Research Article

# Selection of Medical Clinic for Disease Diagnosis by Using TOPSIS Method

**Rana Muhammad Zulqarnain[1]*, Sohaib Abdal[1], Bagh Ali[2], Liaqat Ali[3], Fazal Dayan[4], Muhammad Irfan Ahamad[5], Zeeshan Zafar[5]**

[1.] School of Mathematics, Northwest University, Xian, China.

[2.] Department of Applied Mathematics, Northwestern Polytechnical University, Xi'an, China.

[3.] School of Energy and Power, Xi'an Jiaotong University, Xi'an, China.

[4.] Department of Mathematics, University of Management and Technology, Lahore Pakistan.

[5.] Shaanxi Key Laboratory of Earth Surface System and Environmental Carrying Capacity, College of Urban and Environmental Sciences, Northwest University, Xian, China.

***Corresponding author's E-mail:** ranazulqarnain7777@gmail.com

**Received:** 03-01-2020; **Revised:** 18-02-2020; **Accepted:** 25-02-2020.

**ABSTRACT**

In this paper, we debate the order preference by similarity ideal solution (TOPSIS) method and develop a model for the TOPSIS method. The selection of medical clinics is a very significant portion of our life for disease diagnosis. We select the better medical clinic for disease diagnosis in any case of emergency by using the TOPSIS method in the following research by using hypothetical data.

**Keywords:** Multiple Criteria Decision Making (MCDM), TOPSIS, Positive Ideal Solution (PIS), Negative Ideal Solution (NIS).

## INTRODUCTION

Decision Making is the best procedure to choose a superlative alternative from all feasible alternatives. Almost in all other issues, the overall number of criteria because decision making the general alternatives is pervasive. Such criteria normally contrast one another so there might be no way out satisfying all criteria simultaneously. To deal with such problems the decision-makers want to solve the MCDM problem. There are different methods to solve MCDM problems. One of them presented by Hwang and Yoon in a report[1] is known as a TOPSIS in order to solve the MCDM problem with many alternatives. The core concept of this technique is that the chosen alternative should have the smallest geometrical distance from the PIS and the largest geometrical distance from NIS[2].

Nowadays this technique used in different fields of life such as energy[3–7] medicine[2,8–10] engineering and manufacturing systems[11–16] safety and environmental fields[17–22] chemical engineering[5,23,24] and water resources studies[5,19,23,25]. Chen & Hwang extend the idea of the TOPSIS method and presented a new model for TOPSIS[26]. Moreover to solve uncertain data Chen extended the TOPSIS for Group Decision Making in the fuzzy atmosphere[27] and used the newly proposed method for decision making. The importance weights of multi-criteria and alternative rating w.r.t. these criteria were treated as linguistic variables, evaluated by a group of decision-makers. To facilitate the decision making in a fuzzy environment many researchers extended the TOPSIS technique reported in literature[3,4,18,19,25,28–34,6,8,11–15,17]. The author's developed the idea of generalized interval valued fuzzy soft matrices (IVFSM) in a report[35]. The usage of interval numbers is too a significant enhancement of [36–38] and trapezoidal fuzzy numbers are used for disease identification in[39]. The extension of TOPSIS under fuzzy data has been used to express the prospect of achievement for pancreatic transplantation[8]. A decision-making method on IVFSM introduced in[40] and the authors provided the application of IVFSM[41] and comparative study with a fuzzy soft matrix in[42].

Mahmood zadeh et al. developed a technique for the project selection by combining fuzzy AHP and TOPSIS methods and used the upgraded technique to calculate the weights of each criterion at first and then the TOPSIS algorithm was engaged for ranking the projects to be selected[43]. The authors faced some difficulties to determine the accurate value of the elements of the decision matrix, such as their values were considered as intervals, to overcome these difficulties they extended the TOPSIS method with interval data in[36]. Several approaches have been established for MCDM problems, in[44] the authors provided a proper guideline of how and which method could be used for MCDM problems according to the situation.

