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The Generalized Neutrosophic Cubic Aggregation Operators and Their Application to Multi-Expert Decision-Making Method

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Abstract: In the modern world, the computation of vague data is a challenging job. Different theories are presented to deal with such situations. Amongst them, fuzzy set theory and its extensions produced remarkable results. Smarandache extended the theory to a new horizon with the neutrosophic set (NS), which was further extended to interval neutrosophic set (INS). Neutrosophic cubic set (NCS) is the generalized version of NS and INS. This characteristic makes it an exceptional choice to deal with vague and imprecise data. Aggregation operators are key features of decision-making theory. In recent times several aggregation operators were defined in NCS. The intent of this paper is to generalize these aggregation operators by presenting neutrosophic cubic generalized unified aggregation (NCGUA) and neutrosophic cubic quasi-generalized unified aggregation (NCQGUA) operators. The accuracy and precision are a vital tool to minimize the potential threat in decision making. Generally, in decision making methods, alternatives and criteria are considered to evaluate the better outcome. However, sometimes the decision making environment has more components to express the problem completely. These components are named as the state of nature corresponding to each criterion. This complex frame of work is dealt with by presenting the multi-expert decision-making method (MEDMM).

Keywords: neutrosophic cubic set (NCS); neutrosophic cubic generalized unified aggregation (NCGUA); neutrosophic cubic quasi-generalized unified aggregation (NCQGUA); multi-expert decision-making method (MEDMM)

1. Introduction

In real-life problems complex phenomena occur. One of the complex phenomena is to deal with the vagueness and uncertainty in data. Because uncertainty is inevitable in problems in different areas of life, conventional methods have failed to cope with such problems. The big task was to deal with uncertain information for many years. Many models have been introduced to incorporate uncertainty into the description of the system. *Zadeh presented their theory of* Fuzzy sets [1]. The possibilistic nature of fuzzy set theory attracted researchers to apply it in different fields of sciences like artificial intelligence, decision making theory, information sciences, medical sciences and more. Due to its applicability in sciences and daily life problems, fuzzy set has been extended to interval valued fuzzy sets (IVFS) [2,3], intuitionistic fuzzy sets (IFS) [4], interval valued intuitionistic fuzzy sets (IVIFS) [5], cubic sets [6], etc. Over the last decades, researchers used it for decision making problems [7–12]. Smarandache presented the idea of neutrosophic sets (NS) [13]. NS provide the more general plate form to extend the ideas of classic theory and fuzzy set theory. The NS consists of three components: truth, indeterminacy and falsehood; all three components are independent, and this makes NS more general than IFS. In fact, NS is a generalization of IFS [14]. For sciences and engineering problems, Wang et al. [15] presented single value neutrosophic set (SVNS), which is a class of NS. Wang et al. [16] further characterized neutrosophic sets to interval neutrosophic set (INS). INS range to an interval value within [0, 1], which comfort the selectors to make an appropriate choice. Jun et al. [17] combined INS and NS to form neutrosophic cubic set (NCS). NCS enables us to choose both interval value and single value membership and indeterminacy and falsehood components. The NCS is the generalization of all abovementioned predeccessors. For example, if the interval part is not taken into account, the set becomes NS, and if the second part is not considered, the NS is dealt with. Since the NS is a generalization of IFS, it is concluded that NCS is the generalization of NS, INS, CS, IFS and fuzzy set. Due to this nature of NCS, it provides more general plate form for uncertain and vague data.

The aggregation operators are an important component of decision making. The insufficient and vague data make it challenging for a decision maker to compute the exact decision. This situation can be minimized by the vague nature of NS and its extensions. The vague nature of NS attracted researchers to implement it in the different fields of science, engineering and decision-making theory. The researchers proposed different aggregation operators and multi-criteria decision-making methods in NS and INS [18–27]. The NCS is the more general form of both NS and INS. This nature attracted researchers to apply it in different fields like science, engineering and decision-making theory. Khan et al. [28] presented neutrosophic cubic Einstein geometric aggregation operators. Zhan et al. [29] worked on multi-criteria decision making on neutrosophic cubic sets. Banerjee et al. [30] used grey rational analysis (GRA) techniques to neutrosophic cubic sets. Lu and Ye [31] defined cosine measure to neutrosophic cubic set. Pramanik et al. [32] used similarity measure to neutrosophic cubic set. Shi and Ji [33] defined Dombi aggregation operators on neutrosophic cubic sets. Ye [34] defined aggregation operators over the neutrosophic cubic numbers. Alhazaymeh et al. [35] presented hybrid geometric aggregation operator with application to multi-attribute decision-making method on neutrosophic cubic sets.

Contribution. The methodologies to measure the generalized aggregations of neutrosophic cubic values.

- First neutrosophic cubic generalized unified aggregation operators are proposed.
- Second neutrosophic cubic quasi-generalized unified aggregation operators are proposed.
- The multi-expert decision-making method is proposed.
- The method is furnished upon numeric data of EMU European Monitory union as an application.
- Comparison is given between some aggregation operators.

Organization. The remaining manuscript is structured as follows. In Section 2, the preliminary work is reviewed. In Section 3, the NCGUA operators are defined. In Section 4, the NCQGU operators are defined. In Section 5, MEDMM is proposed and applied to a numeric data of EMU as an application. Lastly, the comparison of some aggregation operators is provided.

2. Preliminaries

This section consists of some work that provides the foundation for our work.

Definition 1. [13] *A structure* $N=\{(T_N(u), I_N(u), F_N(u)) \mid u \in U\}$ *is NS, where* $\{T_N(u), I_N(u), F_N(u) \in \left]0^-, 1^+\right[\}$ *and* $T_N(u), I_N(u), F_N(u)$ *are truth, indeterminacy and falsehood respectively.*

Definition 2. [15] *A structure* $N=\{(T_N(u),I_N(u),F_N(u))\mid u\in U\}$ *is SVNS, where* $\{T_N(u),I_N(u),F_N(u)\in[0,1]\}$ *respectively called truth, indeterminancy and falsehood are simply denoted by* $N=(T_N,I_N,F_N)$.

Definition 3. [16] *An INS in* U *is a structure* $N=\{(\tilde{T}_N(u),\tilde{I}_N(u),\tilde{F}_N(u))\mid u\in U\}$ *where* $\{\tilde{T}_N(u),\tilde{I}_N(u),\tilde{F}_N(u)\in D[0,1]\}$ *are respectively called truth, indeterminacy and falsehood in* U, *is simply denoted by* $N=(\tilde{T}_N,\tilde{I}_N,\tilde{F}_N)$. *For convenience denoted by* $N=(\tilde{T}_N,\tilde{I}_N,\tilde{F}_N)$ *by* $N=(\tilde{T}_N=[T_N^L,T_N^U],\tilde{I}_N=[I_N^L,I_N^U],\tilde{F}_N=[F_N^L,F_N^U])$.

