}, \quad \text{and} \tag{24}$$

$$\vartheta_i^{pr} = \frac{1 + u_i^{pr}}{1 + \max_i u_i^{pr}}, \tag{25}$$

where: ϑ_i^{sd}, ϑ_i^{pd}, ϑ_i^{sr}, and ϑ_i^{pr} denote recalculated values of u_i^{sd}, u_i^{pd} u_i^{sr} and u_i^{pr}, respectively, and $\max_i u_i^{sd}$, $\max_i u_i^{pd}$, $\max_i u_i^{sr}$ and $\max_i u_i^{pr}$ denote the maximum values of the right end points of four utility measures, respectively.

Step 6. Evaluate the total utility ϑ_i for each alternative by the rule

$$\vartheta_i = \frac{1}{4}\left(\vartheta_i^{sd} + \vartheta_i^{pd} + \vartheta_i^{sr} + \vartheta_i^{pr}\right). \tag{26}$$

Step 7. Rank available alternatives and choose the most justifiable one. In cases of evaluating alternatives in the Simple WISP method, the alternative with the highest overall utility is the most admissible one.

Using the approach presented above, decision-makers can take advantage of the previously discussed benefits that SVN sets provide when gathering respondents' attitudes. Also, using Eq. (12) decision-makers can vary the impact of truth, indeterminacy, and falsity membership functions and consider different scenarios, from very pessimistic to very optimistic. The possibility of considering different scenarios candidates the proposed approach for using in the process of the project evaluation and selection where it is important and necessary to overview every circumstance that may occur.

4. An Illustrative Example

In order to give a demonstration of the applicability of the presented extension of the WISP procedure, one example of selecting a tourist destination for Nature & Rural Tourism was considered.

After considering alternatives from Serbia, Montenegro, Albania, Bulgaria, and Romania, it is determined that the demonstration was carried out on the example of choosing a tourist tour of Natural and Rural Tourism in Romania. One of the main reasons for choosing Romania was a wealth of useful information regarding tourist tours, including a wealth of photographs that enchant the natural beauties of the Transylvania region located in central Romania.

To attest the applicability of the proposed extension of the WISP method, an example of evaluation of a tourist destination, that is evaluation of rural tourist tours, is discussed in this section. The evaluation of several below mentioned alternatives was performed according to the following criteria:

– C_1, Destination attractiveness,
– C_2, Additional facilities,
– C_3, Accommodation and comfort,
– C_4, Transportation and accessibility, and
– C_5, Price.

The evaluation criteria were selected based on the criteria proposed by Ryglova *et al.* (2017). In their research, Ryglova *et al.* (2017) considered the application, i.e. significance, of 19 criteria for determining the quality of rural tourism destinations. However, the use of a large number of evaluation criteria, without their hierarchical organization, maybe impractical for MCDM evaluation. In addition, the use of three membership functions allows utilization of a smaller number of complex criteria, which is why more significant criteria considered by Ryglova *et al.* (2017) are aggregated to the previously mentioned five criteria.

The meaning of the above criteria can be described as follows: the criterion Destination attractiveness includes the presence of natural attractions, mountain ranges, lakes, rivers, landscapes, beauties of untouched nature, diversity of flora and fauna, and so on. The criterion Additional facilities include facilities such as hiking, climbing, visiting man-made facilities such as castles and fortifications, cultural and social attractions, and so on, while the criterion Accommodation and comfort include the type of accommodation and additional amenities such as the Internet, Wi-Fi, television, and so on. The criterion Transportation and accessibility includes the way of arriving at the starting points of the tourist tour from the residence of the respondents. Finally, since the considered tours have different durations, the Price criterion is considered as a complex criterion that includes the price on a daily basis and the total price of the tourist tour.

In this research, the following rural tourist tours were selected for evaluation:

– Wildlife Tour in Romania,
– Family Tour of Romania,

Table 2
The questionnaire obtained from the selected respondent.