In[45], the authors extended the TOPSIS to Atanassov intuitionistic fuzzy set and proposed the algorithm of extended TOPSIS for multi-attribute group decision-making problem. The idea of multiple attribute intuitionistic fuzzy group decision-making algorithm was introduced in[45]. Many researchers worked on the TOPSIS method and used in medical diagnosis and for decision making in different fields of life reported in literature[46–49].

Firstly, in this paper, we study and discuss some basic concepts of the TOPSIS method. Secondly, the graphical model is proposed in this research. Nowadays the selection of better hospitals (medical clinics) for the treatment of any disease is very necessary. In the following work, we choose the better hospital (medical clinic) for disease diagnosis by using the TOPSIS method.

**The Efficiency of Topsis** [50]

First, it is important to discuss the efficiency of the TOPSIS method. The calculation time of the TOPSIS method rises slightly when the number of criteria increases to 16. However, the point to be noted is that the time does not exceed 10 seconds as follows in the Figure 1.

The TOPSIS is examined by changing the number of criteria and users, and it was determined that the efficiency is high when the number of users is under 320 and the number of criteria is not more than 16.

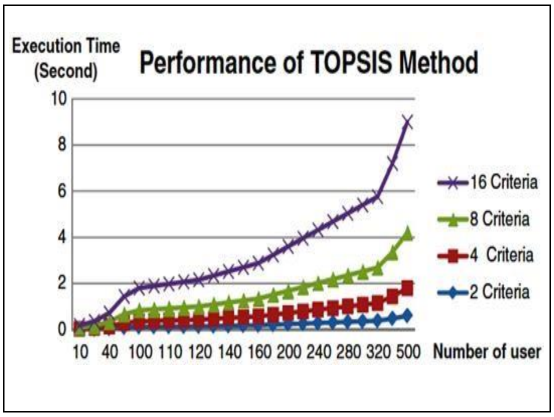


**Figure 1:** Relation between time and the number of criteria

**TOPSIS Method**

Hwang and Yoon[1]developed a technique to resolve MCDM known as the TOPSIS method. To support the shortest Euclidean distance, they proposed the PIS and NIS and each criterion needs to be maximized or minimized. They claimed that the TOPSIS method is helpful for ranking alternatives closeness which based on optimum ideal solution and obtained the maximum level from available alternatives. The best alternative has rank one and the worst alternative approaches rank zero. For every alternative, there is an intermediate ranking between the best answer extremes. An identical set of choice criteria permits correct weighting of relative disease and therefore the optimum disease is alarming which needs attention. Here are presented the steps for the TOPSIS technique. TOPSIS views an MCDM problem with m-alternatives as a geometric system with m points in the n-dimensional space [51].The core concept of this technique is that the chosen alternative should have the smallest geometrical distance from the PIS and the largest geometrical distance from the NIS[52]. In order to apply TOPSIS [53], a common assumption is that criteria should be either monotonically increasing or decreasing so that PIS and NIS can be easily identified.

**Classical Topsis Algorithm**

**Step 1: Establishment of DM**

Construct the decision matrix as follows

$$DM = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_p \end{array} \begin{array}{c} \begin{array}{cccc} R_1 & R_2 & \cdots & R_q \end{array} \\ \begin{bmatrix} c_{11} & c_{12} & \cdots & c_{1q} \\ c_{21} & c_{22} & \cdots & c_{2q} \\ \vdots & \vdots & \ddots & \vdots \\ c_{p1} & c_{p2} & \cdots & c_{pq} \end{bmatrix} \end{array}$$

Where $l$ is the alternative index ($l = 1, 2, ..., q$); $n$ is the number of potential sites and $m$ is the criteria index ($m = 1, 2, ..., p$).

The elements $R_1, R_2, ..., R_q$ of the DM define the criteria while $A_1, A_2, \ldots, A_p$ defining the alternatives.