Definition 4. [16] *A structure* N = $\{(u,\tilde{T}_N(u),\tilde{I}_N(u),\tilde{F}_N(u),T_N(u),I_N(u),F_N(u))\mid u\in U\}$ *is NCS in* U, *in which* $(\tilde{T}_N=[T_N^L,T_N^U],\tilde{I}_N=[I_N^L,I_N^U],\tilde{F}_N=[F_N^L,F_N^U])$ *is an INS and* (T_N,I_N,F_N) *is NS in* U, *is simply denoted by* $N=(\tilde{T}_N,\tilde{I}_N,\tilde{F}_N,T_N,I_N,F_N)$, $[0,0]\le\tilde{T}_N+\tilde{I}_N+\tilde{F}_N\le[3,3]$, *and* $0\le T_N+I_N+F_N\le 3$. N^U *denotes the collection of NCS in* U, *which is simply denoted by* $N=(\tilde{T}_N,\tilde{I}_N,\tilde{F}_N,T_N,I_N,F_N)$.

Definition 5. [29] *The sum of two NCS,* $A=(\tilde{T}_A,\tilde{I}_A,\tilde{F}_A,T_A,I_A,F_A)$, *where* $\tilde{T}_A=[T_A^L,T_A^U],\tilde{I}_A=[I_A^L,I_A^U],\tilde{F}_A=[F_A^L,F_A^U]$ *and* $B=(\tilde{T}_B,\tilde{I}_B,\tilde{F}_B,T_B,I_B,F_B)$, *where* $\tilde{T}_B=[T_B^L,T_B^U],\tilde{I}_B=[I_B^L,I_B^U],\tilde{F}_B=[F_B^L,F_B^U]$ *is defined as*

$$A\oplus B=\left(\left[T_A^L+T_B^L-T_A^LT_B^L,T_A^U+T_B^U-T_A^UT_B^U\right],\left[I_A^L+I_B^L-I_A^LI_B^L,I_A^U+I_B^U-I_A^UI_B^U\right],\left[F_A^LF_B^L,F_A^UF_B^U\right],T_AT_B,I_AI_B,F_A+F_B-F_AF_B\right)$$

Definition 6. [29] *The product of two NCS,* $A=(\tilde{T}_A,\tilde{I}_A,\tilde{F}_A,T_A,I_A,F_A)$, *where* $\tilde{T}_A=[T_A^L,T_A^U],\tilde{I}_A=[I_A^L,I_A^U],\tilde{F}_A=[F_A^L,F_A^U]$ *and* $B=(\tilde{T}_B,\tilde{I}_B,\tilde{F}_B,T_B,I_B,F_B)$, *where* $\tilde{T}_B=[T_B^L,T_B^U],\tilde{I}_B=[I_B^L,I_B^U],\tilde{F}_B=[F_B^L,F_B^U]$ *is defined as*

$$A\otimes B=\left(\left[T_A^LT_B^L,T_A^UT_B^U\right],\left[I_A^LI_B^L,I_A^UI_B^U\right],\left[F_A^L+F_B^L-F_A^LF_B^L,F_A^U+F_B^U-F_A^UF_B^U\right],T_A+T_B-T_AT_B,I_A+I_B-I_AI_B,F_AF_B\right)$$

Definition 7. [29] *The scalar multiplication on a NCS,* $A=(\tilde{T}_A,\tilde{I}_A,\tilde{F}_A,T_A,I_A,F_A)$ *where* $\tilde{T}_A=[T_A^L,T_A^U],\tilde{I}_A=[I_A^L,I_A^U],\tilde{F}_A=[F_A^L,F_A^U]$ *and a scalar* k *is defined*

$$kA=\left(\left[1-(1-T_A^L)^k,1-(1-T_A^U)^k\right],\left[1-(1-I_A^L)^k,1-(1-I_A^U)^k\right],\left[\left(F_A^L\right)^k,\left(F_A^U\right)^k\right],(T_A)^k,(I_A)^k,1-(1-F_A)^k\right)$$

Definition 8. [29] *Let* $A=([T_A^L,T_A^U],[I_A^L,I_A^U],[F_A^L,F_A^U],T_A,I_A,F_A)$, *be an NCS and* $A^*=([1,1],[1,1],[0,0],0,0,1)$ *be maximum NCS, then the cosine measure*(C_m) *is defined as*

$$C_m(A)=\left\{\frac{\pi}{18}\left(1-T_A^L+1-T_A^U+1-I_A^L+1-I_A^U+F_A^L+F_A^U+T_A+I_A+1-F_A\right)\right\},C_m(A)\in[0,1]$$

For comparison of two NCS cosine measure is used.

3. The Neutrosophic Cubic Generalized Unified Aggregation Operator

The NCGUA operators are the generalization of many aggregation operators. The NCGUA operators unify several aggregations operators consequent upon their importance to analyze the imprecise data according to their importance. Moreover, it allows to use arithmetic, quadratic and geometric aggregation operators. By including a wide range of systems, it can adopt different scenario without losing any information.

Definition 9. *The NCGUA is defined as,* $NCGUA(A_1, A_2, \ldots, A_n) = \sum_{j=1}^{m} C_j \left(\sum_{i=1}^{n} w_i^j A_i^{\lambda_j} \right)^{1/\lambda_j}$

where C_j *is the relevance that each sub-aggregation has in the system with* $C_j \in [0,1]$ *and* $\sum_{j=1}^{m} C_j = 1$; w_i^j *is the* ith *weight of the* jth *weighing vector* W *with* $w_i^j \in [0,1]$, $\lambda_j = 1$, ϑ_h *is the parameter such that* $\lambda_j \in R$ *and* A_i *is the argument value of neutrosophic cubic value.*

Definition 10. *The further generalization can be expressed as,*

$$NCGUA(A_1, A_2, \ldots, A_n) = \left(\left(\sum_{j=1}^{m} C_j \left(\sum_{i=1}^{n} w_i^j A_i^{\lambda_j} \right)^{1/\lambda_j} \right)^{\delta} \right)^{1/\delta}$$

where $\delta \in (-\infty, \infty)$. *Usually* λ_j *remain same but for complex type of aggregation different values can be assumed.*

The operation used on NC is defined by [29].

NCGUA operators accomplish properties like monotonicity, boundness and idempotency.

