Review on developments and applications of EDAS (Evaluation based on Distance from Average Solution)

Edmundas Kazimieras Zavadskas, Mehdi Keshavarz Ghorabaee, Muhammet Deveci, Jurgita Antuchevičienė

A lot of multiple criteria decision-making (MCDM) methods have been developed by members of EWG ORSDCE. New developments and extensions of methods are usually mentioned in our yearly Newsletters.
The methods are widely applied by other researchers for different engineering and management problems. Several review papers about MCDM methods developed by members of EWG ORSDCE have been written by other researchers. The main of them are the following [1-6].
The most recent review paper about Evaluation based on Distance from Average Solution (EDAS) was published this year by Ali Ebadi Torkayesh, Muhammet Deveci, Selman Karagoz and Jurgita Antuchevičienė in Expert Systems with Applications, 2023 [7].
Keshavarz Ghorabaee, Zavadskas, Oflat and Turskis in 2015 [8] developed EDAS method, as a ranking method to tackle complicated decision-making problems where number of alternatives should be prioritized with respect to multiple criteria. Compared to other methods, one of the major differences of EDAS is reflected in its normalization process. Unlike traditional methods such as TOPSIS and VIKOR which are designed to determine best alternative according to ideal and anti-ideal solutions, in real-life decision-making problems lower distance to ideal solution and higher distance to anti ideal solution would not guarantee to get the most suitable solution. Therefore, EDAS aims to determine the best alternative according to average solution-based normalization technique. To determine the score of each alternative and determine their relative ranking order, EDAS utilizes two measures, named PDA (positive distance from average value), and NDA (negative distance from average value).

The steps for using the EDAS method are as follows [9]:

Step 1. Calculation of the elements of average solution ($\mathcal{g}_j$):

$$\mathcal{g}_j = \frac{\sum_{i=1}^{n} x_{ij}}{n} \tag{2}$$

Step 2. Determination of the positive ($\mathcal{P}_{ij}^d$) and negative ($\mathcal{N}_{ij}^d$) distances:

$$\mathcal{P}_{ij}^d = \begin{cases} \dfrac{max\left(0, x_{ij} - \mathcal{g}_j\right)}{\mathcal{g}_j} & if\ j \in B \\ \dfrac{max\left(0, \mathcal{g}_j - x_{ij}\right)}{\mathcal{g}_j} & if\ j \in C \end{cases} \tag{3}$$

$$\mathcal{N}_{ij}^{d} = \begin{cases} \dfrac{max\left(0, g_j - x_{ij}\right)}{g_j} & if\ j \in B \\ \dfrac{max\left(0, x_{ij} - g_j\right)}{g_j} & if\ j \in C \end{cases} \tag{4}$$

where B and C are the sets of benefit and cost criteria, respectively.

Step 3. Computation of the weighted summation of the distances:

$$\mathcal{P}_i^w = \sum_{j=1}^{m} w_j \mathcal{P}_{ij}^d \tag{5}$$

$$\mathcal{N}_i^w = \sum_{j=1}^{m} w_j \mathcal{N}_{ij}^d \tag{6}$$

Step 4. Normalization of the values of the weighted summations:

$$\mathcal{P}_i^n = \frac{\mathcal{P}_i^w}{\max_k \mathcal{P}_k^w} \tag{7}$$

$$\mathcal{N}_i^n = 1 - \frac{\mathcal{N}_i^w}{\max_k \mathcal{N}_k^w} \tag{8}$$

Step 5. Calculation of the appraisal score of each alternative:

$$\mathcal{S}_i = \frac{1}{2}\left(\mathcal{P}_i^n + \mathcal{N}_i^n\right) \tag{9}$$

Step 6. Rank the alternatives according to decreasing values of $\mathcal{S}_i$.

The effectiveness of crisp EDAS method with respect to the defined rank reversal phenomenon measures was shown in [9]. Later, after development of the original crisp EDAS, many studies attempted to enhance the reliability and capability of this method by implementing different uncertainty sets to efficiently tackle real-life complex problems (Table 1). The comprehensive description of the developments including respective references can be found in [7].

