A SVTrN-number approach of multi-objective optimisation on the basis of simple ratio analysis based on MCDM method

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Abstract

An essential process in the study of human work behaviour or human resource management is the personnel selection/recruitment and a major challenge of an organization is to determine the most potential personnel. From this perspective, this paper tries to formulate MOOSRA approach in the neutrosophic environment to select potential personnel in organizations. The method proves to reduce complexity in computation and is comprehensible. An illustrative example is shown for better understanding of the proposed method.

Keywords: MCDM, Personnel Selection, Neutrosophic Set, SVTrN-number, MOOSRA Method

1 Introduction

The quality of an organization can be estimated by being able to select efficient personnel for the organization. Hence it is the essential process of human resource management. Sometimes the numerous and conflict personnel criteria may result in confusing the decision maker to select suitable persons. In view of rectifying such situations, the classical ideas or methods need to be enhanced with our recent trends. The study of literature reveals that many researchers used fuzzy set theory as an important tool for solving the multi critria decision making approach such as ELECTRE[1] , LINMAP (Linear Programming Techniques for Multidimensional Analysis of Preference)[2] , VIKOR model[3] , Analytic Hierarchic Process (AHP)[4,5] , TOPSIS[6,7] , WASPAS[8] , COPRAS[9] , and MOORA[10] . These methods can be employed in any of the fields which requires a decision making situation of fuzzy nature.

Fuzzy sets theories have been developed and generalised but found to be not able to deal with every situation of uncertainty that we come across in real problems. For example, Atanassov's intuitionistic fuzzy sets[11] deal with the degree of membership, non-membership and indeterminacy, and furthermore these functions are entirely mutually dependent. Therefore, this necessitated the emergence of new theories. F. Smarandache introduced a new theory which accounts for the truth, indeterminacy and falsity membership functions simultaneously and the corresponding set is called a neutrosophic set[12] . This notion laid a new path to research on uncertainty and many theories evolved from it in the last two decades and a good number of researchers have applied it to decision making science[16–18] .

Subas (2015) described single valued triangular neutrosophic (SVTrN) numbers as a special type of single valued neutrosophic numbers. From the available literature we can see that single valued triangular neutrosophic (SVTrN) numbers have been extended to different forms[19] . This SVTrN-numbers are used in many decision-making problems[20,21] and several complexities and dynamic issues arise in decision-making applications. Further, this paper makes an attempt to develop an new decision approach called neutrosophic MOOSRA method based on SVTrN-numbers which have broad application fields. It goes without saying that the personnel selection depends on many criteria and having to choose from many alternatives the decision makers' job of obtaining the best candidate becomes tedious. As these conflicting criteria and alternatives have the nature of full, partially full and null possibilities, employing neutrosophic sets in this context is justified.

The organisation of the rest of the paper: in section 2 the basic concepts of fuzzy sets are explained, section 3 provides detailed explanation of neutrosophic MOOSRA method. An illustration presented in section 4 validates the proposed theory and finally the conclusion based on the study is presented.

Doi : https://doi.org/10.54216/IJNS.050102

Received: January 01, 2020 Revised: March 28, 2020 Accepted: April 27, 2020

2 Basic Concepts

This section recalls some of the fundamental concepts of fuzzy sets[13] and neutrosophic notion

Definition 2.1. [13] If x is a particular element of universe of discourse X, then a fuzzy set A is defined by a fuzzy membership function (μ_A) which takes the membership values in the unit closed interval of zero and one. i.e. $\mu_A : X \longrightarrow [0,1]$

Definition 2.2. A fuzzy decision matrix of the order $m \times n$ is defined as $A = [\mu_{ij}]_{m\times n}$, where μ_{ij} is the fuzzy membership values of the element in A which is generated by decision makers according to the alternatives on criteria.

Definition 2.3. [12] Let B be a neutrosophic set in the universal discourse or non empty set X and any object x in B has the form $B = \{< x, \mu_B(x), \sigma_B(x), \gamma_B(x) >; x \in X\}$, where $\mu_B(x), \sigma_B(x)$ and $\gamma_B(x)$ represent the degree of truth, the degree of indeterminacy and the degree of falsity membership functions respectively which take their values in the unit closed interval of zero and one, and it satisfies the following relation $0 \leq \mu_B(x) + \sigma_B(x) + \gamma_B(x) \leq 3$.

