Scientific Inquiry and Review (SIR)

Volume 4, Issue 2, June 2020

ISSN (P): 2521-2427, ISSN (E): 2521-2435

Journal DOI: https://doi.org/10.32350/sir

Issue DOI: https://doi.org/10.32350/sir.42

Homepage: https://journals.umt.edu.pk/index.php/SIR/Home

Journal QR Code:

Indexing & Abstracting

Crossref

OCLC WorldCat

Genamics JournalSeek

ROAD Directory of Open Access Scholarly Resources

Academic Resource Index ResearchBib

J-Gate

Article

A Comparative Study of FCSM, FSAW and TOPSIS Techniques using Triangular Fuzzy Numbers

Author(s) Muhammad Saeed, Usman Ali, Fazal Dayan

Online Published June 2020

Article DOI https://doi.org/10.32350/sir.42.02

QR Code of Article

Muhammad Saeed

To cite this Article: Saeed M, Ali U, Dayan F. A comparative study of FCSM, FSAW and TOPSIS techniques using triangular fuzzy numbers. *Sci Inquiry Rev.* 2020;4(2):17–30. Crossref

A publication of the
School of Science, University of Management and Technology
Lahore, Pakistan.

A Comparative Study of FCSM, FSAW and TOPSIS Techniques using Triangular Fuzzy Numbers

Muhammad Saeed*, Usman Ali, Fazal Dayan

Department of Mathematics, School of Science,
University of Management and Technology, Lahore, Pakistan

*muhammad.saeed@umt.edu.pk

Abstract

This paper presents a comparative study of different techniques used for fuzzy multi-criteria expert's decision-making (FMCEDM). These include CSM1, CSM2, CSM3, FSAW, and TOPSIS. We developed the methods CSM1 and CSM3 respectively and studied their validity by comparing their illustration results with that of CSM2, FSAW and TOPSIS. Expert's ratings and weights were assigned in linguistic variables in terms of triangular fuzzy numbers (TFNs) to the FMCEDM problem. Airport performance evaluation and a personnel selection problem were studied as alternatives under different decision criteria and experts.

Keywords: Fuzzy Multiple Criteria Expert Decision-Making (FMCEDM), fuzzy simple additive weighting, fuzzy cosine similarity measures, technique for order performance by similarity to ideal solution

Introduction

Several researchers have presented extremely useful analytical models to deal with the situations involving conflict management. Multi-criteria experts decision making (MCEDM) is a methodology available to deal with these situations [1]. Decision-makers have described the aims and objectives to select the final best option provided as an alternative. The category of MCEDM is highlighted and the administrators are called ‘‘decision-makers’’. They have a direct influence on the solution anticipated by the technical division [2]. The choice is usually taken with reference to political considerations, discarding completely the solution proposed based on some technical principles and/or criteria [3]. Hence, a system analyst can assist the process of decision-making by carrying out an all-inclusive analysis of the problem [4]. Indeed, a lot of disproportionate data is involved which makes it difficult to accept a solution suggested by a specific technique.

TOPSIS, FCSM and FSAW are among the foremost methods adopted to solve the FMCEDM issues. All these techniques are helpful for experts to formulate difficulties, perform analysis, and suggest the preferred order of alternatives [5]. These techniques are extensively used due to their logicality, rationality, and computational ease. During the past decade, TOPSIS, FCSM and FSAW have been effectively applied to the areas of inter-company comparison, performance evaluation, weapon selection, customer evaluation, personnel selection, machine selection, desired location selection, supplier evaluation, risk management and many others [6,7].

Similarity measures between two fuzzy sets have been under study for several years. The extent of being similar or dissimilar with the alternatives plays an important role in decision-making [8]. In vector space, FCSM is widely used in reference analysis as well as in automatic sorting and information recovery. However, it rarely deals with triangular fuzzy information and FMCEDM problems. With the help of the expected weight and weighted FCSM between each available alternative and the ideal alternative, we can determine the preference order of all alternatives and the best can be easily figured out [9, 10].