Table 1. Uncertainty sets used for EDAS [7]

Uncertainty	# of studies	Uncertainty	# of studies
Crisp	56	2-tuple linguistic neutrosophic	1
Type-1 fuzzy set	27	Linguistic neutrosophic environment	1
Intuitionistic fuzzy set	6	Single-valued complex neutrosophic environment	1
Grey theory	4	Four-branch fuzzy set	2
Picture fuzzy set	3	Single-valued neutrosophic soft set	1
Probabilistic linguistic set	4	Interval numbers	2
Hesitant fuzzy set	3	Interval-valued complex fuzzy soft set	1
Interval type-2 fuzzy set	4	Interval-valued fuzzy set	1
Interval-valued neutrosophic set	2	Interval-valued Pythagorean fuzzy set	1
Single-valued neutrosophic set	2	Picture 2-tuple linguistic set	1
q-rung orthopair fuzzy set	3	Pythagorean 2-tuple linguistic set	1
Rough theory	2	Refined single-valued neutrosophic soft Set	1
2-dimension uncertain linguistic variables	1	Stochastic environment	1
Double hierarchy fuzzy set	1	Epistemic uncertainty	1
Fermatean fuzzy set	1	Interval rough	1
Intuitionistic fuzzy rough set	3	Pythagorean probabilistic hesitant fuzzy set	1
Trapezoidal bipolar fuzzy set	1	Trapezoidal neutrosophic set	1

Based on the detailed review of published EDAS studies, nine applications groups are found out which cover all the studies. Fig. 1 presents yearly distribution of studies conducted in nine application areas. According to this figure, EDAS method is mostly applied in business management, construction management, supply chain management, and energy and natural resources.

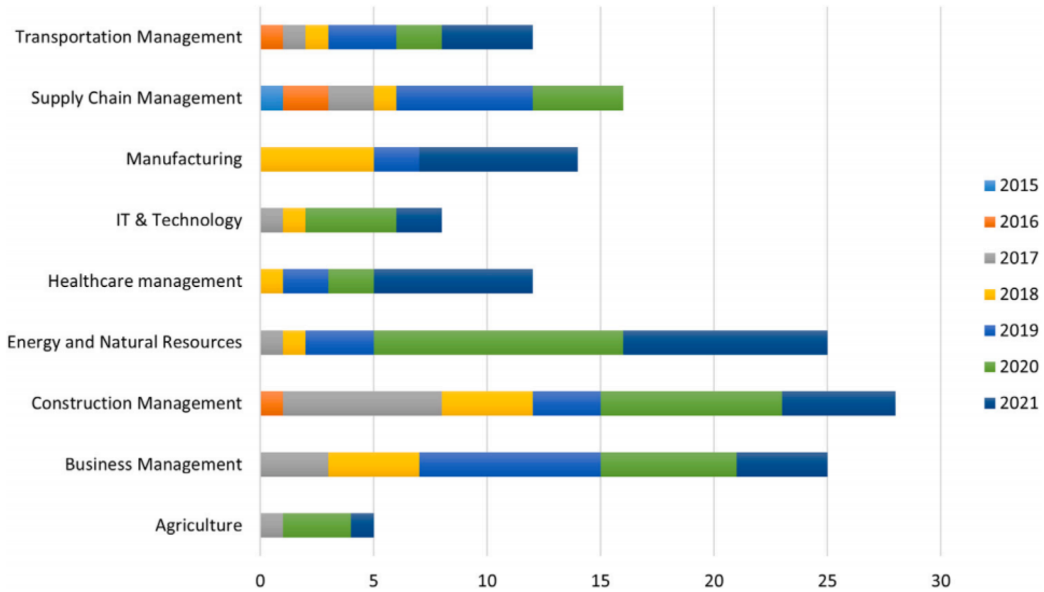

Fig. 1. Application based yearly distribution of papers [7]

Fig. 2 discloses statistics of various MCDM methods in the literature combined with the EDAS approach. According to the figure, most of the researchers preferred to combine EDAS with the AHP method. As AHP considers hierarchical structure in the decision-making process, is simple to apply real-world cases with a small or moderate number of criteria and is consistent in quality assurance, it is the most preferred technique by the researchers. After AHP, TOPSIS, SWARA and WASPAS are the most popular hybrid methods used with EDAS.