**Step 2: Calculation of the Normalized Decision Matrix (NDM)**

To represent the relative performance of the alternatives the NDM constructed as follows.

$$NDM = L_{lm} = \frac{c_{lm}}{\sqrt{\sum_{l=1}^{q} c_{lm}^2}}$$

**Step 3: Determination of the Weighted Normalized Decision Matrix (WNDM)**

By multiplying every element of each column of NDM got a weighted decision matrix.

$$V = V_{lm} = W_m \times L_{lm}$$

**Step 4: Identification of the PIS and NIS**

The PIS ($I^+$) and the NIS ($I^-$) are defined with respect to the weighted decision matrix as follows

$$\text{NIS} = I^- = \{V_1^-, V_2^-, \ldots, V_q^-\}, \text{ where:}$$

$$V_m^- = \{(\text{mini}(V_{lm}) \text{ if } m \in J); (\text{maxi } V_{lm} \text{ if } m \in J')\}$$

Where $J'$ is associated with the non-beneficial attributes and

$J$ is associated with beneficial attributes.

**Step 5: Separation Distance from PIS and**

**NIS of each alternative**

$$S_l^+ = \sqrt{\sum_{m=1}^{p} (V_m^+ - V_{lm})^2} \; ; l = 1, 2, \ldots, q$$

$$S_l^- = \sqrt{\sum_{m=1}^{p} (V_m^- - V_{lm})^2} \; ; l = 1, 2, \ldots, q$$

Where, $l$ = Alternative index,

$m$ = Criteria index.

**Step 6: Relative Closeness to the Ideal Solution.**

The relative closeness of the ideal solution is computed as

$$C_l = \frac{S_l^-}{(S_l^+ + S_l^-)}\ ,\ 0 \le C_l \le 1$$

**Step 7: Ranking of Preference Order**

Ranking is done based on the values of $C_l$ the higher value of the relative closeness has a high rank and hence the better performance of the alternative. Rank the preference in descending order to compare the better performances of alternative.

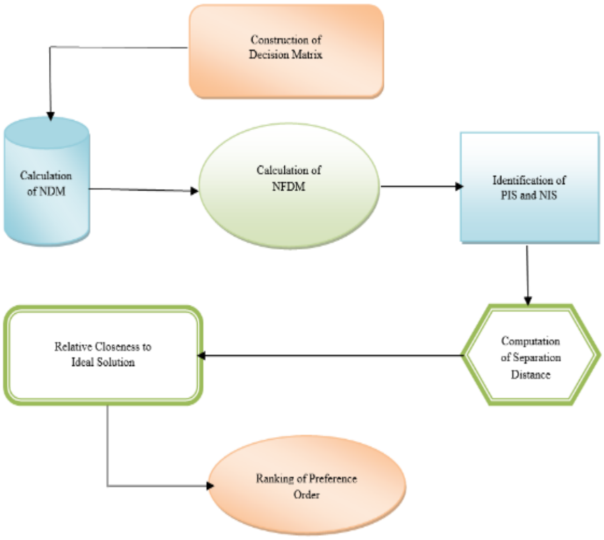


**Figure 2:** Graphical Model for TOPSIS

**Application of TOPSIS Method**

The government of any country wants to choose the better hospital (medical clinic) for renowned personalities. For the selection of best medical clinic government hires a team of three experts (decision-makers) such as (l = 3) represented by D = $D_1$, $D_2$, $D_3$}. Firstly, the experts select four best hospitals from the capital of the country as follows H = {$H_1$, $H_2$, $H_3$, $H_4$} and decide the four evaluation criteria represented by C = {Security, Environment, Qualified staff, Expenses} for selection of one of the best hospital out of four.

$$C = \begin{cases} \text{benefit criteria} \\ \text{Cost criteria} \end{cases}$$

$$J_1 = \begin{cases} X_1: \text{ Security} \\ X_2: \text{Environment} \\ X_3: \text{Qualified staff} \end{cases} \quad J_2 = \{X_4 : \text{Expense}$$

**Solution by TOPSIS**

TOPSIS method will be illustrated with the help of a hospital selection for well-known personalities of any country at the government level. The set of alternatives is H = {$H_1$, $H_2$, $H_3$, $H_4$} and the set of evaluation criteria is C = {Security (Sec), Environment (Env), Qualified staff (Quf), Expenses (Exp)

**Step 1: Construction of a Decision Matrix**

The decision matrix is given in the following table.