Definition 2.4. [14] A triangular single valued neutrosophic number $B = \langle (l_1, m_1, u_1)\,; \mu_B(x), \sigma_B(x), \gamma_B(x)\rangle$ is a special type of neutrosophic set on real number set R, whose degree of truthness, indeterminacy and falsity membership functions are defined as

$$\mu_B(x) = \begin{cases} \frac{(x-l_1)T_B}{m_1-l_1} & (l_1 \leq x \leq m_1), \\ T_B & (x = m_1), \\ \frac{(u_1-x)T_B}{u_1-m_1} & (m_1 \leq x \leq u_1), \\ 0 & otherwise. \end{cases}$$

$$\sigma_B(x) = \begin{cases} \frac{(m_1-x+I_B(x-l_1))}{m_1-l_1} & (l_1 \leq x \leq m_1), \\ I_B & (x = m_1), \\ \frac{(x-u_1+I_B(u_1-x))}{u_1-m_1} & (m_1 \leq x \leq u_1), \\ 1 & otherwise. \end{cases}$$

$$\gamma_B(x) = \begin{cases} \frac{(m_1-x+F_B(x-l_1))}{m_1-l_1} & (l_1 \leq x \leq m_1), \\ I_B & (x = m_1), \\ \frac{(x-u_1+F_B(u_1-x))}{u_1-m_1} & (m_1 \leq x \leq u_1), \\ 1 & otherwise. \end{cases}$$

respectively, where $T_B, I_B, F_B \in [0,1]$ and $l_1, m_1, u_1 \in R$.

3 Neutrosophic MOOSRA Methodology

MOOSRA was first introduced by Das et al.[15] and further many more researchers utilized it in selection process. Formation of a decision matrix is the first step in method which involves four parameters namely, alternatives available for selection, criteria upon which the selection has to be made, weights attributed to individual alternative and calculation of performance by alternatives over the fixed set of criteria. The similar process is adopted here for the neutrosophic MOOSRA method, for which the detailed procedure is described below.

Step 1 Form neutrosophic triangular scale

Step 2 Set the consistency for pairwise comparison matrix

Step 3 Create random consistency index for various criterion

PHASE I Acquire the expert's information in neutrosophic environment

Phase I starts with the concept of neutrosophic matrix in which the output of each alternative in relation to each criteria is evaluated.

Step 4 Create the pairwise comparison decision matrix of each criteria by decision maker's judgments as mentioned

$$C^M = \begin{bmatrix} B_{11}^M & \cdots & B_{1z}^M \\ \vdots & \ddots & \vdots \\ B_{y1}^M & \cdots & B_{yz}^M \end{bmatrix}$$

Step 5 Find crisp values of aggregated pairwise comparison matrix of criteria

The formula for finding the aggregate pairwise decision matrix is

$$B_{uv} = \left\langle \left(\frac{1}{M}\sum_{i=1}^{M} l_{uv}^i, \frac{1}{M}\sum_{i=1}^{M} m_{uv}^i, \frac{1}{M}\sum_{i=1}^{M} u_{uv}^i \right); \frac{1}{M}\sum_{i=1}^{M} T_{uv}^i, \frac{1}{M}\sum_{i=1}^{M} I_{uv}^i, \frac{1}{M}\sum_{i=1}^{M} F_{uv}^i \right\rangle$$

where, M - number of decision makers, l_{uv}^M, m_{uv}^M, u_{uv}^M are lower, middle, upper bound of neutrosophic numbers, and T_{uv}^M, I_{uv}^M, F_{uv}^M are truth, indeterminacy, falsity membership values respectively.

By using score function of B_{uv} convert neutrosophic scales to crisp values,

$$s(B_{uv}) = \left| \frac{(l_{uv} * m_{uv} * u_{uv})^{(T_{uv}+I_{uv}+F_{uv})}}{9} \right| \tag{1}$$

where l, m, u denote lower, middle, upper scale of triangular neutrosophic numbers respectively.

PHASE II

Step 6 Calculate weight of criteria (w_u^y)

Compute average value of row by $w_u = \dfrac{\sum_{i=1}^{z} s(B_{uv})}{z}$; $u = 1, 2, 3, \ldots, y$; $v = 1, 2, 3, \ldots, z$

Step 7 The given equation measures normalization of crisp values

$$w_u^y = \frac{w_u}{\sum_{u=1}^{y} w_u} \tag{2}$$

PHASE III Evaluate expert judgement using consistency rate

Step 8 Calculate weighted columns sum i.e. Multiply the weights of criteria with each value of pairwise comparison matrix

Step 9 Next, weighted sum values is divided by the weights of each criteria

Step 10 Compute λ_{max} values by finding the means of previous step

Step 11 Compute consistency index by the formula

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

where, n is the number of criteria.

