Journal of Universal Mathematics
Vol.7 No.1 pp.56-63 (2024)
ISSN-2618-5660
DOI: 10.33773/jum.1407286

PREDICTION OF STUDENT SUCCESS WITH DECISION-MAKING METHODS

ERHAN ÇETINKAYA, ALI SINAR, AND AHU MERYEM CUVALCIOĞLU

0009-0008-4158-5830, 0009-0009-4273-4639 and 0009-0007-0987-1207

Abstract. Thanks to intuitionistic fuzzy sets, it has provided many benefits in application areas where the degree of precision is also taken into account. Education, one of these application areas, is an area where decision-making mechanisms play a very important role. Predicting student success and guiding the student in the future by taking into account every situation is an important step for decision makers and educators.

1. INTRODUCTION

Researchers who think that binary logic is insufficient in combating uncertainty have tried to find new ways over time. As a result of these efforts, the concept of fuzzy logic emerged [1]. Over time, fuzzy logic has become the basis of much research, and intuitionistic fuzzy logic, an expansion of fuzzy logic that is still up to date, has also introduced the degree of sensitivity [3]. With the degree of sensitivity also in play, the results of many studies have become much more objective. Decision makers made clearer decisions thanks to intuitionistic fuzzy sets, where they could also indicate uncertainty in their decisions. Efficient results have emerged thanks to the combination of decision-making methods with intuitionistic fuzzy sets. Thanks to the PROMETHEE method used in this study, positive and negative results will be evaluated simultaneously and a clear result will be obtained [4, 5, 6, 7, 8, 9, 10, 16, 17, 39, 26, 25]. Nowadays, intuitionistic fuzzy sets and decision-making methods attract the attention of many researchers [12, 14, 15, 21, 22, 23, 24, 27, 28, 29, 30, 31, 32, 33, 37].

2. PRELIMINARIES

Definition 1. *([3, 2])Let $X \neq \emptyset$. An intuitionistic fuzzy set A in X;*

$$A = \{\langle x, \mu_A(x), \nu_A(x)\rangle |\ x \in X\},$$

$$\mu_A(x), \nu_A(x), \pi_A(x) : X \to [0, 1]$$

Date: **Received:** 2023-12-20; **Accepted:** 2024-01-29.
Key words and phrases. Intuitionistic Fuzzy sets, Decision Making.
Mathematics Subject Classification: 03E72.

defined membership, nonmembership and hesitation degree of the element $x \in X$ respectively.

$$\mu_A(x) + \nu_A(x) + \pi_A(x) = 1.$$

Intuitionistic fuzzy value (IFV) defined by Xu ([36]). Intuitionistic fuzzy value (IFV) is shown as follows: $\tilde{a} = (\mu_{\tilde{a}}, \nu_{\tilde{a}}, \pi_{\tilde{a}})$, where $\mu_{\tilde{a}}, \nu_{\tilde{a}}, \pi_{\tilde{a}} \in [0, 1]$
For each IFS $\tilde{A}$;

$$\pi_{\tilde{A}} = 1 - \mu_{\tilde{A}} - \nu_{\tilde{A}} \tag{2.1}$$

For IFVs $\tilde{a} = (\mu_{\tilde{a}}, \nu_{\tilde{a}})$ and $\tilde{b} = (\mu_{\tilde{b}}, \nu_{\tilde{b}})$ the following operations have been carried out([36, 35]):

$$(1) \quad \tilde{a} \oplus \tilde{b} = \quad (\mu_{\tilde{a}} + \mu_{\tilde{b}} - \mu_{\tilde{a}}\mu_{\tilde{b}}, \nu_{\tilde{a}}\nu_{\tilde{b}}) \tag{2.2}$$

$$(2) \quad \tilde{a} \otimes \tilde{b} = \quad (\mu_{\tilde{a}}\mu_{\tilde{b}}, \nu_{\tilde{a}} + \nu_{\tilde{b}} - \nu_{\tilde{a}}\nu_{\tilde{b}}) \tag{2.3}$$

$$(3) \quad \oplus_{j=1}^{m} \tilde{a}_j = \quad (1 - \prod_{j=1}^{m}(1 - \mu_j), \prod_{j=1}^{m} \nu_j) \tag{2.4}$$

$$(4) \quad \otimes_{j=1}^{m} \tilde{a}_j = \quad (\prod_{j=1}^{m} \mu_j, \prod_{j=1}^{m}(1 - \nu_j)) \tag{2.5}$$

This function is used to rank IFVs:

$$\rho(\alpha) = 0.5(1 + \pi_\alpha)(1 - \mu_\alpha)) \tag{2.6}$$

As the $\rho(\alpha)$ value decreases, the preferred value α increases.