**Table 1:** Decision Matrix D = $[x_{ij}]_{m \times n}$

| H | Sec | Env | Qus | Exp |
|---|---|---|---|---|
| $H_1$ | 7 | 9 | 9 | 8 |
| $H_2$ | 8 | 7 | 8 | 7 |
| $H_3$ | 9 | 6 | 8 | 9 |
| $H_4$ | 6 | 7 | 8 | 6 |

**Step 2: Normalization**

By using the following formula, we get

**Table 2:** Calculating $\sqrt{\sum_{i=1}^{m} x_{ij}^2}$

| H | Sec | Env | Qus | Exp |
|---|---|---|---|---|
| $H_1$ | 49 | 81 | 81 | 64 |
| $H_2$ | 64 | 49 | 64 | 49 |
| $H_3$ | 81 | 36 | 64 | 81 |
| $H_4$ | 36 | 49 | 64 | 36 |
| $\sum_{i=1}^{m} x_{ij}^2$ | 230 | 215 | 273 | 230 |
| $\sqrt{\sum_{i=1}^{m} x_{ij}^2}$ | 15.17 | 14.66 | 16.52 | 15.17 |

To normalize the decision matrix dividing each entry by $\sqrt{\sum_{i=1}^{m} x_{ij}^2}$

**Table 3:** Normalized Decision Matrix R = $[r_{ij}]_{m \times n}$

| | Sec | Env | Qus | Exp |
|---|---|---|---|---|
| $H_1$ | 0.46 | 0.61 | 0.54 | 0.53 |
| $H_2$ | 0.53 | 0.48 | 0.48 | 0.46 |
| $H_3$ | 0.59 | 0.41 | 0.48 | 0.59 |
| $H_4$ | 0.40 | 0.48 | 0.48 | 0.40 |

**Step 3: Computation of the weight matrix**

The weights assigned by the experts (decision makers) to the criteria are given by the matrix

W = [$w_1$ (Security) = 0.1, $w_2$ (Environment) = 0.4, $w_3$ (Qualified staff) = 0.3, $w_4$ (Expenses) = 0.2]$^{Transpose}$

**Step 4: Computation of WNDM Ŕ = $[r'_{ij}]_{m \times n}$**

To get WNDM, multiplying each column of NDM in Table 3 by weights $w_j$, of weight vector computed in the step 3.

**Table 4:** Weighted Normalized Decision Matrix $\acute{R} = [r_{ij}']_{m\times n}$

| Weights $w_j$ | 0.1 | 0.4 | 0.3 | 0.2 |
|---|---|---|---|---|
| H | Sec | Env | Qus | Exp |
| $H_1$ | 0.046 | 0.244 | 0.162 | 0.106 |
| $H_2$ | 0.053 | 0.192 | 0.144 | 0.092 |
| $H_3$ | 0.059 | 0.164 | 0.144 | 0.118 |
| $H_4$ | 0.040 | 0.192 | 0.144 | 0.080 |

**Step 5: The calculation of PIS and NIS**

To find the PIS H*

**Table 5:** Positive Ideal Solution

| | Benefit Criteria ∈J⁺ | | | Cost Criteria∈J⁻ |
|---|---|---|---|---|
| H | Sec | Env | Qus | Exp |
| $H_1$ | 0.046 | $0.244=v_2^*$ | $0.162=v_3^*$ | 0.106 |
| $H_2$ | 0.053 | 0.192 | 0.144 | 0.092 |
| $H_3$ | $0.059=v_1^*$ | 0.164 | 0.144 | $0.118=v_4^*$ |
| $H_4$ | 0.040 | 0.192 | 0.144 | 0.080 |

Therefore H* = {0.059, 0.244, 0.162, 0.080}

To find the NIS $H^-$

**Table 6:** Negative Ideal Solution

| | Benefit Criteria ∈J⁺ | | | Cost Criteria∈J⁻ |
|---|---|---|---|---|
| H | Sec | Env | Qus | Exp |
| $H_1$ | 0.046 | 0.244 | 0.162 | 0.106 |
| $H_2$ | 0.053 | 0.192 | 0.144 | 0.092 |
| $H_3$ | 0.059 | $0.164 = v_2'$ | $0.144=v_3'$ | 0.118 |
| $H_4$ | $0.040=v_1'$ | 0.192 | 0.144 | $0.080=v_4^*$ |