Step 12 Compute consistency rate by the following equation

$$CR = \frac{CI}{RI} \tag{3}$$

Here, CR - consistency rate, CI - consistency index, RI - random index for consistency matrix

PHASE IV MOOSRA Method

Step 13 Form decision judgment values of each alternative on criteria interms of triangular neutrosophic pairwise comparison decision matrix

Step 14 Ultilize the score function to calculate crisp values of aggregated comparison decision matrix

Step 15 Next, find the normalization of the decision matrix by

$$B_{uv}^{*} = \frac{B_{uv}}{\sqrt{\sum_{u=1}^{y} B_{uv}^{2}}}$$

Step 16 Compute the sum of beneficial and non-beneficial criteria of weighted normalized values of matrix and denote as Y^{+} and Y^{-} respectively.

$$Y^{+} = \sum_{j=1}^{g} w_v x_{ij}^{*}$$

$$Y^{-} = \sum_{j=g+1}^{n} w_v x_{ij}^{*}$$

Step 17 Overall performances of each alternatives is obtained by MOOSRA method using the following equation

$$y_i^{*} = \frac{\sum_{j=1}^{g} x_{ij}^{*}}{\sum_{j=g+1}^{n} x_{ij}^{*}}$$

Step 18 Ranking of the alternatives is obtained according to the overall performance score of each alternative y_i^{*}

4 Illustration of the Proposed method

An illustrative example is chosen based on the above framework for explaining the research work and the importance of the proposed model. The case study is about how to select an organization's employees. The following criteria are used in the case study namely Boldness (C_1), Good in work (C_2), Team management (C_3), Uniqueness (C_4), Good character (C_5), Commitment (C_6) and five alternatives have been taken. Here C_1, C_2, C_4, C_5 are beneficial criteria and C_3, C_6 are non-beneficial criteria and also four decision makers are provided to form decision matrix.

The beginning frame work has been taken in the following table.1-3.

Table 1: Neutrosophic triangular scale

Satty scale	Significance level	Neutrosophic triangular scale
1	Even	$\bar{1} =<< 1, 1, 1 >$; 0.50, 0.50, 0.50>
3	A little	$\bar{3} =<< 2, 3, 4 >$; 0.30, 0.75, 0.70>
5	Powerful	$\bar{5} = << 4, 5, 6 >$; 0.80, 0.15, 0.20>
7	Completely powerful	$\bar{7} = << 6, 7, 8 >$; 0.90, 0.10, 0.10>
9	Absolute	$\bar{9} = << 9, 9, 0 >$; 1.00, 0.00, 0.00>
2	Values lying between two close scales	$\bar{2} = << 1, 2, 3 >$; 0.40, 0.60, 0.65>
4		$\bar{4} = << 3, 4, 5 >$; 0.35, 0.60, 0.40>
6		$\bar{6} = << 5, 6, 7 >$; 0.70, 0.25, 0.30>
8		$\bar{8} = << 7, 8, 9 >$; 0.85, 0.10, 0.15>

Table 2: The consistency rate for pair-wise comparison matrix

N	4*4	5*5	N>4
CR≤	0.58	0.90	1.12

Table 3: Random Consistency Table

Size of matrix	1	2	3	4	5	6	7	8	9	10
Random Consistency	0.00	0.00	0.58	0.0	1.12	1.24	1.32	1.41	1.45	1.49

Next, the decision makers provide pairwise comparison decision matrix of each criteria and their judgments values are listed in the appendix A from table.9 to table.12

Using score function formula 1 , we convert neutrosophic values to crisp values

$$\begin{aligned} C_1C_2 \implies & << 4,5,6 >; 0.80, 0.15, 0.20 >, \\ & << 2,3,4 >; 0.30, 0.75, 0.70 >, \\ & << 2,3,4 >; 0.30, 0.75, 0.70 >, \\ & << 4,5,6 >; 0.80, 0.15, 0.20 > . \end{aligned}$$

$$\begin{aligned} C_1C_2 \implies & << 12,16,20 >; 2.2, 1.8, 1.8 >, \\ & << 3,4,5 >; 0.55, 0.45, 0.45 >, \\ & \Rightarrow (60)^{0.161111111} = 1.93410, \end{aligned}$$

Similarly, we get all the other values presented in the below table.