Families of NCGUA Operators

The main aspect of NCGUA operator is that it characterizes a variety of aggregation operators. The aim of this section is to analyze these sub aggregations operators. First generalized NCOWA, NCWA and NCPOWA operators are analyzed.

$$NCGUA(A_1, A_2, \ldots, A_n) = C_1 \sum_{i=1}^{n} w_i^1 A_i + C_2 \sum_{i=1}^{n} w_i^2 A_i + C_3 \sum_{i=1}^{n} w_i^3 A_i \quad (1)$$

where A_i is the ith largest of A_n, and w^1, w^2, w^3 represent the weights corresponding to the NCOWA, NCWA and NCPOWA operators, $\lambda_j = \delta = 1$.

Note that in NCOWA operator, an additional order is made of $(A_1, A_2, \ldots, A_n)$, then it is weighted.

$$C_1 = 1, C_2 = C_3 = 0 \Rightarrow NCOWA \quad (2)$$

$$C_2 = 1, C_1 = C_3 = 0 \Rightarrow NCWA \quad (3)$$

$$C_3 = 1, C_1 = C_2 = 0 \Rightarrow NCPOWA \quad (4)$$

Some other family of aggregation operators can be analyzed by assigning values to λ_j and δ, these values depend on the type of problem under discussion.

The averaging aggregation operators have a most practical operator among their competitors, but in some situations, other operators like geometric, quadratic, cubic operators are in a much better position to evaluate the values.

- If $\lambda = \delta = 1$ and for all *j*, the aggregation operator is deduced to NCUA.

$$NCUA\left(A_1, A_2, ..., A_n\right) = \sum_{j=1}^{m} C_j \sum_{i=1}^{n} w_i^j A_i \tag{5}$$

- If $\lambda \to 1, \delta = 1$ and for all *j*, the aggregation operator is deduced to NCUG.

$$NCUG\left(A_1, A_2, ..., A_n\right) = \sum_{j=1}^{m} C_j \prod_{i=1}^{n} A_i^{w_j} \tag{6}$$

- If $\lambda = 2, \delta = 1$ and for all *j*, the aggregation operator is deduced to NCUQA.

$$NCUQA\left(A_1, A_2, ..., A_n\right) = \sum_{j=1}^{m} C_j \left(\sum_{i=1}^{n} w_i^j A_i^2\right)^{1/2} \tag{7}$$

- If $\lambda \to 0, \delta \to 0$ and for all *j*, the aggregation operator is deduced to NCGUG.

$$NCGUG\left(A_1, A_2, ..., A_n\right) = \prod_{j=1}^{m} C_j \prod_{i=1}^{n} A_i^{w_j} \tag{8}$$

- If $\lambda = 2, \delta = 2$ and for all *j*, the aggregation operator is deduced to NCQUQA.

$$NCQUQA\left(A_1, A_2, ..., A_n\right) = \left(\sum_{j=1}^{m} C_j^2 \left(\sum_{i=1}^{n} w_i^j A_i^2\right)^{1/2}\right)^{1/2} \tag{9}$$

The particular cases of NCUA operators can be analyzed by different values of λ and δ as shown in Table 1.

Table 1. Types of family of neutrosophic cubic generalized unified aggregation (NCGUA) operators.

	$\lambda = -\infty$	$\lambda \to 0$	$\lambda = 2$	$\lambda = \infty$
$\delta = -\infty$	Min	Min	Min	Max
$\delta \to 0$	Min	NCUGA		Max
$\delta = 1$	Min	NCUGA		max
$\delta = 2$	Min	NCUGA		Max
$\delta = \infty$	Min	NCUGA		Max

λ and δ have different values in the sub-aggregation operators. Thus, the aggregation operators have listed aggregation operators above. For further analysis, assume that aggregation operators follow the weighted averaging aggregation approach. Observe that a different scenario may be constructed by assigning different values to λ and δ. Today's world has much more complex phenomena; to deal with such situation, complex aggregation operators become a vital tool. Note that the complex and simple aggregation operators can be studied by assigning different values not only to λ and δ but to the weight as well.

4. Neutrosophic Cubic Quasi-Generalized Unified Aggregation Operators

The NCGUA operator can further be generalized by quasi- arithmetic means by neutrosophic cubic quasi-generalized unified aggregation (NCQGUA) operator. The characteristic of NCQGUA operators is that they are a generalization of not only NCGUA operators but of some other aggregation operators by the function introduced in NCQGUA.

Definition 11. *The NCQGUA operator can be defined as*

$$NCQGUA\left(A_1, A_2, \ldots, A_n\right) = f_j^{-1}\left(\sum_{j=1}^{m} C_j f_j\left(g_j^{-1}\left(\sum_{i=1}^{n} w_i^j g_j\left(A_i\right)\right)\right)^{1/2}\right)^{1/2}$$

where f_j *and* g_j *are strictly continuous monotone functions.*

The NCQGUA operator can be deduced to a wide range of aggregation operators. The table 2 illustrates the range generated by NCQGUA operators.

Table 2. Types of family neutrosophic cubic quasi-generalized unified aggregation (NCQGUA) operators.

$g_j = a$	$f_j = C_j$	**NCAO operator**
$g_j = a^2$	$f_j = C_j$	NCQA operator
$g_j = a^{-1}$	$f_j = C_j$	NCHA operator
$g_j = a^3$	$f_j = C_j$	NCCA operator
$g_j = a^0$	$f_j = C_j$	NCGA operator
$g_j = a^2$	$f_j = C_j^2$	NCAUAQA operator
$g_j = a^{-1}$	$f_j = C_j^-$	NCHUHA operator
$g_j = a^3$	$f_j = C_j^3$	NCUCA operator
$g_j = a^0$	$f_j = C_j^0$	NCUGA operator

In Table 1 it is assumed that $g_1 = g_2 = \ldots = g_m$ for all j.

5. The Application of NCQGUA and NCGUA Operators to Multi-Expert Decision-Making Method

The NCQGUA and NCGUA aggregation operators are generalized forms of most of the aggregation operators that can easily be deduced under some special conditions. This characteristic offers a great advantage when applying them to different MCDM. For this purpose, the multi-expert decision-making method MEDMM is proposed. This method is specially designed for complex situations where need of more than one criterion has a further classification, which is the state of nature. In the modern world, the areal study becomes a vital tool to set foreign policy or investments to a country or region. The choice of country or region to invest is a risk-taking job. The countries and multinational companies hire experts for these regions to come up with profitable decisions. For such situation MEDMM is developed under a NC environment that is a neutrosophic cubic multi-expert decision-making method (NCMEDMM).

5.1. Algorithm

This decision-making technique, which is specially designed for the problem, has different criteria, and each criterion has different classifications named as state of nature. The choice of alternatives in such a situation becomes different from the group decision making studied until now. Due to this phenomenon the following method is proposed.