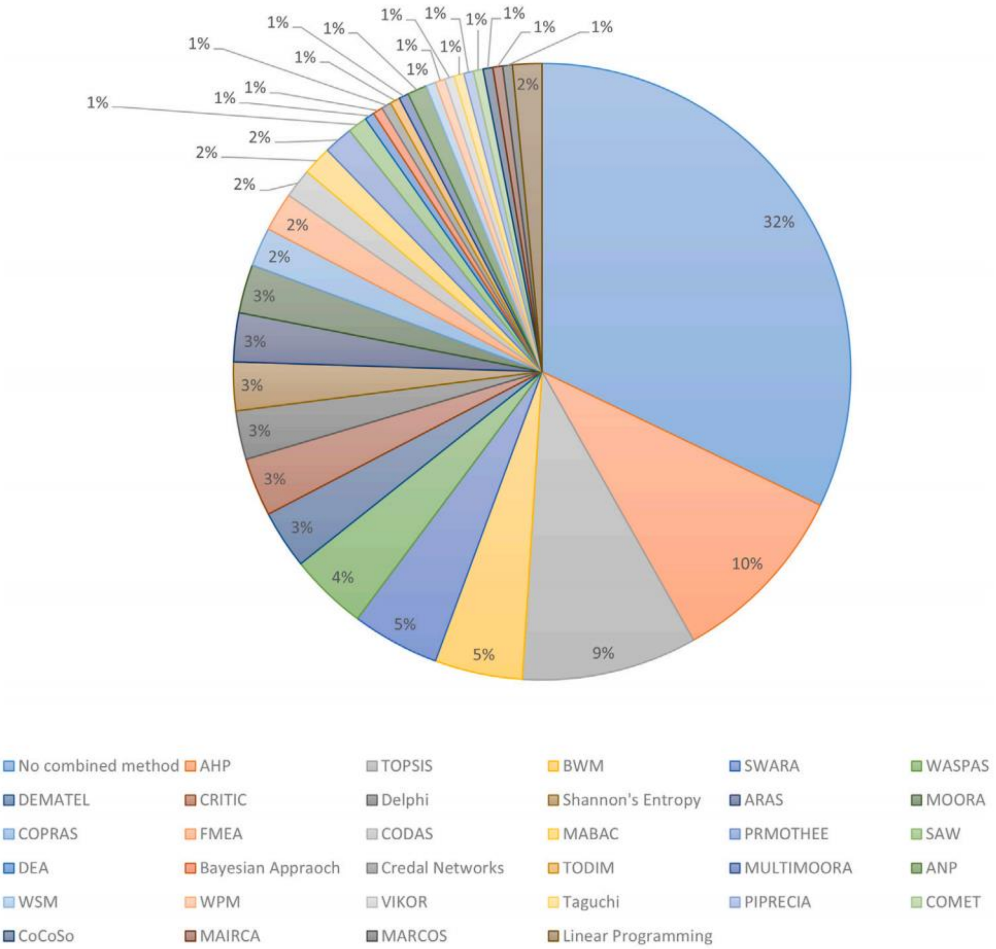

Fig. 2. Distribution of hybrid methods [7]

As the review paper about EDAS was prepared and submitted to the journal in 2022, papers published between 2015 and 2021 were included in the study. Therefore, the number of studies published up to 2021 and the citations up to then are shown in Fig. 3.