Table 4: Aggregated crisp value of pairwise comparison decision matrix

criteria	C_1	C_2	C_3	C_4	C_5	C_6
C_1	1	1.93410	1.91656	1.99676	1.98939	1.93410
C_2	0.51703	1	1.81218	1.64382	2.06426	2.13217
C_3	0.52176	0.55182	1	1.97710	1.93410	1.64382
C_4	0.50081	0.60833	0.50579	1	1.83468	2.04143
C_5	0.50266	0.48443	0.51703	0.54505	1	1.58543
C_6	0.51703	0.46900	0.60833	0.48985	0.63074	1

PHASE 2

Weights of each criteria is calculated by step.6

w_1 = 10.77091, w_2 = 9.16946, w_3 = 7.6286, w_4 = 6.49104, w_5 = 4.6346, w_6 = 3.71495

Using equation.2 the normalization of crisp value is calculated and the values are listed as follows:

$$\begin{aligned} \sum_{i=1}^{6} w_i &= w_1 + w_2 + w_3 + w_4 + w_5 + w_6 \\ &= 10.77091 + 9.16946 + 7.6286 + 6.49104 + 4.6346 + 3.71495 \\ \sum_{i=1}^{6} w_i &= 42.40956 \end{aligned}$$

$$w_1 = \frac{10.77091}{42.40956} \Rightarrow w_1 = 0.25397$$

similarly, w_2 = 0.21621, w_3 = 0.17987, w_4 = 0.15305, w_5 = 0.10928, w_6 = 0.08759

PHASE 3 Compute weighted column sum

The weighted criteria are multiplied by each column in the pairwise comparison decision matrix and adding these values we can get weighted columns sum and the values are given as

w_1 = 1.70927, w_2 = 1.33740, w_3 = 1.08962, w_4 = 0.88204, $w_5 = 0.65696$, $w_6 = 0.57362$

Therefore, λ_{max} = 6.21137

Consistency index

The formula for finding the consistency index is CI = $\frac{\lambda_{max}-n}{n-1}$ where, n is the number of criteria

The value of CI = 0.04227.

Consistency ratio

Consistency Rate (CR) = $\frac{ConsistencyIndex}{RandomIndex}$ = $\frac{0.04227}{1.24}$ = 0.03408

PHASE 4 Judgment values of each alternative on criteria is formed interms of triangular neutrosophic decision matrix from four decision makers and the values are represented in the appendix B from tables 13 to 15.

Using score function formula 1, we can convert the neutrosophic values to crisp values

$A_1C_1 \implies << 4, 5, 6 >; 0.80, 0.15, 0.20 >, << 4, 5, 6 >; 0.80, 0.15, 0.20 >,$

$<< 6, 7, 8 >; 0.90, 0.10, 0.10 >, << 5, 6, 7 >; 0.70, 0.25, 0.30 >$.

$\Rightarrow << 4.75, 5.75, 6.75 >; 0.8, 0.1625, 0.2 >$ = $(184.359375)^{0.129166666}$ = 1.96177

similarly all the other values are obtained and presented below in table.5

Table 5: The aggregated pairwise comparision decision matrix

A/C	C_1	C_2	C_3	C_4	C_5	C_6
A_1	1.96177	2.03598	1.93410	2.03931	1.43878	1.90053
A_2	2.08883	2.02514	1.87745	1.79506	1.99676	2.04893
A_3	2.03699	2.03931	1.91059	2.03948	1.55864	2.10585
A_4	2.02744	1.83493	1.84362	2.05460	2.12452	2.08595
A_5	1.98352	2.03931	1.68484	1.77208	2.01160	1.85179

Utiling the formula of normalization, we can get table.6

Table 6: The normalization decision matrix

A/C	C_1	C_2	C_3	C_4	C_5	C_6
A_1	0.43428	0.45604	0.46698	0.46906	0.34847	0.42470
A_2	0.46240	0.45361	0.45330	0.41288	0.48362	0.45786
A_3	0.45093	0.45679	0.46130	0.46909	0.37750	0.47058
A_4	0.44881	0.41101	0.44513	0.47257	0.51456	0.46614
A_5	0.43909	0.45679	0.40680	0.40759	0.48721	0.41381

Let Y^+=$\sum_{v=1}^{g} w_v \ B^*_{uv}$ be a beneficial criteria and Y^-=$\sum_{v=1}^{z} \ w_v \ B^*_{uv}$ be a non-beneficial criteria.