Therefore $H^-$ ={0.040,0.164,0.144,0.118}

**Step 6: Determine the separation measures for each alternative**

Calculating separation from PIS H*

**Table 7:** Calculation of $S_i^*$

| | Sec | Env | Qus | Exp | $\sum_{j=1}^{n}(v_j^* - v_{ij})^2$ | $S_i$* |
|---|---|---|---|---|---|---|
| $H_1$ | $(0.046\text{-}0.059)^2$ | $(0.244\text{-}0.244)^2$ | $(0)^2$ | $(0.026)^2$ | 0.000845 | 0.029 |
| $H_2$ | $(0.053\text{-}0.059)^2$ | $(0.192\text{-}0.244)^2$ | $(-0.018)^2$ | $(0.012)^2$ | 0.003208 | 0.057 |
| $H_3$ | $(0.053\text{-}0.059)^2$ | $(0.164\text{-}0.244)^2$ | $(-0.018)^2$ | $(0.038)^2$ | 0.008186 | 0.090 |
| $H_4$ | $(0.053\text{-}0.059)^2$ | $(0.192\text{-}0.044)^2$ | $(-0.018)^2$ | $(0)^2$ | 0.003389 | 0.058 |

Calculating separation from NIS A⁻

**Table 8:** Calculation of $S_i'$

| | Sec | Env | Qus | Exp | $\sum_{j=1}^{n}(v_j^* - v_{ij})^2$ | $S_i'$ |
|---|---|---|---|---|---|---|
| $H_1$ | $(0.046\text{-}0.040)^2$ | $(0.244\text{-}0.164)^2$ | $(0.018)^2$ | $(-0.012)^2$ | 0.006904 | 0.083 |
| $H_2$ | $(0.053\text{-}0.040)^2$ | $(0.192\text{-}0.164)^2$ | $(0)^2$ | $(-0.026)^2$ | 0.001629 | 0.040 |
| $H_3$ | $(0.053\text{-}0.040)^2$ | $(0.164\text{-}0.164)^2$ | $(0)^2$ | $(0)^2$ | 0.000361 | 0.019 |
| $H_4$ | $(0.053\text{-}0.040)^2$ | $(0.192\text{-}0.164)^2$ | $(0)^2$ | $(-0.038)^2$ | 0.002228 | 0.047 |

**Step 7:** Computation of RCC to the ideal solution $C_i^*$

RCC to the ideal solution $C_i^*$ is computed as follows

$C_1^* = \frac{S_i'}{S_i' + S_i^*} = \frac{0.083}{0.112} = 0.74$ (Best)

Similarly we can get

$C_2^* = 0.41$

$C_3^* = 0.17$

$C_4^* = 0.45$

Hence, "$H_1$" is the best medical clinic for disease diagnosis with the above evaluation criteria.

## CONCLUSION

The selection of the hospital in any case of emergency is very necessary for disease diagnosis. In this paper, we discuss the TOPSIS method in detail and constructed a graphical model for the TOPSIS method. Finally, we choose the best hospital for disease diagnosis in any case of emergency by using hypothetical data.

## REFERENCES


1. Yoon CH and K. *Multiple Attribute Decision Making: Methods and Applications, A State of the Art Survey 1*. Berlin Heidelberg Springer, 1981.

2. Bi Y, Lai D, Yan H. Synthetic evaluation of the effect of health promotion : Impact of a UNICEF project in 40 poor western counties of China. *R Soc Public Heal*. 124, 2010, 376-391. doi:10.1016/j.puhe.2010.03.015

3. Chamodrakas I, Martakos D. A utility-based fuzzy TOPSIS method for energy efficient network selection in heterogeneous wireless networks. *Appl Soft Comput J*. 11(4), 2011, 3734-3743. doi:10.1016/j.asoc.2011.02.003

4. Zulqarnain R. M, Dayan F, Ali B, Abdal S, Saqlain M, Ahamad M. I,Zeeshan Z. Generalized Fuzzy TOPSIS to Solve Multi-Criteria Decision-Making Problems. *Submitt to J New Theory*.