	C_1			C_2			C_3			C_4			C_5		
	t	i	f	t	i	f	t	i	f	t	i	f	t	i	f
A_1	6.5	EL	1.5	M		EL	5.5			ML		1.5	M		2.5
A_2	VH			VH		EL	MH			M			VL	0.5	6.5
A_3	MH		EL	EH	EL	VL	ML	EL	VL	ML			L		MH
A_4	MH		0.7	VH	EL	EL	L	ML	ML	ML			L		M
A_5	EH			VH		EL	M	VL	EL	VH			ML	0.5	M
A_6	EH			H			H	VL	VL	VH			ML		VH

Table 3
A transformed questionnaire with the attitudes of the selected respondent.

	C_1			C_2			C_3			C_4			C_5		
	t	i	f	t	i	f	t	i	f	t	i	f	t	i	f
A_1	6.5	1	1.5	5	0	1	5.5	0	0	4	0	1.5	5	0	2.5
A_2	8	0	0	8	0	1	6	0	0	5	0	0	2	0.5	6.5
A_3	6	0	1	9	1	2	4	1	2	4	0	0	3	0	6
A_4	6	0	0.7	8	1	1	3	4	4	4	0	0	3	0	5
A_5	9	0	0	8	0	1	5	2	1	8	0	0	4	0.5	5
A_6	9	0	0	7	0	0	7	2	2	8	0	0	4	0	8

– Maramures and Bucovina Tour, and
– 4-Day Carpathian Trek: Bucegi Mountains and Piatra Craiului National Park,
– Village Life in Transylvanian Carpathian Mountains, and
– 14 Days Full Donau Delta, Braşov and Apuseni Tour.

Information regarding the above rural tourist tours is available on the following web-sites:

– https://true-romania.tours/rural-tourism/ (True-Romania) and,
– https://www.viator.com/Romania-tours/Nature-and-Wildlife/ (Romania-tours).

The evaluation of alternatives, i.e. checking the usability and efficacy of the proposed procedure, was done on a small number of respondents. More precisely, the examination was performed on a sample of fifteen examinees. From the collected questionnaires, one characteristic was chosen to show in detail the steps of the proposed calculation procedure.

The completed questionnaire with the attitudes of the selected respondents, filled in with the combined use of linguistic variables and numbers, is shown in Table 2. After the transformation of linguistic variables into numerical values, as well as filling in the values of unused membership functions, the transformed questionnaire is shown in Table 3.

A normalized intuitionistic decision matrix, generated utilizing Eq. (12), is arranged in Table 4. The average reliability of the data contained in the SVNNs in Table 4, determined using Eq. (9), is 0.674.

For further applying the proposed calculation procedure, the weights of the criteria are necessary after this step. In the observed case, the weights of criteria were defined

Table 4
A normalized intuitionistic decision-making matrix.

	C_1	C_2	C_3	C_4	C_5
A_1	⟨0.7, 0.1, 0.2⟩	⟨0.5, 0.0, 0.1⟩	⟨0.6, 0.0, 0.0⟩	⟨0.4, 0.0, 0.2⟩	⟨0.5, 0.0, 0.3⟩
A_2	⟨0.8, 0.0, 0.0⟩	⟨0.8, 0.0, 0.1⟩	⟨0.6, 0.0, 0.0⟩	⟨0.5, 0.0, 0.0⟩	⟨0.2, 0.1, 0.7⟩
A_3	⟨0.6, 0.0, 0.1⟩	⟨0.9, 0.1, 0.2⟩	⟨0.4, 0.1, 0.2⟩	⟨0.4, 0.0, 0.0⟩	⟨0.3, 0.0, 0.6⟩
A_4	⟨0.6, 0.0, 0.1⟩	⟨0.8, 0.1, 0.1⟩	⟨0.3, 0.4, 0.4⟩	⟨0.4, 0.0, 0.0⟩	⟨0.3, 0.0, 0.5⟩
A_5	⟨0.9, 0.0, 0.0⟩	⟨0.8, 0.0, 0.1⟩	⟨0.5, 0.2, 0.1⟩	⟨0.8, 0.0, 0.0⟩	⟨0.4, 0.1, 0.5⟩
A_6	⟨0.9, 0.0, 0.0⟩	⟨0.7, 0.0, 0.0⟩	⟨0.7, 0.2, 0.2⟩	⟨0.8, 0.0, 0.0⟩	⟨0.4, 0.0, 0.8⟩

Table 5
The weights of the criteria.