FSAW method is known as the simplest and the clearest method. It is often used as a benchmark to compare the results obtained from this method and other FMCEDM methods when applied to the same problem. TOPSIS approaches uniquely and in a very logical way to solve the FMCEDM problem. However, it is computationally more complex as compared to FSAW and Cosine similarity measures. SAW, FCSM and TOPSIS require the quantification of performance attributes for particular alternatives. For these methods, the weights used to express the relative importance of attributes can be determined either analytically or empirically by the decision-maker himself [11, 12].

Since TFNs are instinctive, computationally simple, easy to handle, useful to exemplify and process the data in a fuzzy environment, they can be conveniently applied to solve FMCEDM problems in which the values of criteria and weights are supported by TFNs [13]. In the current study, we developed FCSM1 and FCSM3 techniques and then applied these techniques on the best performing airport [14] and personnel selection [15] problems. The results were then compared with the results of these problems when solved with already developed techniques of FCSM2, FSAW and TOPSIS [16]. Zulqarnain et al. [17] applied interval valued fuzzy soft matrix to solve a decision-making problem. They also made a comparison between fuzzy soft matrix and interval valued fuzzy soft matrix in decision-making [18]. Zulqarnain et al. also developed a new decision-making method using interval valued fuzzy soft matrix [19]. Zulqarnain et al. have used TOPSIS analysis for the prediction of diabetes based on the general characteristics of human beings [20].

Currently, researchers are focused on the development of new theories to solve MCDM problems. Zulqarnain et al. applied interval valued fuzzy soft max-min decision-making method for decision-making in medical diagnosis [21]. Zulqarnain et al. also applied TOPSIS method in the recruitment of medical staff in health department, car selection and the selection of medical clinic for disease diagnosis [22, 23].

Muhammad Saeed et al. developed a new technique known as fuzzy soft relative method [24]. They discovered the maximal set and applied it to FS-set to get a relative set containing relative fuzzy approximation functions values. FS-relative operator was generated and the values were applied to the maximal set by FS-relative operator to get a single relative fuzzy set. The method was applied to find the optimum solution for selecting the best teacher in a high school based on teacher specific characteristics. Dayan F. and Zulqarnain M. applied generalized fuzzy soft sets and generalized fuzzy soft matrices in decision-making [25, 26].

2. Preliminaries

2.1. Definition

Let S be a universal set. The fuzzy set A of S is a function that maps every element of A to a closed interval [0, 1].

2.2. Definition

A triangular fuzzy number (TFN) is a fuzzy number with a piecewise linear membership function α_A defined as follows:

$$\alpha_A = \begin{cases} \frac{a-e_1}{e_2-e_1}, e_1 \leq a \leq e_2 \\ \frac{e_3-a}{e_3-e_2}, e_2 \leq a \leq e_3 \\ 0, otherwise. \end{cases}$$

This can be denoted as triplet (e_1, e_2, e_3) .

3. Cosine Similarity Measures

3.1. CSM Method 1

We developed a method of CSM between TFNs for FMCGDM problem with fuzzy weights. This method for trapezoidal numbers was proposed by Jun Ye [27]; however, we developed it for TFNs and applied it on the best airport performance problem and personnel selection problem to compare our outcomes.

Let $A = \{A_1, A_2, \ldots, A_s\}$ and $C = \{C_1, C_2, \ldots, C_t\}$ be the sets of criteria and alternatives, respectively. The preference value of C_j ($j = 1, 2, \ldots, t$), a criterion on A_i ($i = 1, 2, \ldots, s$), an alternative is a TFN $a_{ij} = (e_{ij1}, e_{ij2}, e_{ij3})$, where $i = 1, 2, \ldots, t$, $j = 1, 2, \ldots, s$, $e_{ij1}, e_{ij2}, e_{ij3} \in R$ and $e_{ij1} \leq e_{ij2} \leq e_{ij3}$, which shows the extent to which A_i fulfills C_j by the expert decision according to previously assessed criteria.