3. The Intuitionistic Fuzzy PROMETHEE Method

The criteria's weights could be depicted as IFVs: $\tilde{w}_j$ where $\mu_{\tilde{w}_j} \in [0, 1], \nu_{\tilde{w}_j} \in [0, 1], \mu_{\tilde{w}_j} + \nu_{\tilde{w}_j} \leq 1, j = 1, 2, ..., m$. According to the weights, $\mu_{\tilde{\omega}_j}$ and $\nu_{\tilde{\omega}_j}$ demonstrate the membership and non-membership degrees of the alternative x_i respectively. Some methods can help decision makers in determining intuitionistic fuzzy weights ([18, 19, 34, 38, 11, 13]). In this study, linguistic terms were used to make the evaluation more accurate. Also, V shape criterion type has been used:

$$P(d) = \begin{cases} 0, & d \leq q \\ \frac{d-q}{p-q}, & q < d \leq p \\ 1, & d > p \end{cases} \tag{3.1}$$

Parameter thresholds q and p are indicated as indifference and strict preference, respectively. Evaluate the alternatives $x_i (i = 1, 2, ..., n)$ with respect to the criteria $c_j (j = 1, 2, ..., m)$ and determine the deviations based on pairwise comparisons:

$$d_j(x, y) = c_j(x) - c_j(y) \tag{3.2}$$

where $d_j(x, y)$ shows the distinction between the alternatives' the assessments x and y on the criterion c_j.

Definition 2. *([37]) An intuitionistic fuzzy preference relation R on the set $X = x_1, x_2, ..., x_n$ is represented by a matrix $R = (r_{ik})_{n \times n}$, where $r_{ik} = \langle (x_i, x_k), \mu(x_i, x_k), \nu(x_i, x_k) \rangle$ for all $i, k = 1, 2, ..., n$. For convenience, we let $r_{ik} = (\mu_{ik}, \nu_{ik})$ where μ_{ik} denotes the degree to which the object x_i is preferred to the object x_k, ν_{ik} indicates the degree to which the object x_i is not preferred to the object*

x_k, *and* $\pi(x_i, x_k) = 1 - \mu(x_i, x_k) - \nu(x_i, x_k)$ *is interpreted as an indeterminacy degree or a hesitancy degree, with the condition:*

$$\mu_{ik},\ \nu_{ik} \in [0,1],\ \mu_{ik} + \nu_{ik} \leq 1,\ \mu_{ik} = \nu_{ki},\ \mu_{ki} = \nu_{ik},$$
$$\mu_{ii} = \nu_{ii} = 0.5,\ \pi_{ik} = 1 - \mu_{ik} - \nu_{ik},$$
$$for\ all\ i,k = 1,2,...,n \tag{3.3}$$

The preferences μ_{ik} between the alternatives x_i and x_k according to the criterion c_j could be calculated by Equations (3.2) and (3.1), and then the preference matrix according to the criterion c_j is obtained as follows ([20]):

$$U^{(j)} = (\mu_{ik}^{(j)})_{n\times n} = \begin{bmatrix} - & \mu_{12}^{(j)} & \dots & \mu_{1n}^{(j)} \\ \mu_{21}^{(j)} & - & \dots & \mu_{2n}^{(j)} \\ \vdots & \vdots & - & \vdots \\ \mu_{n1}^{(j)} & \mu_{n2}^{(j)} & \dots & - \end{bmatrix} \tag{3.4}$$

Matrix of the intuitionistic fuzzy preference relation is obtained:

$$R^{(j)} = (r_{ik}^{(j)})_{n\times n} = \begin{bmatrix} - & (\mu_{12}^{(j)}, \nu_{12}^{(j)}) & \dots & (\mu_{1n}^{(j)}, \nu_{1n}^{(j)}) \\ (\mu_{21}^{(j)}, \nu_{21}^{(j)}) & - & \dots & (\mu_{2n}^{(j)}, \nu_{2n}^{(j)}) \\ \vdots & \vdots & - & \vdots \\ (\mu_{n1}^{(j)}, \nu_{n1}^{(j)}) & (\mu_{n2}^{(j)}, \nu_{n2}^{(j)}) & \dots & - \end{bmatrix} \tag{3.5}$$