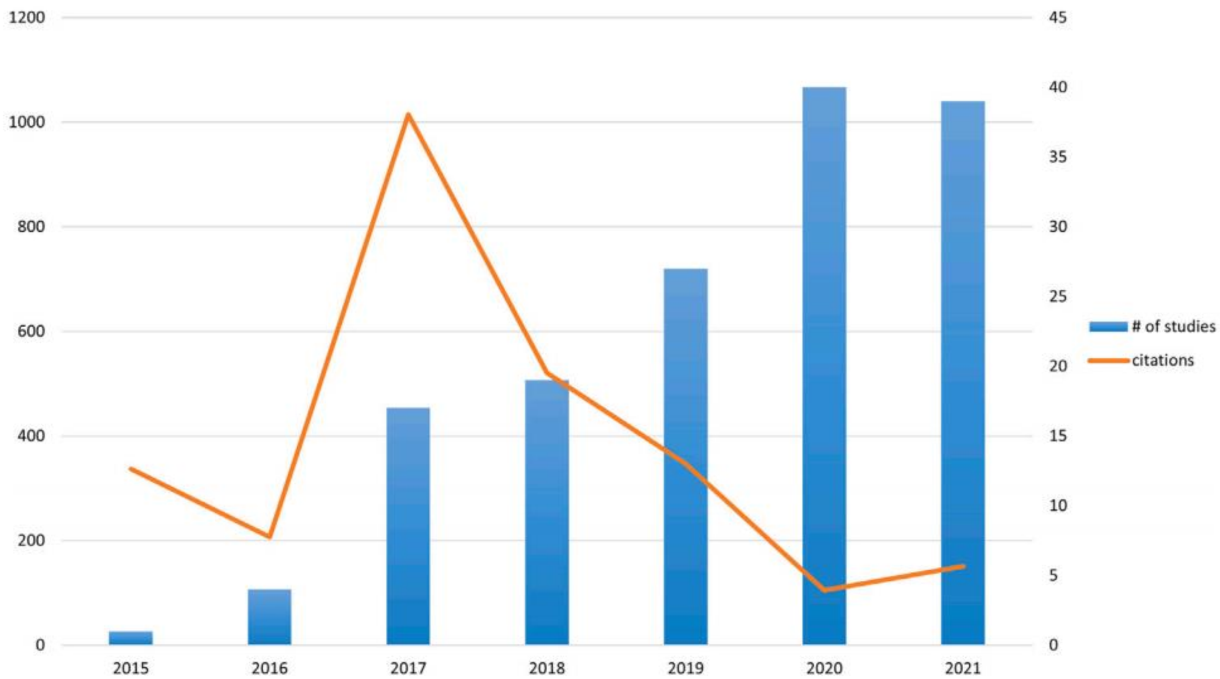

Fig. 3. Annual publications and citations [7]

However, the method does not lose its popularity, and the number of publications as well as citations is increasing. The newest data from Web of Science data base is presented in Figs. 4 -6.

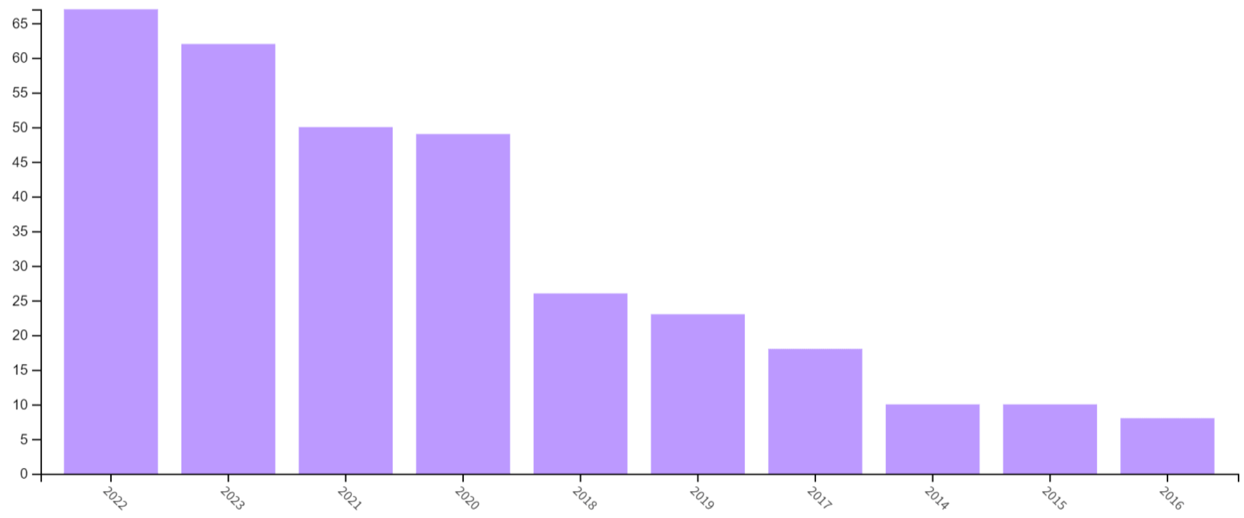

Fig. 4. Number of publications using EDAS method (https://www.webofscience.com/wos/woscc)*

*Please note, that slight inconsistencies may exist in the Fig. 4, because the search was made according to author keyword "EDAS" in WoS, but the results were not screened manually.

As of July/August 2023, this highly cited paper of Keshavarz Ghorabaee, Zavadskas, Oflat and Turskis (2015) [8] received enough citations to place it in the top 1% of the academic field of Computer Science based on a highly cited threshold for the field and publication year. It is cited 582 times in total in Web of Science referred publications (searched on 2023-12-04 in Clarivate Analytic WoS data base).