The problem consist of n alternatives $A = \{A_1, A_2, A_3, \ldots, A_n\}$ corresponding to k $C = \{C_1, C_2, C_3, \ldots, C_k\}$ criteria and has $S = \{S_1, S_2, S_3, \ldots, S_m\}$ m state of nature corresponding to each criterion.

- Construction of expert's criteria matrices for each criterion corresponding to the given alternatives and finite state of nature.

- Transformation of expert criteria matrices to general group expert's matrix by aggregation operator.
- Transformation of all the general group experts' matrices to a single matrix by aggregation operator.
- Ranking of alternatives.

5.2. Model Formulation

European Monetary Union EMU is an organization working for the benefit of the EU. The EMU formation has a lot of micro- and macro-finance decisions to build a productive state. All the areas like economics, finance, politics, marketing, management and EU laws are taken into account for making any decision.

Consider an illustrative example in multi-person decision making in the EMU [36–39]. This type of problem in macroeconomics usually deals with huge amounts of capital or other variables. This makes it critical to find the accurate decision; otherwise, a small deviation may cause huge economic difference in the region. The two different criteria are considered to analyze MPDMM. It is very common that a decision of EMU is usually influenced by several experts and criteria.

The model consists of the following data.

Criteria

$Cr1:$ Internal economic condition.

$Cr2:$ Global economic condition.

Alternative

$A_1:$ Increase the rates 1%.

$A_2:$ Increase the rates 0.5%.

$A_3:$ No change in rates.

$A_4:$ Decrease the rates 0.5%.

$A_5:$ Decrease the rates 1%.

State of nature

$S_1:$ Negative growth.

$S_2:$ Growth close to 0.

$S_3:$ Positive growth.

The company collected the data regarding these alternatives. The assumption is that this decision has potential states of nature benefit corresponding to the two criteria.

$Cr1:$ Internal economic condition

$S_1:$ Negative growth.

$S_2:$ Growth close to 0.

$S_3:$ Positive growth.

$Cr2:$ Global economic condition.

$S_1:$ Negative growth.

$S_2:$ Growth close to 0.

$S_3:$ Positive growth.

The EMU nominates individuals responsible for this decision which is divided into three groups; each group provides their opinion regarding the outcome and the possible strategy. The data of expert 1 subject to criterion 1 is shown in tables 3.

Table 3. Expert 1–Criterion 1.

S_1	S_2	S_3

A_1	$\left([0.25,0.35],[0.35,0.45],[0.45,0.55],0.30,0.40,0.50\right)$	$\left([0.55,0.65],[0.45,0.55],[0.75,0.85],0.60,0.70,0.80\right)$	$\left([0.75,0.85],[0.87,0.97],[0.75,0.85],0.30,0.50,0.60\right)$
A_2	$\left([0.45,0.60],[0.35,0.50],[0.73,0.89],0.30,0.45,0.80\right)$	$\left([0.85,0.95],[0.55,0.65],[0.30,0.40],0.75,0.40,0.59\right)$	$\left([0.45,0.55],[0.35,0.48],[0.61,0.81],0.40,0.60,0.70\right)$
A_3	$\left([0.45,0.55],[0.65,0.75],[0.25,0.45],0.50,0.30,0.60\right)$	$\left([0.40,0.55],[0.43,0.53],[0.45,0.55],0.35,0.50,0.40\right)$	$\left([0.60,0.75],[0.25,0.35],[0.40,0.55],0.70,0.20,0.30\right)$
A_4	$\left([0.28,0.37],[0.41,0.53],[0.40,0.50],0.33,0.52,0.50\right)$	$\left([0.40,0.50],[0.25,0.35],[0.65,0.78],0.30,0.50,0.80\right)$	$\left([0.28,0.40],[0.35,0.43],[0.25,0.45],0.30,0.20,0.50\right)$
A_5	$\left([0.35,0.55],[0.30,0.50],[0.50,0.60],0.30,0.40,0.40\right)$	$\left([0.60,0.70],[0.48,0.60],[0.70,0.80],0.60,0.50,0.80\right)$	$\left([0.45,0.55],[0.53,0.65],[0.80,0.85],0.50,0.58,0.70\right)$

The data of expert 1 subject to criterion 2 is shown in tables 4.

Table 4. Expert 1–Criterion 2.

	S_1	S_2	S_3
A_1	$\left([0.50,0.60],[0.25,0.35],[0.45,0.55],0.55.40,0.50\right)$	$\left([0.25,0.35],[0.45,0.55],[0.50,0.60],0.30,0.45,0.50\right)$	$\left([0.35,0.45],[0.45,0.55],[0.50,0.55],0.40,0.50,0.60\right)$
A_2	$\left([0.65,0.75],[0.50,0.55],[0.75,0.85],0.70,0.80,0.90\right)$	$\left([0.40,0.55],[0.35,0.45],[0.50,0.60],0.40,0.50,0.50\right)$	$\left([0.50,0.60],[0.55,0.65],[0.65,0.75],0.40,0.50,0.60\right)$
A_3	$\left([0.25,0.35],[0.45,0.55],[0.75,0.85],0.30,0.50,0.60\right)$	$\left([0.65,0.75],[0.75,0.85],[0.85,0.95],0.70,0.80,0.90\right)$	$\left([0.20,0.35],[0.35,0.45],[0.45,0.55],0.30,0.40,0.50\right)$
A_4	$\left([0.55,0.65],[0.45,0.55],[0.75,0.85],0.50,0.70,0.80\right)$	$\left([0.45,0.55],[0.55,0.60],[0.70,0.80],0.50,0.50,0.70\right)$	$\left([0.45,0.55],[0.50,0.55],[0.80,0.90],0.50,0.60,0.70\right)$
A_5	$\left([0.20,0.30],[0.30,0.40],[0.50,0.60],0.30,0.40,0.60\right)$	$\left([0.60,0.70],[0.55,0.65],[0.6,0.75],0.70,0.50,0.70\right)$	$\left([0.35,0.45],[0.35,0.45],[0.75,0.85],0.70,0.50,0.70\right)$

Subject to this information, the first criterion is weighted as 0.70 and the second criterion as 0.30. The NCGUA operators are applied to form the general matrix, which represents the matrix of the group of experts illustrated in table 5..

Table 5. Expert 1–General result.