Table 7: The weighted normalized decision matrix

A/C	C_1	C_2	C_3	C_4	C_5	C_6
A_1	0.110294	0.098600	0.083995	0.071789	0.038080	0.037199
A_2	0.117435	0.098075	0.081535	0.063191	0.052849	0.040103
A_3	0.114522	0.098762	0.082974	0.071794	0.041253	0.041218
A_4	0.113984	0.08864	0.080065	0.072326	0.056231	0.040829
A_5	0.111515	0.098762	0.073171	0.062381	0.053242	0.036245

Table 8: Over all performances of the alternatives

	$\sum_{j=1}^{g} x_{ij}^*$	$\sum_{j=g+1}^{n} x_{ij}^*$	Y_i^*	Ranking
A_1	0.318763	0.121194	2.63018	4
A_2	0.33155	0.121638	2.72571	3
A_3	0.326331	0.124192	2.62763	5
A_4	0.331405	0.120894	2.741285	2
A_5	0.32590	0.109416	2.97854	1

5 Conclusion

To test the efficiency of the proposed neutrosophic MOOSRA method, a decision matrix is derived in consultation with experts and is utilized to finding the potential personnel selection in an organization. The application of the proposed technique implies that A5 is the best alternative or the requirement of the organization. Hence we propose that the decision makers can utilize neutrosophic MOOSRA method as the method is shown to be effective in personnel selection and reduces computational complexity and provides desired results in neutrosophic environment.

Acknowledgments: The authors are highly grateful to the editors and referees for their constructive suggestions and motivations.

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Received: date / Accepted: date

Doi :10.5281/zenodo.3788321

Appendix A

PHASE-I

Table 9: The pairwise comparison neutrosophic decision matrix of each criteria

		C_1	C_2	C_3	C_4	C_5	C_6
	C_1	<<1,1,1>; 0.50,0.50,0.50>	<<4,5,6>; 0.80,0.15,0.20>	<<6,7,8>; 0.90,0.10,0.10>	<<3,4,5>; 0.35,0.60,0.40>	<<2,3,4>; 0.30,0.75,0.70>	<<5,6,7>; 0.70,0.25,0.30>
	C_2	1/<<4,5,6>; 0.80,0.15,0.20>	<<1,1,1>; 0.50,0.50,0.50>	<<3,4,5>; 0.35,0.60,0.40>	<<5,6,7>; 0.70,0.25,0.30>	<<6,7,8>; 0.90,0.10,0.10>	<<2,3,4>; 0.30,0.75,0.70>
	C_3	1/<<6,7,8>; 0.90,0.10,0.10>	1/<<3,4,5>; 0.35,0.60,0.40>	<<1,1,1>; 0.50,0.50,0.50>	<<2,3,4>; 0.30,0.75,0.70>	<<5,6,7>; 0.70,0.25,0.30>	<<4,5,6>; 0.80,0.15,0.20>
DM1	C_4	1/<<3,4,5>; 0.35,0.60,0.40>	1/<<5,6,7>; 0.70,0.25,0.30>	1/<<2,3,4>; 0.30,0.75,0.70>	<<1,1,1>; 0.50,0.50,0.50>	<<4,5,6>; 0.80,0.15,0.20>	<<7,8,9>; 0.85,0.10,0.15>
	C_5	1/<<2,3,4>; 0.30,0.75,0.70>	1/<<6,7,8>; 0.90,0.10,0.10>	1/<<5,6,7>; 0.70,0.25,0.30>	1/<<4,5,6>; 0.80,0.15,0.20>	<<1,1,1>; 0.50,0.50,0.50>	<<3,4,5>; 0.35,0.60,0.40>
	C_6	1/<<5,6,7>; 0.70,0.25,0.30>	1/<<2,3,4>; 0.30,0.75,0.70>	1/<<4,5,6>; 0.80,0.15,0.20>	1/<<7,8,9> 0.85,0.10,0.15>	1/ <<3,4,5> 0.35,0.60,0.40>	<<1,1,1>; 0.50,0.50,0.50>