5. Behzadian M, Khanmohammadi Otaghsara S, Yazdani M, Ignatius J. A state-of the-art survey of TOPSIS applications. *Expert Syst Appl*. 39(17), 2012, 13051-13069. doi:10.1016/j.eswa.2012.05.056

6. 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*. 6(9), 2017, 691-694. doi:10.21275/ART20176512

7. Yang L, Deuse J. Multiple-attribute decision-making approach for an energy-efficient facility layout design. *Publ by Elsevier BV*. 3, 2012, 149-154. doi:10.1007/s00170-012-4367-x

8. La G, Aiello G, Rastellini C, Micale R, Cicalese L. Multi-Criteria Decision Making support system for pancreatic islet transplantation. *Expert Syst Appl*. 38(4),2011, 3091-3097. doi:10.1016/j.eswa.2010.08.101

9. Chen T. A signed-distance-based approach to importance assessment and multi-criteria group decision analysis based on interval type-2 fuzzy set. *Knowl Inf Syst*. 35, 2013, 193-231. doi:10.1007/s10115-012-0497-6

10. Kuo R, Wu Y, Hsu T. Integration of fuzzy set theory and TOPSIS into HFMEA to improve outpatient service for elderly patients in Taiwan. *J Chinese Med Assoc*. 75, 2012, 341-348. doi:10.1016/j.jcma.2012.05.001

11. Im K, Cho H. A systematic approach for developing a new business model using morphological analysis and integrated fuzzy approach. *Expert Syst Appl*. 40(11), 2013, 4463-4477. doi:10.1016/j.eswa.2013.01.042

12. Khalili-damghani K, Sadi-nezhad S, Tavana M. Solving multi-period project selection problems with fuzzy goal programming based on TOPSIS and a fuzzy preference relation. *Inf Sci (Ny)*. 1, 2013. doi:10.1016/j.ins.2013.05.005

13. Nakhaeinejad M, Nahavandi N. An interactive algorithm for multi-objective flow shop scheduling with fuzzy processing time through resolution method and TOPSIS. *Int J Adv Manuf Technol*. July, 2012. doi:10.1007/s00170-012-4388-5

14. Hosseini H, Milani AS. An improvement of quantitative strategic planning matrix using multiple criteria decision making and fuzzy numbers. *Appl Soft Comput J*. 12(8), 2012, 2246-2253. doi:10.1016/j.asoc.2012.03.010

15. Taleizadeh A, Taghi S, Niaki A. A hybrid method of Pareto, TOPSIS and genetic algorithm to optimize multi- product multi-constraint inventory control systems with random fuzzy replenishments A Hybrid Method of Pareto, TOPSIS and Genetic Algorithm to Optimize Multi-Product Multi-Constr. *Math Comput Model*. 2009. doi:10.1016/j.mcm.2008.10.013

16. Lee-Ing Tong · Chung-Ho Wang · Hung-Cheng Chen. Optimization of multiple responses using principal component analysis and. *Int J Adv Manuf Techno*. 27, 2005, 407-414. doi:10.1007/s00170-004-2157-9

17. Krohling RA, Campanharo VC. Fuzzy TOPSIS for group decision making: A case study for accidents with oil spill in the sea. *Expert Syst Appl*. 38(4), 2011, 4190-4197. doi:10.1016/j.eswa.2010.09.081

18. Wang X, Chan HK. A hierarchical fuzzy TOPSIS approach to assess improvement areas when implementing green supply chain initiatives. *Int J Prod Res*. 51(10), 2013, 3117-3130. doi:10.1080/00207543.2012.754553

19. Kim Y, Chung ES, Jun SM, Kim SU. Prioritizing the best sites for treated wastewater instream use in an urban watershed using fuzzy TOPSIS. *Resour Conserv Recycl*. 73, 2013, 23-32. doi:10.1016/j.resconrec.2012.12.009