	C_1	C_2	C_3	C_4	C_5
w_j	0.23	0.18	0.20	0.18	0.22

Table 6
Sums and products of weight-normalized neutrosophic ratings of alternatives achieved based on beneficial and non-beneficial criteria.

	$S_i^{\max}$	$S_i^{\min}$	$P_i^{\max}$	$P_i^{\min}$
A_1	⟨0.39, 0.00, 0.00⟩	⟨0.14, 0.00, 0.73⟩	⟨0.61, 1.00, 1.00⟩	⟨0.86, 1.00, 0.27⟩
A_2	⟨0.27, 0.00, 0.00⟩	⟨0.30, 0.51, 0.91⟩	⟨0.73, 1.00, 1.00⟩	⟨0.70, 0.49, 0.09⟩
A_3	⟨0.38, 0.00, 0.00⟩	⟨0.23, 0.00, 0.89⟩	⟨0.62, 1.00, 1.00⟩	⟨0.77, 1.00, 0.11⟩
A_4	⟨0.43, 0.00, 0.00⟩	⟨0.23, 0.00, 0.86⟩	⟨0.57, 1.00, 1.00⟩	⟨0.77, 1.00, 0.14⟩
A_5	⟨0.21, 0.00, 0.00⟩	⟨0.18, 0.51, 0.86⟩	⟨0.79, 1.00, 1.00⟩	⟨0.82, 0.49, 0.14⟩
A_6	⟨0.18, 0.00, 0.00⟩	⟨0.18, 0.00, 0.95⟩	⟨0.82, 1.00, 1.00⟩	⟨0.82, 1.00, 0.05⟩

by means of the PIPRECIA method. The weights calculated based on the attitudes of the selected respondent are shown in Table 5.

After determining criteria weights, the sums and products of weighted normalized neutrosophic ratings of the alternatives were calculated, for beneficial and non-beneficial criteria, as presented in Table 6.

Deneutrosophied values of sums and products of the weighted normalized neutrosophic ratings are shown in Table 7. In this case, deneutrosophization, i.e. transformation of SVNNs into crisp values, was performed using Eq. (7), but it can also be performed using Eq. (12), as mentioned above.

The values of four utility measures u_i^{sd}, u_i^{pd}, u_i^{sr}, and u_i^{pr}, calculated using Eqs. (18) to (21) are also shown in Table 7.

The recalculated values of four utility measures ϑ_i^{sd}, ϑ_i^{pd}, ϑ_i^{sr}, and ϑ_i^{pr} are shown in Table 8.

As it can be concluded on the basis of data in Table 8, the alternative A_5 is the most suitable rural tourist tour, based on the attitudes obtained from the selected respondent. From Table 8, it can also be observed that all considered alternatives have approximately similar values of the overall utilities, which indicates that the use of Eq. (12), for deneutrosophization, could cause changes in the ranking order of considered alternatives.

Table 7
Deneutrosophied values of sums and products of weighted normalized neutrosophic ratings.

	$S_i^{\max}$	$S_i^{\min}$	$P_i^{\max}$	$P_i^{\min}$	u_i^{sd}	u_i^{pd}	u_i^{sr}	u_i^{pr}
A_1	0.80	0.47	0.20	0.53	0.33	−0.33	1.70	0.38
A_2	0.76	0.29	0.24	0.71	0.46	−0.46	2.58	0.34
A_3	0.79	0.45	0.21	0.55	0.35	−0.35	1.77	0.37
A_4	0.81	0.46	0.19	0.54	0.35	−0.35	1.76	0.35
A_5	0.74	0.27	0.26	0.73	0.47	−0.47	2.72	0.36
A_6	0.73	0.41	0.27	0.59	0.32	−0.32	1.77	0.46

Table 8
Recalculated values of four utility measures, overall utility measures, and ranking order of alternatives.

	ϑ_i^{sd}	ϑ_i^{pd}	ϑ_i^{sr}	ϑ_i^{pr}	ϑ_i	Rank
A_1	0.91	0.98	0.73	0.94	0.889	5
A_2	1.00	0.78	0.96	0.92	0.916	2
A_3	0.92	0.96	0.75	0.94	0.889	4
A_4	0.92	0.95	0.74	0.92	0.884	6
A_5	1.00	0.78	1.00	0.93	0.927	1
A_6	0.90	1.00	0.74	1.00	0.910	3

Similar evaluations, done again with the attitudes of the remaining respondents, showed that there were some differences in the ranks of considered alternatives, which was expected. However, it also emphasizes the need for developing a neutrosophic extension of the WISP method that can be used for group decision-making. Unfortunately, the development of such an extension has not yet been considered.