Doi :10.5281/zenodo.3788321

Table 10: The pairwise comparison neutrosophic decision matrix of each criteria

		C_1	C_2	C_3	C_4	C_5	C_6
DM2	C_1	<<1,1,1>; 0.50,0.50,0.50>	<<2,3,4>; 0.30,0.75,0.70>	<<1,1,1>; 0.50,0.50,0.50>	<<3,4,5>; 0.35,0.60,0.40>	<<6,7,8>; 0.90,0.10,0.10>	<<1,2,3>; 0.40,0.60,0.65>
	C_2	1/<<2,3,4>; 0.30,0.75,0.70>	<<1,1,1>; 0.50,0.50,0.50>	<<4,5,6>; 0.80,0.15,0.20>	<<1,2,3>; 0.40,0.60,0.65>	<<3,4,5>; 0.35,0.60,0.40>	<<5,6,7>; 0.70,0.25,0.30>
	C_3	1/<<1,1,1>; 0.50,0.50,0.50>	1/<<4,5,6>; 0.80,0.15,0.20>	<<1,1,1>; 0.50,0.50,0.50>	<<4,5,6>; 0.80,0.15,0.20>	<<1,2,3>; 0.40,0.60,0.65>	<<2,3,4>; 0.30,0.75,0.70>
	C_4	1/<<3,4,5>; 0.35,0.60,0.40>	1/<<1,2,3>; 0.40,0.60,0.65>	1/<<4,5,6>; 0.80,0.15,0.20>	<<1,1,1>; 0.50,0.50,0.50>	<<4,5,6>; 0.80,0.15,0.20>	<<3,4,5>; 0.35,0.60,0.40>
	C_5	1/<<6,7,8>; 0.90,0.10,0.10>	1/<<3,4,5>; 0.35,0.60,0.40>	1/<<1,2,3>; 0.40,0.60,0.65>	1/<<4,5,6>; 0.80,0.15,0.20>	<<1,1,1>; 0.50,0.50,0.50>	<<2,3,4>; 0.30,0.75,0.70>
	C_6	1/<<1,2,3>; 0.40,0.60,0.65>	1/<<5,6,7>; 0.70,0.25,0.30>	1/<<2,3,4>; 0.30,0.75,0.70>	1/<<3,4,5> 0.35,0.60,0.40>	1/<<2,3,4> 0.30,0.75,0.70>	<<1,1,1>; 0.50,0.50,0.50>

Table 11: The pairwise comparison neutrosophic decision matrix of each criteria

		C_1	C_2	C_3	C_4	C_5	C_6
DM3	C_1	<<1,1,1>; 0.50,0.50,0.50>	<<2,3,4>; 0.30,0.75,0.70>	<<4,5,6 >; 0.80,0.15,0.20>	<<6,7,8>; 0.90,0.10,0.10>	<<3,4,5>; 0.35,0.60,0.40>	<<1,2,3>; 0.40,0.60,0.65>
	C_2	1/<<2,3,4>; 0.30,0.75,0.70>	<<1,1,1>; 0.50,0.50,0.50>	<<3,4,5>; 0.35,0.60,0.40>	<<1,2,3>; 0.40,0.60,0.65>	<<5,6,7>; 0.70,0.25,0.30>	<<7,8,9>; 0.85,0.10,0.15>
	C_3	1/<<4,5,6>; 0.80,0.15,0.20>	1/<<3,4,5>; 0.35,0.60,0.40>	<<1,1,1>; 0.50,0.50,0.50>	<<5,6,7>; 0.70,0.25,0.30>	<<2,3,4>; 0.30,0.75,0.70>	<<1,2,3>; 0.40,0.60,0.65>
	C_4	1/<<6,7,8>; 0.90,0.10,0.10>	1/<<1,2,3>; 0.40,0.60,0.65>	1/<<5,6,7>; 0.70,0.25,0.30>	<<1,1,1>; 0.50,0.50,0.50>	<< 4, 5, 6 >; 0.80,0.15,0.20>	<<3,4,5>; 0.35,0.60,0.40>
	C_5	1/<<3,4,5>; 0.35,0.60,0.40>	1/<<5,6,7>; 0.70,0.25,0.30>	1/<<2,3,4>; 0.30,0.75,0.70>	1/<<4,5,6>; 0.80,0.15,0.20>	<<1,1,1>; 0.50,0.50,0.50>	<<1,2,3>; 0.40,0.60,0.65>
	C_6	1/<<1,2,3>; 0.40,0.60,0.65>;	1/<<7,8,9>; 0.85,0.10,0.15>;	1/<<1,2,3>; 0.40,0.60,0.65>;	1/<<3,4,5> 0.35,0.60,0.40>;	1/<<1,2,3> 0.40,0.60,0.65>;	<<1,1,1>; 0.50,0.50,0.50>;