	S_1	S_2	S_3
A_1	$\left([0.4967,0.5981],[0.3214,0.4217],[0.4500,0.5500],0.3598,0.4000,0.5000\right)$	$\left([0.4754,0.5785],[0.4500,0.5500],[0.6641,0.7656],0.4873,0.6131,0.7367\right)$	$\left([0.6670,0.7785],[0.7996,0.9324],[0.6641,0.7459],0.3270,0.5000,0.6000\right)$
A_2	$\left([0.5167,0.6526],[0.3992,0.5155],[0.6314,0.8618],0.3868,0.5348,0.8375\right)$	$\left([0.7726,0.9033],[0.4975,0.5992],[0.3497,0.4517],0.6211,0.4277,0.5648\right)$	$\left([0.4655,0.5656],[0.4179,0.5382],[0.6217,0.7915],0.4000,0.56810,0.7121\right)$

A_3	([0.3964, 0.4975], [0.5991, 0.7017], [0.3476, 0.5445], 0.4289, 0.3497, 0.8375)	([0.4896, 0.6227], [0.5549, 0.6663], [0.7044, 0.6036], 0.4309, 0.5757, 0.8375)	([0.3502, 0.6670], [0.3500, 0.4361], [0.2982, 0.4779], 0.6131, 0.2662, 0.3868)
A_4	([0.3746, 0.4718], [0.4223, 0.5361], [0.4830, 0.5862], 0.3738, 0.5139, 0.6202)	([0.4155, 0.5155], [0.3565, 0.4381], [0.6646, 0.7859], 0.3496, 0.5000, 0.7741)	([0.3358, 0.4496], [0.3500, 0.4360], [0.3544, 0.5540], 0.3496, 0.2780, 0.5710)
A_5	([0.3353, 0.4862], [0.3000, 0.4718], [0.5000, 0.6000], 0.3000, 0.6000, 0.4687)	([0.6000, 0.7000], [0.5020, 0.6157], [0.6683, 0.7846], 0.6283, 0.5000, 0.607741)	([0.3817, 0.5228], [0.4819, 0.5992], [0.7646, 0.8500], 0.6328, 0.5547, 0.7000)

The data of expert 2 subject to criterion 1 is shown in tables 6.

Table 6. Expert 2–Criterion 1.

	S_1	S_2	S_3
A_1	([0.22, 0.35], [0.40, 0.50], [0.45, 0.55], 0.30, 0.45, 0.55)	([0.70, 0.75], [0.75, 0.85], [0.70, 0.80], 0.60, 0.70, 0.85)	([0.70, 0.85], [0.15, 0.30], [0.25, 0.35], 0.80, 0.50, 0.20)
A_2	([0.20, 0.30], [0.30, 0.40], [0.60, 0.70], 0.25, 0.45, 0.70)	([0.35, 0.45], [0.45, 0.60], [0.30, 0.40], 0.15, 0.40, 0.10)	([0.50, 0.60], [0.45, 0.55], [0.40, 0.53], 0.70, 0.30, 0.60)
A_3	([0.10, 0.25], [0.25, 0.75], [0.25, 0.45], 0.30, 0.20, 0.50)	([0.25, 0.35], [0.40, 0.55], [0.40, 0.50], 0.35, 0.50, 0.40)	([0.60, 0.75], [0.20, 0.35], [0.45, 0.55], 0.70, 0.20, 0.40)
A_4	([0.55, 0.65], [0.40, 0.50], [0.45, 0.50], 0.70, 0.50, 0.40)	([0.60, 0.70], [0.25, 0.35], [0.45, 0.55], 0.80, 0.50, 0.30)	([0.25, 0.40], [0.35, 0.43], [0.75, 0.85], 0.30, 0.40, 0.85)
A_5	([0.70, 0.85], [0.20, 0.40], [0.40, 0.50], 0.90, 0.20, 0.40)	([0.70, 0.90], [0.40, 0.50], [0.50, 0.60], 0.90, 0.50, 0.40)	([0.15, 0.25], [0.25, 0.35], [0.80, 0.85], 0.30, 0.30, 0.70)

The data of expert 2 subject to criterion 2 is shown in tables 7.

Table 7. Expert 2–Criterion 2.

	S_1	S_2	S_3
A_1	([0.40, 0.50], [0.50, 0.60], [0.55, 0.65], 0.55.20, 0.60)	([0.55, 0.65], [0.40, 0.50], [0.50, 0.65], 0.60, 0.45, 0.60)	([0.15, 0.25], [0.35, 0.55], [0.55, 0.65], 0.40, 0.50, 0.70)
A_2	([0.30, 0.45], [0.50, 0.55], [0.70, 0.80], 0.20, 0.60, 0.70)	([0.10, 0.20], [0.30, 0.40], [0.40, 0.50], 0.10, 0.40, 0.45)	([0.40, 0.50], [0.25, 0.35], [0.65, 0.75], 0.40, 0.30, 0.60)
A_3	([0.70, 0.85], [0.45, 0.55], [0.25, 0.35], 0.80, 0.50, 0.40)	([0.15, 0.25], [0.70, 0.80], [0.75, 0.85], 0.20, 0.80, 0.90)	([0.30, 0.45], [0.35, 0.45], [0.55, 0.65], 0.30, 0.40, 0.65)
A_4	([0.55, 0.65], [0.25, 0.35], [0.85, 0.95], 0.50, 0.30, 0.80)	([0.35, 0.45], [0.55, 0.60], [0.20, 0.30], 0.50, 0.50, 0.30)	([0.50, 0.50], [0.50, 0.55], [0.40, 0.50], 0.50, 0.50, 0.45)
A_5	([0.70, 0.80], [0.30, 0.40], [0.40, 0.60], 0.85, 0.40, 0.35)	([0.30, 0.40], [0.55, 0.65], [0.40, 0.50], 0.40, 0.50, 0.50)	([0.35, 0.45], [0.35, 0.45], [0.70, 0.80], 0.40, 0.40, 0.70)

Subject to this information, the first criterion is weighted as 0.70 and the second criterion as 0.30. The NCGUA operators are applied to form the general matrix, which represents the matrix of the group of experts illustrated in table 8..

Table 8. Expert 2–General result.