The normalization of criteria values is achieved to eliminate the disparity between data values. This normalization is achieved by using expected value operator in order to obtain decision matrix $A = (e_{ij})_{mxn}$.. Moreover, the fuzzy weight vector is also normalized.

The criteria can be of two types. It can be a profit criterion and a cost criterion respectively in the FMCGDM problem.

(1) For Benefit Criterion
$$f_{ij} = \frac{s_{ij}}{\sqrt{\sum_{i=1}^{m} (E(s_{ij}))^2}}$$

(2) For Cost Criterion
$$f_{ij} = \frac{m_j - s_{ij}}{\sqrt{\sum_{i=1}^{m} (E(m_j - s_{ij}))^2}}$$

This will give us normalized decision matrix. Now, the weight vector $w = (w_1, w_2, \ldots, w_n)$ is obtained as follows:

$$w_j = \frac{E(w_j)}{\sum_{j=1}^{n} E(w_j)}$$

which satisfies the conditions

$$w_j \geq 0, and \sum\nolimits_{j=1}^{n} w_j = 1$$

Next, we define an ideal TFN "I" as f_j* = (1, 1, 1) and

$$C(I, A_i) = \sum_{j=1}^{n} w_j \frac{\sum_{m=1}^{3} f_{jm}^{*} f_{ijm}}{\sqrt{\sum_{m=1}^{3} (f_{jm}^{*})^2} \sqrt{\sum_{m=1}^{3} (f_{ijm})^2}}$$

3.2. CSM Method 2

Let $C = \{C_1, C_2, ..., C_n\}$ and $A = \{A_1, A_2, ..., A_n\}$ be the sets of criteria and alternatives, respectively. Experts are then required to make the decision. Let $E = \{E_1, E_2, ..., E_p\}$ be a set of experts. They will anticipate the linguistic value of TFNs [15]. The alternative vectors given by $E = \{E_1, E_2, ..., E_p\}$ are represented by TFNs. In this method, weights are also assigned to different experts as $\alpha = \{\alpha_1, \alpha_2, \dots, \alpha_p\}$. Expert opinion vector will be calculated as follows:

$$V_i = \{\left\langle C_1, (\sum_{k=1}^{p} \alpha_k a_{i11}^k, \sum_{k=1}^{p} \alpha_k a_{i12}^k, \sum_{k=1}^{p} \alpha_k a_{i13}^k,) \right\rangle, \left\langle C_2, (\sum_{k=1}^{p} \alpha_k a_{i21}^k,, \sum_{k=1}^{p} \alpha_k a_{i22}^k, \sum_{k=1}^{p} \alpha_k a_{i23}^k,) \right\rangle, ...,$$
$$\left\langle C_n, (\sum_{k=1}^{p} \alpha_k a_{in1}^k,, \sum_{k=1}^{p} \alpha_k a_{in2}^k, \sum_{k=1}^{p} \alpha_k a_{in3}^k) \right\rangle\}$$

After obtaining the decision matrix, weights normalization is achieved as described in the above method. We can obtain our results using the Cosine similarity formula.

3.3. CSM Method 3

We developed this method by eliminating the procedure of normalizing the criteria values in Method 1 and using them directly to obtain the Cosine similarity measure between them. All three CSM methods were applied on the best airport performance evaluation and personnel selection problem to compare and analyze the outcomes.