Numerous articles and studies dealing with the application of MCDM methods in the tourism and hospitality industry can be found in scientific and professional journals. A comprehensive overview of previously conducted research in this area can be found in Ahmad (2016).

A similar approach to choosing a tourist destination was considered in Genç and Filipe (2016), where they applied a fuzzy MCDM approach for evaluating a tourist destination in Portugal. Besides, Alptekin and Büyüközkan (2011) considered the use of MCDM system for web-based tourism destination planning, while Peng and Tzeng (2012) considered the use of MCDM model for evaluating strategies for promoting tourism competitiveness. Stanujkic *et al.* (2015, 2019) evaluate the quality of websites in a rural tourism and hospitality industry using Atanassov intuitionistic fuzzy sets, bipolar neutrosophic sets. Popovic *et al.* (2021) applied the PIPRECIA model for identifying key determinants of tourism development in Serbia while Hosseini and Paydar (2022) prioritized the factors affecting tourist absorption for ecotourism centres using MCDM methods.

5. Conclusion

An upgrading of the Simple WISP method based on the usage of single-valued neutrosophic numbers is proposed in this article.

The SVN numbers use three membership functions for expressing truth, indeterminacy, and falsity which is why they can be used for expressing beliefs, uncertainties, and doubts about some occurrences, conditions, or events. For this reason, these numbers can be very useful for collecting respondents' attitudes because they provide respondents with a very flexible way of expressing attitudes. It is known that the three membership functions are mutually independent and that each function can have a value from the interval [0, 1]. Based on this, respondents can express their preferences using three zeros or three ones, or with any other combination of numbers from the interval [0, 1].

The use of SVN numbers for collecting respondents' attitudes also allows the use of complex criteria for evaluating alternatives. Of course, the use of these numbers requires the use of customized questionnaires, as well as adapted linguistic variables for expressing the respondents' preferences, which are also discussed in the article.

Some initial research conducted during the development of the proposed approach pointed to certain problems related to the collection of attitudes from respondents who are not familiar with the use of neutrosophic sets. The questionnaire proposed in this article is certainly not suitable for collecting the views of respondents "on the street", but can be used to collect the views of respondents who are familiar with the basic elements of fuzzy, intuitionistic, and neutrosophic sets.

Therefore, the intention to conduct a study with a significantly larger number of respondents using the proposed approach can be stated as one of the directions of future research. Adoption of the proposed approach for use in a group decision-making environment can also be mentioned as one of the further potential directions of research regarding the proposed approach.

An approach for deneutrosophication, i.e. the transformation of information contained in SVN numbers into crisp numbers is also considered in the article. Using this approach, decision-makers can analyse a variety of scenarios, from pessimistic to optimistic, similar as in many fuzzy and intuitionistic extensions of other MCDM methods.

Using the proposed approach, decision-makers can take advantage of the fact SVN sets provide for gathering respondents' attitudes based on a smaller number of complex evaluation criteria. Also, using approach proposed for deneutrosophication, decision-makers can vary the impact of truth, indeterminacy, and falsity membership functions and consider different scenarios, from very pessimistic to very optimistic. And finally, the evaluations performed with the proposed extension of the Simple WISP method confirmed its applicability and efficiency.

Besides the outlined usefulness of the proposed approach, it could not be denied that it has some limitations, as well. Maybe the crucial shortcoming of the proposed approach reflects in its complexity for application by ordinary decision-makers that are not familiar with neutrosophic sets logic. In that sense, its application is limited only to those decision-makers who understand and successfully work with this type of decision-making aiding technique.

The results of conducted research proved the reliability and usability of the proposed extension, so it is considered that it would be also an adequate decision-making aid in other business fields such as project management, human resource management, production management, and so on. Besides, the recommendation of the future work involves the proposing of the extension of the WISP method based on the multi-valued neutrosophic numbers to acknowledge the vagueness and uncertainty of the environment to a greater extent.

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