	S_1	S_2	S_3
A_1	$\begin{pmatrix}[0.2832,0.4235],\\ [0.4489,0.5625],\\ [0.5423,0.6235],\\ 0.4623,0.3233,0.5436\end{pmatrix}$	$\begin{pmatrix}[0.6235,0.7135],\\ [0.6145,0.7023],\\ [0.6235,0.7235],\\ 0.6000,0.6123,0.7127\end{pmatrix}$	$\begin{pmatrix}[0.3523,0.5515],\\ [0.2523,0.3124],\\ [0.3931,0.4956],\\ 0.6123,0.5000,0.4456\end{pmatrix}$
A_2	$\begin{pmatrix}[0.2645,0.3845],\\ [0.4124,0.5142],\\ [0.6496,0.7485],\\ 0.2124,0.5217,0.7000\end{pmatrix}$	$\begin{pmatrix}[0.2345,0.3325],\\ [0.3854,0.5123],\\ [0.3485,0.4489],\\ 0.1223,0.4000,0.6625\end{pmatrix}$	$\begin{pmatrix}[0.4659,0.7152],\\ [0.3645,0.4153],\\ [0.5189,0.6478],\\ 0.6478,0.2485,0.5123\end{pmatrix}$
A_3	$\begin{pmatrix}[0.4125,0.5689],\\ [0.4351,0.6628],\\ [0.2500,0.3485],\\ 0.5489,0.5000,0.4658\end{pmatrix}$	$\begin{pmatrix}[0.2134,0.3125],\\ [0.5681,0.7125],\\ [0.5678,0.5000],\\ 0.2189,0.6456,0.6478\end{pmatrix}$	$\begin{pmatrix}[0.4691,0.6123],\\ [0.3500,0.4485],\\ [0.5986,0.7458],\\ 0.3000,0.4489,0.7674\end{pmatrix}$
A_4	$\begin{pmatrix}[0.5500,0.6500],\\ [0.3456,0.4657],\\ [0.6647,0.7456],\\ 0.5987,0.3985,0.6123\end{pmatrix}$	$\begin{pmatrix}[0.4875,0.5825],\\ [0.3645,0.5621],\\ [0.3245,0.6987],\\ 0.4989,0.6487,0.3000\end{pmatrix}$	$\begin{pmatrix}[0.3825,0.4658],\\ [0.4360,0.5032],\\ [0.5687,0.6689],\\ 0.3958,0.4489,0.6658\end{pmatrix}$
A_5	$\begin{pmatrix}[0.7000,0.8354],\\ [0.2658,0.4680],\\ [0.4000,0.5489],\\ 0.887200,0.3152,0.3254\end{pmatrix}$	$\begin{pmatrix}[0.5125,0.6652],\\ [0.4658,0.5684],\\ [0.4458,0.5482],\\ 0.6685,0.5000,0.4458\end{pmatrix}$	$\begin{pmatrix}[0.2145,0.3641],\\ [0.3125,0.4128],\\ [0.7458,0.8285],\\ 0.3456,0.3456,0.7000\end{pmatrix}$

The data of expert 3 subject to criterion 1 is shown in tables 9.

Table 9. Expert 3–Criterion 1.

	S_1	S_2	S_3
A_1	$\begin{pmatrix}[0.20,0.40],[0.30,0.40],\\ [0.55,0.65],0.30,0.40,0.60\end{pmatrix}$	$\begin{pmatrix}[0.55,0.65],[0.60,0.75],\\ [0.70,0.80],0.60,0.70,0.75\end{pmatrix}$	$\begin{pmatrix}[0.30,0.40],[0.40,0.50],\\ [0.60,0.70],0.30,0.45,0.65\end{pmatrix}$
A_2	$\begin{pmatrix}[0.35,0.45],[0.35,0.45],\\ [0.60,0.75],0.30,0.45,0.70\end{pmatrix}$	$\begin{pmatrix}[0.50,0.60],[0.55,0.65],\\ [0.20,0.30],0.50,0.55,0.20\end{pmatrix}$	$\begin{pmatrix}[0.50,0.60],[0.40,0.50],\\ [0.60,0.75],0.50,0.50,0.70\end{pmatrix}$
A_3	$\begin{pmatrix}[0.55,0.65],[0.60,0.75],\\ [0.70,0.80],0.60,0.70,0.75\end{pmatrix}$	$\begin{pmatrix}[0.55,0.65],[0.60,0.75],\\ [0.70,0.80],0.60,0.70,0.75\end{pmatrix}$	$\begin{pmatrix}[0.60,0.75],[0.25,0.35],\\ [0.50,0.60],0.70,0.20,0.50\end{pmatrix}$
A_4	$\begin{pmatrix}[0.60,0.75],[0.25,0.35],\\ [0.50,0.60],0.70,0.20,0.50\end{pmatrix}$	$\begin{pmatrix}[0.55,0.65],[0.60,0.75],\\ [0.70,0.80],0.60,0.70,0.75\end{pmatrix}$	$\begin{pmatrix}[0.60,0.75],[0.25,0.35],\\ [0.50,0.60],0.70,0.20,0.50\end{pmatrix}$

A_5	$\begin{pmatrix}[0.30,0.40],[0.30,0.40],\\ [0.55,0.65],0.30,0.40,0.60\end{pmatrix}$	$\begin{pmatrix}[0.60,0.70],[0.45,0.60],\\ [0.65,0.80],0.60,0.50,0.70\end{pmatrix}$	$\begin{pmatrix}[0.20,0.40],[0.30,0.40],\\ [0.55,0.65],0.30,0.40,0.60\end{pmatrix}$

The data of expert 3 subject to criterion 2 is shown in tables 10.

Table 10. Expert 3–Criterion 2.

	S_1	S_2	S_3
A_1	$\begin{pmatrix}[0.35,0.45],[0.35,0.45],\\ [0.60,0.75],0.30,0.45,0.70\end{pmatrix}$	$\begin{pmatrix}[0.55,0.65],[0.60,0.75],\\ [0.70,0.80],0.60,0.70,0.75\end{pmatrix}$	$\begin{pmatrix}[0.20,0.40],[0.30,0.40],\\ [0.55,0.65],0.30,0.40,0.60\end{pmatrix}$
A_2	$\begin{pmatrix}[0.55,0.65],[0.60,0.75],\\ [0.70,0.80],0.60,0.70,0.75\end{pmatrix}$	$\begin{pmatrix}[0.40,0.55],[0.35,0.45],\\ [0.50,0.60],0.40,0.50,0.50\end{pmatrix}$	$\begin{pmatrix}[0.35,0.45],[0.35,0.45],\\ [0.60,0.75],0.30,0.45,0.70\end{pmatrix}$
A_3	$\begin{pmatrix}[0.45,0.55],[0.20,0.30],\\ [0.60,0.75],0.50,0.20,0.60\end{pmatrix}$	$\begin{pmatrix}[0.45,0.55],[0.20,0.30],\\ [0.60,0.75],0.50,0.20,0.60\end{pmatrix}$	$\begin{pmatrix}[0.60,0.70],[0.55,0.65],\\ [0.45,0.55],0.70,0.40,0.60\end{pmatrix}$
A_4	$\begin{pmatrix}[0.55,0.65],[0.45,0.55],\\ [0.75,0.85],0.50,0.70,0.80\end{pmatrix}$	$\begin{pmatrix}[0.45,0.55],[0.55,0.60],\\ [0.70,0.80],0.50,0.50,0.70\end{pmatrix}$	$\begin{pmatrix}[0.35,0.45],[0.35,0.45],\\ [0.60,0.75],0.30,0.45,0.70\end{pmatrix}$
A_5	$\begin{pmatrix}[0.35,0.45],[0.35,0.45],\\ [0.60,0.75],0.30,0.45,0.70\end{pmatrix}$	$\begin{pmatrix}[0.45,0.55],[0.20,0.30],\\ [0.60,0.75],0.50,0.20,0.60\end{pmatrix}$	$\begin{pmatrix}[0.35,0.45],[0.30,0.40],\\ [0.75,0.85],0.70,0.50,0.70\end{pmatrix}$

Subject to this information, the first criterion is weighted as 0.70 and the second criterion as 0.30. The NCGUA operators are applied to form the general matrix, which represents the matrix of the group of experts illustrated in table 11.