3.4. SAW Methodology

In this method, we determined our decision matrix by converting our linguistic terms matrix decided by experts into TFNs [28]. Then, we determined A_{ij} which comprises the average fuzzy scores, e which comprises de-fuzzified values, and W_i which comprises the normalized weights of each criteria using the following formulae:

$$\alpha_i = (\alpha_{i1} + \alpha_{i2} + \cdots + \alpha_{in}),\ \beta_i = (\beta_{i1} + \beta_{i2} + \cdots + \beta_{in})$$

and

$$\mu_i = (\mu_{i1} + \mu_{i2} + \cdots + \mu_{in})\ ;\ i = 1,\ 2 \ldots m$$

De-fuzzified values $e_i = \frac{1}{3}(\alpha_i + \beta_i + \mu_i);\ i = 1,2,\ldots,n$

Experts allotted suitable ratings in the form of linguistic variables to each attribute $A_k;\ k = 1,\ 2,\ldots,p$ for all the criteria. Then, they calculated the average fuzzy scores and de-fuzzified scores of each alternative against each criterion. Afterwards, a decision matrix for all the criteria and attributes $[X_{ij}]$ was calculated and we normalized the decision matrix using $[R_{ij}] = x_{ij} / max(x_{1j}, x_{2j}, x_{3j,\ldots,}x_{mj})$. We obtained column matrix for each alternative using TS = $[R_{ij}]$ $[W_j]$. The final column matrix will show the preference order of each alternative and the greatest value will preferably be the best one for the selection.

4. Illustrations

In this section, we discuss two FMCGDM problems and apply the above discussed methods and compare our results.

4.1. Airport Selection Problem

Here, we took an illustration based on example [14]. TOPSIS technique was already applied by Wanga and Lee in which three airports A_1, A_2 and A_3 were taken as alternatives by the experts E_1, E_2, E_3 and E_4 in a FTN's for operation performance against 15 criteria, $c_1, c_2, \ldots, c_{15}$.

C_1: profit return

C_2: coziness and neatness of the airport

C_3: passenger's carriage approach

C_4: indicator and guidance

C_5: airfield control

C_6: safety procedures

C_7: reception and check-out time

C_8: airliners' departure and stacking time

C_9: traffic flow connecting city or out-bound

C_{10}: politeness of aircrew

C_{11}: parking area

C_{12}: airport weighbridge

C_{13}: direction finding apparatus
C_{14}: sound pollution control
C_{15}: aircraft security control

Linguistic values of TFNs for weights being used are $Ee = (0,0,0.3), Dd = (0,0.3,0.5), Cc = (0.3,0.5,0.7), Bb = (0.5,0.7,1), Aa = (0.7,1,1)$ and for performance rating we have $R_7 = (0,0,0.2), R_6 = (0,0.2,0.4), R_5 = (0.2,0.4,0.5), R_4 = (0.4,0.5,0.6), R_3 = (0.5,0.6,0.8), R_2 = (0.6,0.8,1), R_1 = (0.8,1,1)$

Table 1. Linguistic Weights Table

Criteria\Experts	E_1	E_2	E_3	E_4
C_1	Cc	Aa	Cc	Bb
C_2	Bb	Bb	Cc	Aa
C_3	Cc	Cc	Bb	Cc
C_4	Dd	Cc	Aa	Cc
C_5	Aa	Aa	Aa	Aa
C_6	Aa	Bb	Aa	Aa
C_7	Bb	Aa	Cc	Bb
C_8	Cc	Bb	Aa	Cc
C_9	Cc	Cc	Bb	Cc
C_{10}	Dd	Cc	Bb	Aa
C_{11}	Aa	Bb	Aa	Cc
C_{12}	Bb	Bb	Cc	Dd
C_{13}	Bb	Cc	Bb	Bb
C_{14}	Cc	Bb	Cc	Bb
C_{15}	Bb	Aa	Bb	Aa

Linguistic weights were evaluated by expert E_j under criterion C_i, where i = 1,2,...,m ; j = 1,2,..., p. These are given in Table 1. Linguistic performance ratings were evaluated by experts and these are given in Table 2. These linguistic terms were then converted into triangular fuzzy numbers given above and then decision matrix was evaluated according to the methods [29, 30].

The best alternative and ranking order of FSAW, CSM2, and CSM3 is the same, whereas CSM1 and TOPSIS have the same best alternative but a different ranking order (Table 3).