The IFWA operator is used in this paper. The all intuitionistic fuzzy preference index of the alternative x_i to x_k on all criteria can be derived as:

$$r(x_i, x_k) = r_{ik} = \bigoplus_{j=1}^{m} \left(\tilde{w}_j \bigotimes r_{ik}^{(j)} \right) \tag{3.6}$$

where $r(x_i, x_k) = r_{ik}$ shows the degree to which the alternative x_i is preferred to the alternative x_k all criteria. Also, r_{ik} is an IFV. $\tilde{w}_j = (\mu_{\tilde{w}j}, \nu_{\tilde{w}j})$, then according to Equation (2.2), (2.3):

$$\tilde{w}_j \bigotimes r_{ik}^{(j)} = \left(\mu_{ik}^{(j)} \mu_{\tilde{w}j}, \nu_{ik}^{(j)} + \nu_{\tilde{w}j} - \nu_{ik}^{(j)} \nu_{\tilde{w}j} \right) \tag{3.7}$$

If Equations (2.4),(3.6) and (3.7) are combined;

$$\begin{aligned} r(x_i, x_k) &= \bigoplus_{j=1}^{m} \left(\tilde{w}_j \bigotimes r_{ik}^{(j)} \right) \\ &= \left(1 - \prod_{j=1}^{m} (1 - \mu_{ik}^{(j)} \mu_{\tilde{w}j}), \right. \\ &\quad \left. \prod_{j=1}^{m} (\nu_{ik}^{(j)} + \nu_{\tilde{w}j} - \nu_{ik}^{(j)} \nu_{\tilde{w}j}) \right) \end{aligned} \tag{3.8}$$

Overall intuitionistic fuzzy preference relationship is obtained:

$$R = (r_{ik})_{n\times n} = \begin{bmatrix} - & (\mu_{12}, \nu_{12}) & \dots & (\mu_{1n}, \nu_{1n}) \\ (\mu_{21}, \nu_{21}) & - & \dots & (\mu_{2n}, \nu_{2n}) \\ \vdots & \vdots & - & \vdots \\ (\mu_{n1}, \nu_{n1}) & (\mu_{n2}, \nu_{n2}) & \dots & - \end{bmatrix} \tag{3.9}$$

Every alternative is compared to option $(n-1)$. As a result of intuitionistic fuzzy positive and negative outranking flow are achieved:
(1) The intuitionistic fuzzy positive outranking flow:

$$\tilde{\varphi}^{+}(x_i) = \frac{1}{n-1} \bigoplus_{k=1,k\neq i}^{n} r(x_i, x_k) = \frac{1}{n-1} \bigoplus_{k=1,k\neq i}^{n} r_{ik} \tag{3.10}$$

(2) The intuitionistic fuzzy negative outranking flow:

$$\tilde{\varphi}^{-}(x_i) = \frac{1}{n-1} \bigoplus_{k=1,k\neq i}^{n} r(x_k, x_i) = \frac{1}{n-1} \bigoplus_{k=1,k\neq i}^{n} r_{ki} \tag{3.11}$$

4. Student Success Prediction

A total of 15 students were evaluated based on 9 criteria to estimate student success. The first four of these criteria are Turkish, Mathematics, Science and Social courses, and the others are Anxiety, Attitude Toward Turkish, Attitude Toward Mathematics, Attitude Toward Science, Attitude Toward Social Studies, respectively. Student evaluations were graded with guidance counselors and Table 1 was created. Students were evaluated according to the scales determined by the guidance counselor. The values in Table 1 were determined according to the evaluation results.

The alternatives and criteria that form the basis of our algorithm are as follows: $A = \{A_1, A_2, A_3, A_4, A_5, A_6, A_7, A_8, A_9, A_{10}, A_{11}, A_{12}, A_{13}, A_{14}, A_{15}\}$ being set of alternatives, each alternative represents a student. $K = \{K_1, K_2, K_3, K_4, K_5, K_6, K_7, K_8, K_9\}$ being set of criteria.