Table 11. Expert 3–General result.

	S_1	S_2	S_3
A_1	$\begin{pmatrix}[0.2325,0.4103],\\ [0.3102,0.4103],\\ [0.5645,0.6625],\\ 0.3000,0.4102,0.6354\end{pmatrix}$	$\begin{pmatrix}[0.5500,0.6500],\\ [0.6000,0.7500],\\ [0.7000,0.8000],\\ 0.6000,0.7000,0.7500\end{pmatrix}$	$\begin{pmatrix}[0.2145,0.4000],\\ [0.3185,0.4152],\\ [0.5624,0.6625],\\ 0.3000,0.4123,0.6124\end{pmatrix}$
A_2	$\begin{pmatrix}[0.3960,0.4952],\\ [0.4101,0.4963],\\ [0.6000,0.7652],\\ 0.3446,0.4915,0.7124\end{pmatrix}$	$\begin{pmatrix}[0.4215,0.5685],\\ [0.3925,0.4952],\\ [0.2402,0.3446],\\ 0.4781,0.5396,0.2235\end{pmatrix}$	$\begin{pmatrix}[0.4730,0.5736],\\ [0.3912,0.4925],\\ [0.6000,0.7500],\\ 0.4623,0.4921,0.7000\end{pmatrix}$
A_3	$\begin{pmatrix}[0.5315,0.6319],\\ [0.5405,0.6928],\\ [0.6725,0.7821],\\ 0.5748,0.6289,0.7253\end{pmatrix}$	$\begin{pmatrix}[0.5315,0.6319],\\ [0.5405,0.6928],\\ [0.6721,0.7808],\\ 0.5742,0.6235,0.7253\end{pmatrix}$	$\begin{pmatrix}[0.6000,0.7407],\\ [0.3228,0.5344],\\ [0.4852,0.5842],\\ 0.7000,0.2347,0.5218\end{pmatrix}$
A_4	$\begin{pmatrix}[0.5904,0.6500],\\ [0.2951,0.3960],\\ [0.5547,0.6672],\\ 0.6581,0.3324,0.5837\end{pmatrix}$	$\begin{pmatrix}[0.5315,0.6319],\\ [0.5904,0.7253],\\ [0.7000,0.8000],\\ 0.5714,0.6582,0.7407\end{pmatrix}$	$\begin{pmatrix}[0.5592,0.7072],\\ [0.2711,0.3713],\\ [0.5182,0.6235],\\ 0.6446,0.2577,0.5485\end{pmatrix}$

A_5	$\begin{pmatrix}[0.3713,0.4103],\\ [0.3102,0.4103],\\ [0.5886,0.6758],\\ 0.3000,0.4101,0.6822\end{pmatrix}$	$\begin{pmatrix}[0.5736,0.6746],\\ [0.4072,0.5526],\\ [0.4458,0.5482],\\ 0.5972,0.4475,0.6822\end{pmatrix}$	$\begin{pmatrix}[0.2325,0.4103],\\ [0.3000,0.4000],\\ [0.5823,0.6952],\\ 0.6321,0.4103,0.6223\end{pmatrix}$

Now applying NCGUA operator subject to the weight $(0.45,0.35,0.20)$, the following matrix is obtained illustrated in table 12.

Table 12. Collective results of experts.

	S_1	S_2	S_3
A_1	$\begin{pmatrix}[0.3802,0.5076],\\ [0.3670,0.5291],\\ [0.5026,0.5964],\\ 0.3787,0.3731,0.5453\end{pmatrix}$	$\begin{pmatrix}[0.5470,0.6452],\\ [0.5443,0.6537],\\ [0.6565,0.7572],\\ 0.6000,0.6123,0.6293\end{pmatrix}$	$\begin{pmatrix}[0.5009,0.6539],\\ [0.5941,0.7656],\\ [0.5347,0.6313],\\ 0.4003,0.4811,0.5544\end{pmatrix}$
A_2	$\begin{pmatrix}[0.4145,0.5426],\\ [0.4060,0.5112],\\ [0.6232,0.8101],\\ 0.3064,0.5213,0.7742\end{pmatrix}$	$\begin{pmatrix}[0.5808,0.7435],\\ [0.4399,0.5504],\\ [0.3240,0.3805],\\ 0.5053,0.4376,0.5529\end{pmatrix}$	$\begin{pmatrix}[0.4771,0.6266],\\ [0.3943,0.4888],\\ [0.5794,0.6548],\\ 0.4874,0.4579,0.6167\end{pmatrix}$
A_3	$\begin{pmatrix}[0.4316,0.6806],\\ [0.5354,0.6867],\\ [0.3534,0.5007],\\ 0.4957,0.4457,0.7262\end{pmatrix}$	$\begin{pmatrix}[0.4178,0.5368],\\ [0.5523,0.6884],\\ [0.5812,0.5949],\\ 0.3600,0.6088,0.7634\end{pmatrix}$	$\begin{pmatrix}[0.4869,0.6263],\\ [0.3764,0.4808],\\ [0.4194,0.4701],\\ 0.4902,0.3178,0.5282\end{pmatrix}$
A_4	$\begin{pmatrix}[0.4879,0.5788],\\ [0.3720,0.4862],\\ [0.5552,0.6544],\\ 0.4935,0.4309,0.6104\end{pmatrix}$	$\begin{pmatrix}[0.4659,0.5647],\\ [0.4492,0.5537],\\ [0.5225,0.7569],\\ 0.4368,0.5786,0.6550\end{pmatrix}$	$\begin{pmatrix}[0.4512,0.5314],\\ [0.3764,0.5032],\\ [0.4512,0.6059],\\ 0.4126,0.3178,0.6028\end{pmatrix}$
A_5	$\begin{pmatrix}[0.5024,0.6455],\\ [0.2903,0.4587],\\ [0.4777,0.5955],\\ 0.4384,0.4438,0.4788\end{pmatrix}$	$\begin{pmatrix}[0.5658,0.6821],\\ [0.4715,0.5874],\\ [0.5348,0.6441],\\ 0.6356,0.4890,0.5755\end{pmatrix}$	$\begin{pmatrix}[0.2979,0.4495],\\ [0.3925,0.5034],\\ [0.7177,0.7881],\\ 0.5119,0.4425,0.6860\end{pmatrix}$

Now applying NCGUA operator subject to the weight $(0.33,0.33,0.34)$ the following matrix is obtained illustrated in table 13.