Table 2 Linguistic Performance Rating Table

(E_1,E_2,Alternatives E_3,E_4)\Criteria	A_1	A_2	A_3
C_1	(R_3, R_2, R_2, R_1)	(R_1, R_2, R_3, R_3)	(R_3, R_4, R_3, R_4)
C_2	(R_3, R_1, R_2, R_3)	(R_2, R_2, R_1, R_2)	(R_2, R_1, R_2, R_2)
C_3	(R_4, R_4, R_4, R_3)	(R_1, R_2, R_3, R_2)	(R_1, R_1, R_2, R_2)
C_4	(R_1, R_2, R_1, R_1)	(R_4, R_3, R_3, R_3)	(R_3, R_3, R_2, R_3)
C_5	(R_2, R_3, R_4, R_2)	(R_3, R_2, R_4, R_2)	(R_4, R_1, R_2, R_3)
C_6	(R_1, R_2, R_1, R_1)	(R_3, R_1, R_2, R_2)	(R_2, R_4, R_3, R_2)
C_7	(R_4, R_2, R_3, R_2)	(R_2, R_3, R_1, R_3)	(R_1, R_3, R_1, R_2)
C_8	(R_3, R_1, R_3, R_2)	(R_1, R_4, R_1, R_2)	(R_2, R_2, R_1, R_3)
C_9	(R_1, R_2, R_2, R_1)	(R_3, R_2, R_2, R_1)	(R_1, R_2, R_1, R_1)
C_{10}	(R_2, R_2, R_2, R_4)	(R_2, R_3, R_2, R_2)	(R_2, R_1, R_2, R_3)
C_{11}	(R_3, R_1, R_3, R_3)	(R_1, R_3, R_2, R_3)	(R_1, R_3, R_2, R_2)
C_{12}	(R_2, R_1, R_2, R_3)	(R_1, R_2, R_1, R_2)	(R_2, R_2, R_1, R_3)
C_{13}	(R_4, R_3, R_3, R_2)	(R_4, R_3, R_4, R_3)	(R_2, R_2, R_1, R_1)
C_{14}	(R_1, R_3, R_3, R_1)	(R_3, R_3, R_2, R_1)	(R_4, R_3, R_2, R_3)
C_{15}	(R_2, R_1, R_4, R_2)	(R_3, R_4, R_1, R_2)	(R_4, R_4, R_4, R_4)

4.2. Personnel Selection Problem

Here is another illustration of the personnel selection problem [15]. In this problem, a company selects a person using five experts as decision-makers and four persons as alternatives under the five criteria of educational experience, work experience, emotional steadiness, oral communication skills, and personality and self-confidence. All these criteria were used to express opinions in linguistic variables and then converted into TFNs. FSAW and FCSM1 were then applied to compare results with an example already solved by FCSM2 [9].

All the above methods gave the same best alternative and ranking orders. Therefore, these techniques were found to be highly effective in the personnel selection problem (Table 4).

Table 3. The Results of the above Described Techniques on this Illustration

Alternatives\ Techniques	FSAW	FCSM2	FCSM3	FCSM1	TOPSIS
A_1	0.916102	0.986476	0.986578	0.837652	0
A_2	0.895492	0.985448	0.985587	0.854223	1
A_3	0.909839	0.986202	0.986422	0.819746	0.7502
Ranking Order	A1>A3>A2	A1>A3>A2	A1>A3>A2	A2>A1>A3	A2>A3>A1

Table 4. Techniques' Results of Alternatives

Alternatives \ Techniques	FSAW	FCSM2	FCSM3	FCSM1
A1	0.844402	0.9974	0.98669	0.622699
A2	0.882324	0.9988	0.98509	0.618171
A3	0.66693	0.9918	0.975248	0.611144
A4	0.77901	0.9964	0.982469	0.618525
Ranking Order	A1>A2>A4>A3	A1≈A2>A4>A3	A1>A2>A4>A3	A1>A2>A4>A3