20. Li P, Qian H, Wu J, Chen J. Sensitivity analysis of TOPSIS method in water quality assessment: I. Sensitivity to the parameter weights. *Environ Monit Assess*. 185(3), 2013, 2453-2461. doi:10.1007/s10661-012-2723-9

21. Awasthi A, Chauhan SS, Goyal SK. A multi-criteria decision making approach for location planning for urban distribution centers under uncertainty. *Math Comput Model*. 53(1-2), 2011, 98-109. doi:10.1016/j.mcm.2010.07.023

22. Ostad-Ahmad-Ghorabi MJ, Attari M. Advancing environmental evaluation in cement industry in Iran. *J Clean Prod*. 41, 2013, 23-30. doi:10.1016/j.jclepro.2012.10.002

23. Li P, Wu J, Qian H. Groundwater quality assessment based on rough sets attribute reduction and TOPSIS method in a semi-arid area, China. *Env Monit Assess*. 184(Sep), 2012, 4841-4854. doi:10.1007/s10661-011-2306-1

24. Sun Y, Liang Z, Shan C, Viernstein H, Unger F. Comprehensive evaluation of natural antioxidants and antioxidant potentials in Ziziphus jujuba Mill . var . spinosa ( Bunge ) Hu ex H . F . Chou fruits based on geographical origin by TOPSIS method. *Food Chem*. 124(4), 2011, 1612-1619. doi:10.1016/j.foodchem.2010.08.026

25. Yong D. Plant location selection based on fuzzy TOPSIS. *Int J Adv Manuf Technol*. 28(Aug), 2006, 839-844. doi:10.1007/s00170-004-2436-5

26. Hwang SJJC and CL. *Chapter 5 Fuzzy Multiple Attribute Decision Making Methods.* Springer-Verlag Berlin Heidelberg, 1992.

27. Chen CT. Extensions of the TOPSIS for group decision-making under fuzzy environment. *Fuzzy Sets Syst*. 114(1), 2000, 1-9. doi:10.1016/S0165-0114(97)00377-1

28. Anisseh M, Piri F, Reza M. Fuzzy extension of TOPSIS model for group decision. *Artif Intell Rev*. 38, 2012, 325-

338. doi:10.1007/s10462-011-9258-2

29. Dymova L, Sevastjanov P, Tikhonenko A. An approach to generalization of fuzzy TOPSIS method. *Inf Sci (Ny)*. 238, February, 2013; 149-162. doi:10.1016/j.ins.2013.02.049

30. Rouhani S, Ghazanfari M, Jafari M. Evaluation model of business intelligence for enterprise systems using fuzzy TOPSIS. *Expert Syst Appl*. 39(3), 2012, 3764-3771. doi:10.1016/j.eswa.2011.09.074

31. Zulqarnain M, Dayan F. Choose Best Criteria for Decision Making Via Fuzzy Topsis Method. *Math Comput Sci*. 2(6), 2017, 113. doi:10.11648/j.mcs.20170206.14

32. Zulqarnain M, Dayan F. Selection Of Best Alternative For An Automotive Company By Intuitionistic Fuzzy TOPSIS Method. *Int J Sci Technol Res*. 6(10), 2017, 126-132.

33. Kaya T, Kahraman C. Multicriteria decision making in energy planning using a modified fuzzy TOPSIS methodology. *Expert Syst Appl*. 38(6), 2011, 6577-6585. doi:10.1016/j.eswa.2010.11.081

34. Cavallaro F. Fuzzy TOPSIS approach for assessing thermal-energy storage in concentrated solar power ( CSP ) systems. *Appl Energy*. 87(2), 2010, 496-503. doi:10.1016/j.apenergy.2009.07.009

35. 35. Dayan F, Zulqarnain M. On Generalized Interval Valued Fuzzy Soft Matrices. *Am J Math ComputModel*. 3(1), 2018, 1-9. doi:10.11648/j.ajmcm.20180301.11

36. Jahanshahloo GR, Lotfi FH, Davoodi AR. Extension of TOPSIS for decision-making problems with interval data : Interval efficiency. *Math Comput Model*. 49(5-6), 2009, 1137-1142. doi:10.1016/j.mcm.2008.07.009