The value of each criterion for each alternative is calculated as follows in Table 1:

	$K1$	$K2$	$K3$	$K4$	$K5$	$K6$	$K7$	$K8$	$K9$
$A1$	10	11	9	9	11	5	4	5	7
$A2$	15	13	6	6	9	8	8	9	8
$A3$	11	6	9	8	5	4	7	7	7
$A4$	16	11	11	12	4	5	9	8	8
$A5$	18	8	14	5	3	9	9	7	9
$A6$	20	6	6	10	5	8	8	6	10
$A7$	15	5	8	7	6	9	6	5	10
$A8$	21	5	14	12	9	10	7	8	7
$A9$	16	5	3	13	10	5	5	7	9
$A10$	11	10	5	7	8	6	6	6	8
$A11$	12	2	4	5	7	7	9	10	10
$A12$	10	1	6	6	9	8	6	8	9
$A13$	15	1	3	6	4	7	7	8	8
$A14$	15	6	8	4	3	6	9	7	7
$A15$	29	5	20	7	8	5	8	6	6

Table 1. Values of Alternatives by Criteria

In this study, criterion weights were calculated in linguistic terms. The weights of the criteria are as follows: Criterion 1 and Criterion 2 are very important, Criterion 3, Criterion 4, Criterion 5 are important, Criterion 6 and Criterion 7 are medium, Criterion 8 and Criterion 9 are important.
Net outranking flow values are specified as follows:

$\rho(\tilde{\varphi}(x_1)) =$	-0,00000040
$\rho(\tilde{\varphi}(x_2)) =$	-0,00122824
$\rho(\tilde{\varphi}(x_3)) =$	0,00216354
$\rho(\tilde{\varphi}(x_4)) =$	-0,00005168
$\rho(\tilde{\varphi}(x_5)) =$	-0,00000404
$\rho(\tilde{\varphi}(x_6)) =$	-0,00004886
$\rho(\tilde{\varphi}(x_7)) =$	0,00007390
$\rho(\tilde{\varphi}(x_8)) =$	-0,00103610
$\rho(\tilde{\varphi}(x_9)) =$	-0,00002359
$\rho(\tilde{\varphi}(x_{10})) =$	0,00006432
$\rho(\tilde{\varphi}(x_{11})) =$	0,00000052
$\rho(\tilde{\varphi}(x_{12})) =$	0,00004843
$\rho(\tilde{\varphi}(x_{13})) =$	0,00252585
$\rho(\tilde{\varphi}(x_{14})) =$	0,00145190
$\rho(\tilde{\varphi}(x_{15})) =$	-0,00000940

TABLE 2. Intuitionistic Fuzzy Net Outranking Flow Values

To compare the values in Table 2, the order should be made from smallest to largest. It has been stated above that after sorting, the alternative with the lowest value is the best alternative. In addition, the alternative with the highest value in this table will be the last preferred alternative. When the students evaluated with the system created in our study are ranked according to their net flow values, the most successful student is A_2 and the least successful student is A_{13}. Students' achievements can be based on intuitionistic fuzzy net flow values. The lower the net flow value, the higher the student achievement.Thanks to the PROMETHEE method, which evaluates students by ranking them both positively and negatively, researchers are offered the opportunity to make bilateral observations, not one-sided.

5. Conclusion

The main goal of this study, in which intuitionistic fuzzy sets and decision-making methods are used together, is to create a system that takes both course success and psychological characteristics into consideration when evaluating student success. This study, conducted in the field of education where the decision-making mechanism plays an important role, will offer a new way to researchers who want to evaluate student achievements and guide students.

6. Acknowledgments

The authors would like to thank Feride Tuğrul for her significant contributions.

Funding
The authors declared that has not received any financial support for the research, authorship or publication of this study.

The Declaration of Conflict of Interest/ Common Interest

The authors declared that no conflict of interest or common interest

The Declaration of Ethics Committee Approval
This study does not be necessary ethical committee permission or any special permission.

The Declaration of Research and Publication Ethics
The authors declared that they comply with the scientific, ethical, and citation rules of Journal of Universal Mathematics in all processes of the study and that they do not make any falsification on the data collected. Besides, the authors declared that Journal of Universal Mathematics and its editorial board have no responsibility for any ethical violations that may be encountered and this study has not been evaluated in any academic publication environment other than Journal of Universal Mathematics.