5. Conclusion

The comparative application of these methods on the problems of the best airport selection on performance basis and personnel selection gave almost the same results and ranking orders. TOPSIS and FCSM1 use vector normalization, whereas FSAW involves linear normalization. It indicates that our problems don't depend on the normalization process. However, FSAW and FCSM2 both involve simple computation as compared to TOPSIS and FCSM1. It also gives us an idea that which alternatives may be the best options under the same criterion. These methods worked better in the personnel selection problem as compared to the best airport selection problem. Variance in results and ranking orders indicates that selecting an appropriate method is necessary for producing an acceptable solution.

References

[1] Abdullah L, Adawiyah CR. Simple additive weighting methods of multi criteria decision making and applications: A decade review. *Int J Info Proc Manag*. 2014 Feb 1;5(1):39.

[2] Hwang CL, Yoon K. Multiple attribute decision making: a state of the art survey. *Lecture Notes in Eco Math Syst*. 1981;186(1):1-15.

[3] Bellman RE, Zadeh LA. Decision-making in a fuzzy environment. *Manag Sci*. 1970 Dec;17(4):B-141. https://doi.org/10.1287/mnsc.17.4.B141

[4] Manokaran E, Subhashini S, Senthilvel S, Muruganandham R, Ravichandran K. Application of multi criteria decision making tools and validation with optimization technique-case study using TOPSIS, ANN & SAW. *Int J Manag & Business Studies*. 2011 Sep;1(3):112-5.

[5] Opricovic S, Tzeng GH. Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS. *Eur J Oper Res*. 2004 Jul 16;156(2):445-55. https://doi.org/10.1016/S0377-2217(03)00020-1

[6] Jiang J, Chen YW, Tang DW, Chen YW. TOPSIS with belief structure for group belief multiple criteria decision making. *Int J Auto Comp*. 2010 Aug 1;7(3):359-64.

[7] Ling Z. (2006). Expected Value Method for Fuzzy Multiple Attribute Decision Making. *Tsinghua Sci Technol*. 11(1):102-106. 10.1016/S1007-0214(06)70161-4

[8] Beg I, Ashraf S. Similarity measures for fuzzy sets. *Appl Comput. Math*. 2009 Mar 1;8(2):192-202. https://www.researchgate.net/profile/Ismat_Beg/publication/228744370_Similarity_measures_for_fuzzy_sets/links/5835651208aef19cb8224581/Similarity-measures-for-fuzzy-sets.pdf

[9] Deni W, Sudana O, Sasmita A. Analysis and implementation fuzzy multi-attribute decision making SAW method for selection of high achieving students in faculty level. Int J Comp Sci Issues. 2013;10(1):674. https://search.proquest.com/openview/c94386bca63c77f1311000dbefa853ae/1?cbl=55228&pq-origsite=gscholar

[10] Sagar MK, Jayaswal P, Kushwah K. Exploring fuzzy SAW method for maintenance strategy selection problem of material handling equipment. *Int J Current Eng Technol*. 2013 Jun;3(2):600-5.

[11] Biswas P, Pramanik S, Giri BC. Cosine similarity measure based multi-attribute decision-making with trapezoidal fuzzy neutrosophic numbers. *Neutrosophic Sets and Systems*. 2015 Apr 1;8:46-56.