Table 13. Aggregated result of experts.

A_1	$\begin{pmatrix} [0.4808, 0.6079], \\ [0.5117, 0.6644], \\ [0.5606, 0.6578], \\ 0.4491, 0.4790, 0.5778 \end{pmatrix}$
A_2	$\begin{pmatrix} [0.5358, 0.5426], \\ [0.4135, 0.5172], \\ [0.4899, 0.5872], \\ 0.4232, 0.4708, 0.6613 \end{pmatrix}$
A_3	$\begin{pmatrix} [0.4467, 0.6191], \\ [0.4927, 0.6286], \\ [0.4414, 0.5187], \\ 0.4443, 0.4403, 0.6860 \end{pmatrix}$
A_4	$\begin{pmatrix} [0.4684, 0.5585], \\ [0.4000, 0.5151], \\ [0.5071, 0.6688], \\ 0.4460, 0.4282, 0.6214 \end{pmatrix}$
A_5	$\begin{pmatrix} [0.4670, 0.6028], \\ [0.3892, 0.5193], \\ [0.5694, 0.6722], \\ 0.5224, 0.4577, 0.5900 \end{pmatrix}$

For comparison of NC values, the cosine measure is computed of the alternatives, so that the values are ranked.

$$C(A_1) = 0.04055, C(A_2) = 0.4058, \ C(A_3) = 0.04394, \ C(A_4) = 0.03890,$$
$$C(A_5) = 0.03750.$$

From this data the ranking is $A_3 > A_2 > A_1 > A_4 > A_5$.

For comparison purposes, some other aggregation operators are considered, and their results are computed.

The aggregation operators like neutrosophic cubic weighted geometric (NCWG), neutrosophic cubic probabilistic (NCP), neutrosophic cubic maximum (NCmax) and neutrosophic cubic minimum (NCmin) operators are also applied to the data. The following results are obtained.

The graphical comparison of these operators is shown in the following figure.

Figure 1: Graphical representation of Operators.

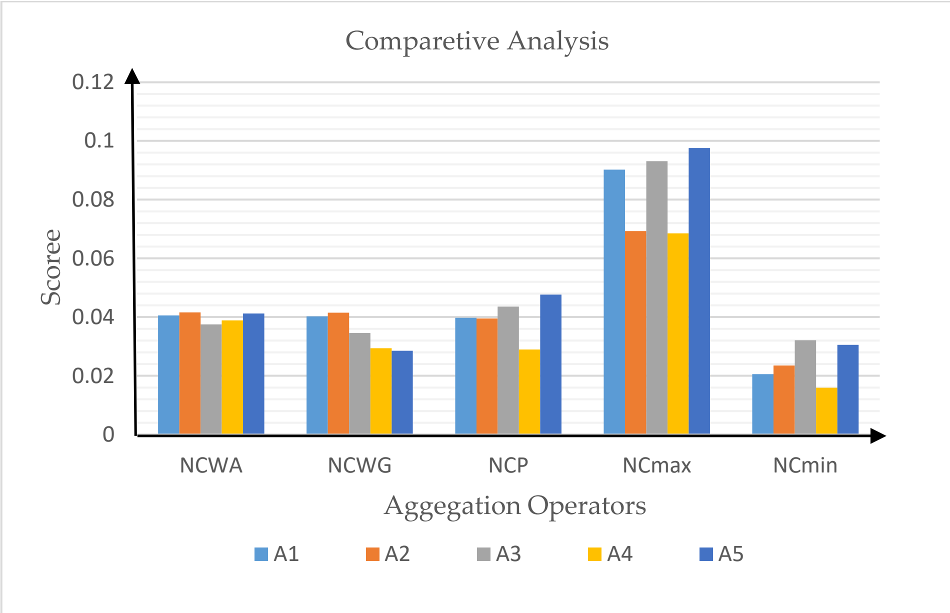

Figure 1. Graphical Comparison of different methods.

The following table also illustrates the comparison of these aggregation operators under the MPDMM.

From the above table with the different alternatives of each decision maker, the alternative in closest accordance to his interests will be selected; this data indicates that the optimal decision is A_5. Thus, the optimal alternative is A_5.

6. Discussion

Jose et al. [40] analyze the data on fuzzy sets and conclude with the following results.

Comparison of Tables 14 and 15. It is observed that in both tables, the optimal alternative is A_5, although individually, some aggregation operators may have different results. The reason may be that NC has more components compared to the FS, like indeterminate and falsehood. Overall comparison has the same result, which ensures the validity of this method. But the advantage of NCS over table FS is that NCS is a generalized version of FS. That is, it enables the expert to deal with inconsistent and indeterminate data more efficiently than the FS.

Table 14. Ranking using different operators.

Operators	Ranking
NCWA	$A_5 > A_2 > A_1 > A_4 > A_3$
NCWG	$A_2 > A_1 > A_3 > A_4 > A_5$
NCP	$A_5 > A_3 > A_1 > A_2 > A_4$
NCmax	$A_5 > A_3 > A_1 > A_2 > A_4$
NCmin	$A_3 > A_5 > A_2 > A_1 > A_4$

Table 15. Ranking using different operators in fuzzy data.

Operators	Ranking
FWA	$A_5 > A_3 > A_1 > A_2 > A_4$
FOWA	$A_3 > A_5 > A_2 > A_1 > A_4$
FPA	$A_5 > A_3 > A_2 > A_1 > A_4$
FMax	$A_5 > A_3 > A_1 > A_2 > A_4$
FMin	$A_2 > A_3 > A_5 > A_1 > A_4$

7. Conclusions

This paper generalized aggregation operators, such as NCGUA operators, which provide a single plate form for researchers and experts to deal with different types of aggregation operators. This generalization helps to work in a complex frame of work where more than one operator is required. The data involves inconsistent and indeterminate factors and is furnished upon a daily life problem. The NCGUA operator is further generalized to NCQGUA aggregation operators. Moreover, it can include complex aggregation operators that deal with complex environments such as problems with a wide range of sub-aggregations. It is shown that some particular aggregation operators like NCWA, NCOWA, NCGA, NCOGA, NCmax, NCmin and other aggregation operators can easily be deduced from NCQGUA or NCGUA operator. A new decision-making method is formed to deal with the problem in which each criterion is further classified into nature of stats. A numeric example involving the EMU is provided as an application. It is concluded that the proposed method provides the best results in comparison to the method previously proposed due to the indeterminate factors involved in data.

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