Table 12: The pairwise comparison neutrosophic decision matrix of each criteria

		C_1	C_2	C_3	C_4	C_5	C_6
DM4	C_1	<<1,1,1>; 0.50,0.50,0.50>	<<4,5,6>; 0.80,0.15,0.20>	<<2,3,4 >; 0.30,0.75,0.70>	<<6,7,8>; 0.90,0.10,0.10>	<<3,4,5>; 0.35,0.60,0.40>	<<5,6,7>; 0.70,0.25,0.30>
	C_2	1/<<4,5,6>; 0.80,0.15,0.20>	<<1,1,1>; 0.50,0.50,0.50>	<<1,2,3>; 0.40,0.60,0.65>	<<1,1,1>; 0.50,0.50,0.50>	<<2,3,4>; 0.30,0.75,0.70>	<<6,7,8>; 0.90,0.10,0.10>
	C_3	1/<<2,3,4>; 0.30,0.75,0.70>	1/<<1,2,3>; 0.40,0.60,0.65>	<<1,1,1>; 0.50,0.50,0.50>	<<3,4,5>; 0.35,0.60,0.40>	<<4,5,6>; 0.80,0.15,0.20>	<<1,1,1>; 0.50,0.50,0.50>
	C_4	1/<<6,7,8>; 0.90,0.10,0.10>	1/<<1,2,3>; 0.40,0.60,0.65>	1/<<5,6,7>; 0.70,0.25,0.30>	<<1,1,1>; 0.50,0.50,0.50>	<<1,2,3>; 0.40,0.60,0.65>	<<2,3,4>; 0.30,0.75,0.70>
	C_5	1/<<3,4,5>; 0.35,0.60,0.40>	1/<<2,3,4>; 0.30,0.75,0.70>	1/<<4,5,6>; 0.80,0.15,0.20>	1/<<1,2,3>; 0.40,0.60,0.65>	<<1,1,1>; 0.50,0.50,0.50>	<<1,1,1>; 0.50,0.50,0.50>
	C_6	1/<<5,6,7>; 0.70,0.25,0.30>;	1/<<6,7,8>; 0.90,0.10,0.10>;	1/<<1,1,1>; 0.50,0.50,0.50>;	1/<<2,3,4> 0.30,0.75,0.70>;	1/<< 1, 1, 1 > 0.50,0.50,0.50>;	<<1,1,1>; 0.50,0.50,0.50>;

Doi :10.5281/zenodo.3788321

Doi :10.5281/zenodo.3788321

Appendix B

PHASE 4 Decision judgments values of each alternatives on criteria is formed interms of neutrosophic decision matrix from multiple decision makers

Table 13: The judgments values of first and second decision makers

		C_1	C_2	C_3	C_4	C_5	C_6
DM1	A_1	<<4,5,6>; 0.80,0.15,0.20>	<<6,7,8>; 0.90,0.10,0.10>	<<2,3,4>; 0.30,0.75,0.70>	<<4,5,6>; 0.80,0.15,0.20>	<<2,3,4>; 0.30,0.75,0.70>	<<4,5,6>; 0.80,0.15,0.20>
	A_2	<<7,8,9>; 0.85,0.10,0.15>	<<7,8,9>; 0.85,0.10,0.15>	<<4,5,6>; 0.80,0.15,0.20>	<<5,6,7>; 0.70,0.25,0.30>	<<6,7,8>; 0.90,0.10,0.10>	<<6,7,8>; 0.90,0.10,0.10>
	A_3	<<7,8,9>; 0.85,0.10,0.15>	<<2,3,4>; 0.30,0.75,0.70>	<<4,5,6>; 0.80,0.15,0.20>	<<7,8,9>; 0.85,0.10,0.15>	<<4,5,6>; 0.80,0.15,0.20>	<<6,7,8>; 0.90,0.10,0.10>
	A_4	<<6,7,8>; 0.90,0.10,0.10>	<<4,5,6>; 0.80,0.15,0.20>	<<4,56>; 0.80,0.15,0.20>	<<4,5,6>; 0.80,0.15,0.20>	<<6,7,8>; 0.90,0.10,0.10>	<<7,8,9> 0.85,0.10,0.15>
	A_5	<<6,7,8>; 0.90,0.10,0.10>	<<2,3,4>; 0.30,0.75,0.70>	<<2,3,4>; 0.30,0.75,0.70>	<<4,5,6>; 0.80,0.15,0.20>	<<7,8,9>; 0.85,0.10,0.15>	<<4,5,6> 0.80,0.15,0.20>

		C_1	C_2	C_3	C_4	C_5	C_6
DM2	A_1	<<4,5,6>; 0.80,0.15,0.20>	<<6,7,8>; 0.90,0.10,0.10>	<<2,3,4>; 0.30,0.75,0.70>	<<2,3,4>; 0.30,0.75,0.70>	<<1,1,1>; 0.50,0.50,0.50>	<<4,5,6>; 0.80,0.15,0.20>
	A_2	<<6,7,8>; 0.90,0.10,0.10>	<<1,2,3>; 0.40,0.60,0.65>	<<1,1,1>; 0.50,0.50,0.50>	<<2,3,4>; 0.30,0.75,0.70>	<<6,7,8>; 0.90,0.10,0.10>	<<3,4,5>; 0.35,0.60,0.40>
	A_3	<<3,4,5>; 0.35,0.60,0.40>	<<6,7,8>; 0.90,0.10,0.10>	<<6,7,8>; 0.90,0.10,0.10>	<<5,6,7>; 0.70,0.25,0.30>	<<1,1,1>; 0.50,0.50,0.50>	<<7,8,9>; 0.85,0.10,0.15>
	A_4	<<6,7,8>; 0.90,0.10,0.10>	<<4,5,6>; 0.80,0.15,0.20>	<<4,56>; 0.80,0.15,0.20>	<<6,7,8>; 0.90,0.10,0.10>	<<6,7,8>; 0.90,0.10,0.10>	<<6,7,8> 0.90,0.10,0.10>
	A_5	<<4,5,6>; 0.80,0.15,0.20>	<<6,7,8>; 0.90,0.10,0.10>	<<2,3,4>; 0.30,0.75,0.70>	<<4,5,6>; 0.80,0.15,0.20>	<<4,5,6>; 0.80,0.15,0.20>	<<4,5,6> 0.80,0.15,0.20>