[12] Keeney RL, Raiffa H, Rajala DW. Decisions with multiple objectives: Preferences and value trade-offs. *IEEE Trans Cybern*. 1979 Jul;9(7):403-. https://ieeexplore.ieee.org/document/4310245

[13] Podvezko V. The comparative analysis of MCDA methods SAW and COPRAS. *Eng Eco*. 2011 Apr 7;22(2):134-46. https://journals.umt.edu.pk/index.php/SIR/Guidelines-for-Authors

[14] Feng CM, Wang RT. Performance evaluation for airlines including the consideration of financial ratios. *J Air Trans Manag*. 2000 Jul 1;6(3):133-42. https://doi.org/10.1016/S0969-6997(00)00003-X

[15] Zhang L, Xu X, Tao L. Some similarity measures for triangular fuzzy number and their applications in multiple criteria group decision-making. *J App Math*. 2013 Jan 1;2013. https://doi.org/10.1155/2013/538261

[16] Thor J, Ding SH, Kamaruddin S. Comparison of multi criteria decision making methods from the maintenance alternative selection perspective. *Int J Eng Sci*. 2013 Jul;2(6):27-34.

[17] Saeed M. An Application of Interval Valued Fuzzy Soft Matrix (Ivfsm) In Decision Making. *Sci Int*. 2016 Jun 30;28(3):2261-.

[18] Zulqarnain M. *Comparative study of fuzzy soft matrix (FSM) and interval valued fuzzy soft matrix (IVFSM) in Decision making* (Doctoral dissertation, University of Management and Technology Lahore).

[19] Zulqarnain M, Saeed M. A new decision making method on interval valued fuzzy soft matrix (IVFSM). *J Advances in Math Comp Sci*. 2017 Feb 25:1-7.

[20] Zulqarnain M, Dayan F, Saeed M. TOPSIS analysis for the prediction of diabetes based on general characteristics of humans. *Int J Pharm Sci Res.* 2018 Jul 1;9(7):2932-9.

[21] Zulqarnain RM, Xin XL, Saeed M, Ahmed N. Application of Interval Valued Fuzzy Soft Max-Min Decision Making Method in Medical Diagnosis. *Int J Pharma Sci Rev Res*. 2020;62(1):56-60.

[22] Zulqarnain RM, Xin XL, Saeed M, Ahmed N. Recruitment of Medical Staff in Health Department by Using TOPSIS Method. *Int J Pharma Sci Rev Res*. 2020;62(1):1-7.

[23] Zulqarnain M, Dayan F. Selection of best alternative for an automotive company by intuitionistic fuzzy TOPSIS method. *Int J Sci Technol Res*. 2017 Oct;6(10).

[24] Saeed M, Ali U, Ali J, Dayan F. Fuzzy Soft Relative Method and its Application in Decision Making Problem. *Proceedings of the Pakistan Academy of Sciences: A. Physical and Computational Sciences*. 2020 Oct 12;57(1):21-30.

[25] Dayan F, Zulqarnain M, Hassan N. A ranking method for students of different socio economic backgrounds based on generalized fuzzy soft sets. *Int J Sci Res* (IJSR). 2017;6(9):2015-8.

[26] Dayan F, Zulqarnain M. On generalized interval valued fuzzy soft matrices. *Am J Math Comp Modelling*. 2018 Mar 30;3(1):1-9. doi: 10.11648/j.ajmcm.20180301.11

[27] Ye J. Multicriteria decision-making method based on a cosine similarity measure between trapezoidal fuzzy numbers. *Int J Eng, Sci Technol*. 2011;3(1). https://www.ajol.info/index.php/ijest/article/view/67654

[28] Pratiwi D, Lestari JP, Agushita D. Decision Support System to Majoring High School Student Using Simple Additive Weighting Method. *Int J Comp Trends Technol*. 2014 Apr;10(3):153-9.

[29] Wei G, Zhao X, Lin R, Wang H. Generalized triangular fuzzy correlated averaging operator and their application to multiple attribute decision making. *App Math Modelling*. 2012 Jul 1;36(7):2975-82. https://doi.org/10.1016/j.apm.2011.09.062

[30] Xu Z, Shang S, Qian W, Shu W. A method for fuzzy risk analysis based on the new similarity of trapezoidal fuzzy numbers. *Expert Systems with Applications*. 2010 Mar 15;37(3):1920-7. https://doi.org/10.1016/j.eswa.2009.07.015