References

[1] L.A. Zadeh, Fuzzy Sets , Information and Control, Vol.8, pp.338-353, (1965).
[2] K.T. Atanassov, Intuitionistic fuzzy sets, Fuzzy Sets and Systems, Vol.20, No.1, pp.87-96, (1986).
[3] K.T. Atanassov, K.T. Intuitionistic Fuzzy Sets, VII ITKR.s Session, Sofia., June, (1983).
[4] J.P. Brans, L'ingenierie de la decision: l'elaboration d'instruments d'aide a la decision. Colloq. d'aide a la decision, Universite Laval, Quebec, Canada, Aou, (1982).
[5] J.P. Brans, B. Mareschal, Chapter 5: PROMETHEE Methods. In:Multiple Criteria Decision Analysis: State of the Art Surveys. International Series in Operations Research- Management Science, Vol.78, Springer, New York, NY., (2005).
[6] J.P. Brans, P. Vincke, A Preference Ranking Organisation Method (The PROMETHEE Method for Multiple Criteria Decision Making). Management Science, Vol.31, No.6, pp.647-656, (1985).
[7] A. Albadvi, Formulating national information technology strategies: A preference ranking model using PROMETHEE method. European Journal of Operational Research, Vol.153, pp.290-296, (2004).
[8] A. Albadvi, S.K. Chaharsooghi, A. Esfahanipour, Decision making in stock trading: An application of PROMETHEE. European Journal of Operational Research, Vol.177, pp.673-683, (2007).
[9] M. Behzadian, RB. Kazemzadeh, A. Albadvi, M. Aghdasi, PROMETHEE:A comprehensive literature reviewon methodologies and applications. European Journal of Operational Research, Vol.200 pp.198-215, (2010).
[10] J.P. Brans, B. Mareschal, P. Vincke, PROMETHEE: a new family of outranking methods in multicriteria analysis. Operational Research, IFORS Vol.84, pp.477-490, (1984).
[11] G. Çuvalcıoğlu, Controlled Set Theory, Bogolyubov Readings DIF-2013, Ukraine, pp.342, (2013).
[12] G. Çuvalcıoğlu, The extension of modal operators' diagram with last operators, Notes on Intuitionistic Fuzzy Sets, Vol.19, No.3, pp.56-61 (2013).
[13] G. Çuvalcıoğlu, Some Properties of Controlled Set Theory, Notes on Intuitionistic Fuzzy Set, Vol.20, No.2, pp.37-42, (2014).
[14] G. Çuvalcıoğlu, E. Aykut, An Application Of Some Intuitionistic Fuzzy Modal Operators To Agriculture, Notes on IFS, Vol.21, No.2, pp.140-149, (2015).
[15] G. Çuvalcıoğlu, V. Bureva, A. Michalíková, Intercriteria Analysis Applied To University Ranking System Of Turkey, Notes on Intuitionistic Fuzzy Sets, Vol.25, No.4, pp.90-97, (2019).
[16] N. Halouani, H. Chabchoub, JM. Martel, PROMETHEEMD- 2T method for project selection, European Journal of Operational Research, Vol.195, pp.841-849, (2009).