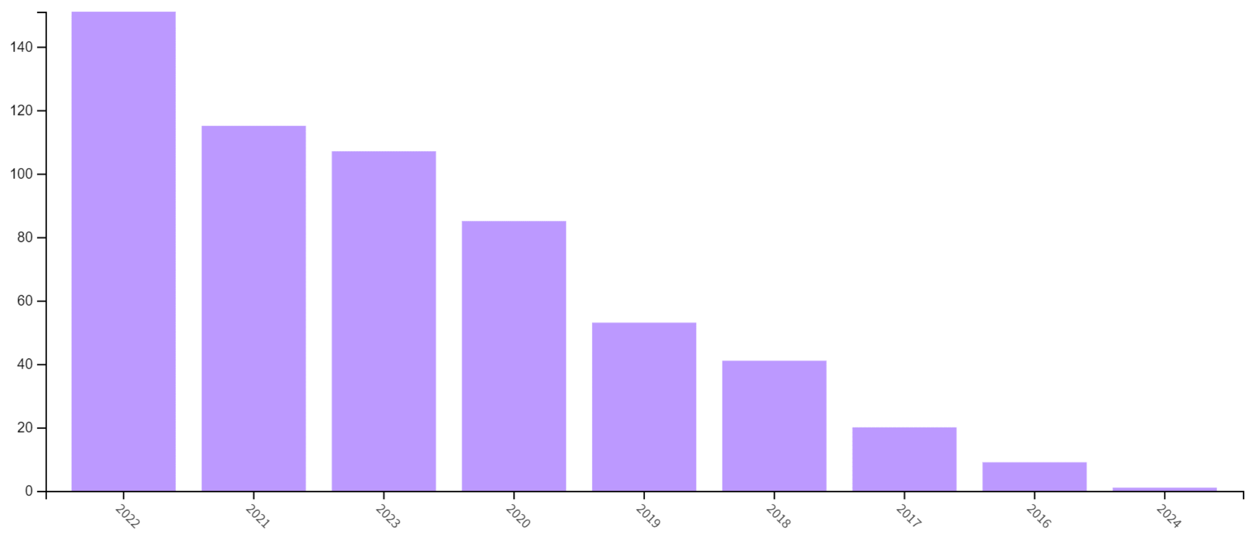

Fig. 5. Number of citations of Keshavarz Ghorabaee et al. [8] paper (https://www.webofscience.com/wos/woscc)

Fig. 6. Journals citing Keshavarz Ghorabaee et al. [8] paper (https://www.webofscience.com/wos/woscc)

REFERENCES:

[1] Mardani, A., Nilashi, M., Zakuan, N., Loganathan, N., Soheilirad, S., Saman, M. Z. M., & Ibrahim, O. A systematic review and metaanalysis of SWARA and WASPAS methods: theory and applications with recent fuzzy developments. Applied Soft Computing, 2017, Vol. 57, 265–292. https://doi.org/10.1016/j.asoc.2017.03.045

[2] Mardani, A., Jusoh, A., Halicka, K., Ejdys, J., Magruk, A., & Ungku Norulkamar U. Ahmad. Determining the utility in management by using multi-criteria decision support tools: a review, Economic Research-Ekonomska Istraživanja, 2018, Vol. 31, iss. 1, 1666–1716. https://doi.org/10.1080/1331677X.2018.1488600

[3] Stefano, N. M., Casarotto Filho, N., Vergara, L. G. L., & Rocha, R. U. G. COPRAS (Complex Proportional Assessment): state of the art research and its applications. IEEE Latin America Transactions, 2015, Vol. 13, iss. 12, 3899–3906. https://doi.org/10.1109/TLA.2015.7404925

[4] Balezentis, T., & Balezentis, A. A Survey on Development and Applications of the Multi-criteria Decision Making Method MULTIMOORA. Journal of Multi-Criteria Decision Analysis, 2014, Vol. 21, iss. (3–4), 209–222. https://doi.org/10.1002/mcda.1501

[5] Hafezalkotob, A., Hafezalkotob, A., Liao, H., & Herrera, F. An overview of MULTIMOORA for multi-criteria decision-making: Theory, developments, applications, and challenges. Information Fusion, 2019, Vol. 51, 145–177. https://doi.org/10.1016/j.inffus.2018.12.002

[6] Liu, N., Xu, Z. An overview of ARAS method: Theory development, application extension, and future challenge. International Journal of Intelligent Systems, 2021, Vol. 36, iss. 7, 3524-3565. https://doi.org/10.1002/int.22425

[7] Torkayesh, A. E., Deveci, M., Karagoz, S., & Antuchevičienė, J. A state-of-the-art survey of evaluation based on distance from average solution (EDAS): Developments and applications. Expert systems with applications, 2023, Vol. 221, 119724. https://doi.org/10.1016/j.eswa.2023.119724

[8] Keshavarz Ghorabaee, M., Zavadskas, E. K., Olfat, L., & Turskis, Z. (2015). Multi-criteria inventory classification using a new method of evaluation based on distance from average solution (EDAS). Informatica, Vol. 26, iss. 3, 435–451. https://doi.org/10.15388/Informatica.2015.57

[9] Keshavarz Ghorabaee, M., Amiri, M., Zavadskas, E. K., Turskis, Z., & Antucheviciene, J. (2018). A Comparative analysis of the rank reversal phenomenon in the EDAS and TOPSIS methods. Economic Computation and Economic Cybernetics Studies and Research, Vol. 52, iss. 3, 121–134. https://doi.org/10.24818/18423264/52.3.18.08