37. Dymova L, Sevastjanov P, Tikhonenko A. A direct interval extension of TOPSIS method. *Expert Syst Appl*. March, 2013. doi:10.1016/j.eswa.2013.02.022

38. Yue Z. An extended TOPSIS for determining weights of decision makers with interval numbers. *Knowledge-Based Syst*. 24(1): 2011, 146-153. doi:10.1016/j.knosys.2010.07.014

39. Zulqarnain R. M, Ali B, Abdal S, Maalik A, Ali L, Ahamad M. I,Zafar Z. Disease identification using trapezoidal fuzzy numbers by Sanchez's approach. *Accepted "International J Pharm Sci Rev Res*.

40. Zulqarnain M, Saeed M. A New Decision Making Method on Interval Valued Fuzzy Soft Matrix (IVFSM). *Br J Math Comput Sci*. 20(5), 2017, 1-17. doi:10.9734/bjmcs/2017/31243

41. Zulqarnain M, Saeed M. An Application of Interval Valued Fuzzy Soft Matrix in Decision Making Problem. *Sci Int*. 28(3), 2016, 2261-2264. doi:10.14445/22315373/ijmtt-v21p503

42. Zulqarnain M, Saeed M, Tbassum MF. COMPARISON BETWEEN FUZZY SOFT MATRIX (FSM) AND INTERVAL VALUED FUZZY SOFT MATRIX (IVFSM) IN DECISION MAKING. *Sci Int*. 28(5), 2016, 4277-4283. https://www.researchgate.net/publication/309667818.

43. S. Mahmoodzadeh, J. Shahrabi, M. Pariazar MSZ. Project selection by using a fuzzy AHP and topsis technique. *World Acad Sci Eng Technol*. 1(6), 2007, 270-275.

44. Velasquez M, Hester PT. An Analysis of Multi-Criteria Decision Making Methods. *Int J Oper Res*. 10(2), 2013, 56-66.

45. Li D. Extension of the TOPSIS for multi-Attribute group Decision making under Atanassov IFS environments. *Int J Fuzzy Syst Appl*. 1(4), 2011, 47-61. doi:10.4018/ijfsa.2011100104

46. Zulqarnain R. M, Abdal S, Maalik A, et al. Application of TOPSIS Method in Decision Making Via Soft Set. *Biomed J Sci Tech Res*. 24(3), 2020, 18208-18215. doi:10.26717/BJSTR.2020.24.004045

47. Sevkli M, Zaim S, Turkyılmaz A, Satır M. An Application of Fuzzy Topsis Method for Supplier Selection. *IEEE Int Conf Fuzzy Syst*. July, 2010. doi:10.1109/FUZZY.2010.5584006

48. Zulqarnain M, Dayan F, Saeed M. TOPSIS Analysis for The Prediction of Diabetes Based on General Characteristics of Humans. *Int J Pharm Sci Res*. 9(7), 2018, 2932. doi:10.13040/IJPSR.0975-8232.9(7).2932-2939

49. Eraslan S. A Decision Making Method via TOPSIS on Soft Sets. *J New Results Sci*. 8, 2015, 57-71.

50. Cheng DY, Chao KM, Lo CC, Tsai CF. *A User Centric Service-Oriented Modeling Approach*. Vol 14, 2011. doi:10.1007/s11280-011-0115-7

51. Fathi MR, Zarei Matin H, Karimi Zarchi M, Azizollahi S. The Application of Fuzzy TOPSIS Approach to Personnel Selection for Padir Company, Iran. *J Manag Res*. 3(2), 2011, 1-14. doi:10.5296/jmr.v3i2.663

52. Triantaphyllou E, Shu B, Sanchez SN, Ray T. Multi-Criteria Decision Making : An Operations Research Approach. *Encycl Electr Electron Eng*. 15(February 1998), 1998, 175-186.

53. Sa W. The mean error estimation of TOPSIS method using a fuzzy reference models. *J Theor Appl Comput Sci*. 7(3), 2013, 40-50.


**Source of Support:** Nil, **Conflict of Interest:** None.