Table 14: The judgments values of third decision maker

		C_1	C_2	C_3	C_4	C_5	C_6
DM3	A_1	<<6,7,8>; 0.90,0.10,0.10>	<<6,7,8>; 0.90,0.10,0.10>	<<4,5,6>; 0.80,0.15,0.20>	<<2,3,4>; 0.30,0.75,0.70>	<<1,1,1>; 0.50,0.50,0.50>	<<6,7,8>; 0.90,0.10,0.10>
	A_2	<<7,8,9>; 0.85,0.10,0.15>	<<6,7,8>; 0.90,0.10,0.10>	<<2,3,4>; 0.30,0.75,0.70>	<<1,1,1>; 0.50,0.50,0.50>	<<3,4,5>; 0.35,0.60,0.40>	<<5,6,7>; 0.70,0.25,0.30>
	A_3	<<4,5,6>; 0.80,0.15,0.20>	<<2,3,4>; 0.30,0.75,0.70>	<<6,7,8>; 0.90,0.10,0.10>	<<3,4,5>; 0.35,0.60,0.40>	<<1,1,1>; 0.50,0.50,0.50>	<<1,2,3>; 0.40,0.60,0.65>
	A_4	<<6,7,8>; 0.90,0.10,0.10>	<<1,1,1>; 0.50,0.50,0.50>	<<4,5,6>; 0.80,0.15,0.20>	<<5,6,7>; 0.70,0.25,0.30>	<<2,3,4>; 0.30,0.75,0.70>	<<1,2,3> 0.40,0.60,0.65>
	A_5	<<2,3,4>; 0.30,0.75,0.70>	<<4,5,6>; 0.80,0.15,0.20>	<<3,4,5>; 0.35,0.60,0.40>	<<1,1,1>; 0.50,0.50,0.50>	<<7,8,9>; 0.85,0.10,0.15>	<<1,2,3> 0.40,0.60,0.65>

Table 15: The judgments values of fourth decision maker

		C_1	C_2	C_3	C_4	C_5	C_6
DM4	A_1	<<5,6,7>; 0.70,0.25,0.30>	<<6,7,8>; 0.90,0.10,0.10>	<<4,5,6>; 0.80,0.15,0.20>	<<6,7,8>; 0.90,0.10,0.10>	<<2,3,4>; 0.30,0.75,0.70>	<<4,5,6>; 0.80,0.15,0.20>
	A_2	<<6,7,8>; 0.90,0.10,0.10>	<<4,5,6>; 0.80,0.15,0.20>	<<6,7,8>; 0.90,0.10,0.10>	<<2,3,4>; 0.30,0.75,0.70>	<<3,4,5>; 0.35,0.60,0.40>	<<5,6,7>; 0.70,0.25,0.30>
	A_3	<<2,3,4>; 0.30,0.75,0.70>	<<4,5,6>; 0.80,0.15,0.20>	<<1,1,1>; 0.50,0.50,0.50>	<<3,4,5>; 0.35,0.60,0.40>	<<2,3,4>; 0.30,0.75,0.70>	<<2,3,4>; 0.30,0.75,0.70>
	A_4	<<3,4,5>; 0.35,0.60,0.40>	<<4,5,6>; 0.80,0.15,0.20>	<<4,5,6>; 0.80,0.15,0.20>	<<2,3,4>; 0.30,0.75,0.70>	<<5,6,7>; 0.70,0.25,0.30>	<<6,7,8> 0.90,0.10,0.10>
	A_5	<<4,5,6>; 0.80,0.15,0.20>	<<2,3,4>; 0.30,0.75,0.70>	<<1,1,1>; 0.50,0.50,0.50>	<<2,3,4>; 0.30,0.75,0.70>	<<4,5,6>; 0.80,0.15,0.20>	<<2,3,4> 0.30,0.75,0.70>