[17] R. Krishankumar, KS. Ravichandran, A.B., Saeid, A New Extension to PROMETHEE Under Intuitionistic Fuzzy Environment For Solving Supplier Selection Problem With Linguistic Preferences, Vol.60, pp.564-576, (2017).
[18] H.C. Liao, Z.S. Xu, Priorities of Intuitionistic Fuzzy Preference Relation Based on Multiplicative Consistency, IEEE Transactions on Fuzzy Systems, Vol.22, No.6, pp.1669-1681, (2014).
[19] H.C. Liao, Z.S. Xu, Some Algorithms For Group Decision Making With Intuitionistic Fuzzy Preference Information, International Journal of Uncertainty Fuzziness and Knowledge-Based Systems, Vol.22, No.4, pp.505-529, (2014).
[20] H.C. Liao, Z.S. Xu, Multi-Criteria Decision Making with Intuitionistic Fuzzy PROMETHEE, Journal of Intelligent Fuzzy Systems, Vol.27, pp.1703-1717, (2014).
[21] M. Majumder, Multi Criteria Decision Making, Chapter 2, Springer, pp.35-47, (2015).
[22] E. Szmidt, J. Kacprzyk, Amount Of Information And Its Reliability In The Ranking Of Atanassov'S Intuitionistic Fuzzy Alternatives, in: E. Rakus-Andersson, R.R. Yager, N. Ichalkaranje, L. Jain, ed. Recent advances in decision making (Studies in Computational Intelligence), Berlin, Germany: Springer, pp.7-19, (2009).
[23] F. Tuğrul, M. Çitil, S. Balcı, On The Determination Students' Aptitude Using Intuitionistic Fuzzy Logic, Journal of Universal Mathematics, Vol.2, No.1, pp.36-41, (2019).
[24] F. Tuğrul, M. Çitil, B. Karasolak, M. Dağlı, Interpretation of Physical Conditions of Schools with Fuzzy Multi Criteria Decision Making, Journal of Universal Mathematics, Vol.3, No.1, pp.46-52, (2020).
[25] F. Tuğrul, Application of Intuitionistic Fuzzy Logic with a New Method in Multi Criteria Decision Making Process. Ph.D. Thesis. Kahramanmaraş Sütcü İmam University, 2021.
[26] F. Tuğrul, M. Çitil, A New Perspective on Evaluation System in Education with Intuitionistic Fuzzy Logic and PROMETHEE Algorithm. Journal of Universal Mathematics. 4(1):13-24, 2021.
[27] F. Tuğrul, Evaluation of Papers According to Offset Print Quality: The Intuitionistic Fuzzy Based Multi Criteria Decision Making Mechanism, Pigment & Resin Technology, https://doi.org/10.1108/PRT-04-2022-0059, (2022).
[28] F. Tuğrul, Personnel Selection Utilizing The Decision Making Mechanism Created with The Intuitionistic Fuzzy TOPSIS Method, Mugla Journal of Science and Technology, Vol.8, No.2, pp.16-21, (2022).
[29] F. Tuğrul, An Approach Utilizing The Intuitionistic Fuzzy TOPSIS Method To Unmanned Air Vehicle Selection, Ikonion Journal of Mathematics, Vol.4, No.2, pp.32-41, (2022).
[30] F. Tuğrul, An Evaluation of Supermarkets From the Lens of Multiple Criteria: The Intuitionistic Fuzzy TOPSIS Method, Black Sea Journal of Engineering and Science, Vol.5, No.4, pp.146-150, (2022).
[31] F. Tuğrul, An Innovative Application on Supermarket Selection Through Using Intuitionistic Fuzzy TOPSIS Method, Sakarya University Journal of Science, Vol.26, No.5, pp.2029-2039, (2022).
[32] F. Tuğrul, M. Çitil, Application of Mathematical Modeling in Multi Criteria Decision Making Process: Intuitionistic Fuzzy PROMETHEE, Journal of Mathematical Sciences and Modelling, Vol.5, No.2, pp.48-56, (2022).
[33] F. Tuğrul, M. Çitil, An Innovative Approach to the Intuitionistic Fuzzy PROMETHEE Method, New Trends in Mathematical Sciences, Vol.10, No.4, pp.63-79, (2022).
[34] Z.J. Wang, Derivation Of Intuitionistic Fuzzy Weights Based On Intuitionistic Fuzzy Preference Relations, Applied Mathematical Modelling, Vol.37, pp.6377-6388, (2013).
[35] Z.S. Xu, R.R. Yager, Some Geometric Aggregation Operators Based On Intuitionistic Fuzzy Set, International Journal of General Systems, Vol.35, pp.417-433, (2006).
[36] Z.S. Xu, Intuitionistic Fuzzy Aggregation Operators, IEEE Transactions on Fuzzy Systems, Vol.15, pp.1179-1187, (2007).
[37] Z.S. Xu, Intuitionistic Preference Relations And Their Application In Group Decision Making, Information Sciences, Vol.177, No.11, pp.2363-2379, (2007).
[38] Z.S. Xu, H.C. Liao, Intuitionistic Fuzzy Analytic Hierarchy Process, IEEE Transactions on Fuzzy Systems, Vol.22, No.4, pp.749-761, (2014).
[39] K.J. Zhang, C. Kluck, G. Achari, A Comparative Approach For Ranking Contaminated Sites Based On The Risk Assessment Paradigm Using Fuzzy PROMETHEE, Environmental Management, Vol.44, pp.952-967, (2009).

(Erhan Çetinkaya) 15 Temmuz Şehitleri Secondary School, Mezitli, Mersin, Türkiye
Email address: erhan.ctnky@gmail.com

(Ali Sınar) 15 Temmuz Şehitleri Secondary School, Mezitli, Mersin, Türkiye
Email address: sinarali33@gmail.com

(Ahu Meryem Cuvalcıoğlu) Pakize Kokulu Anatolian High School, Mezitli, Mersin, Türkiye