*Research paper*      ,

# A Literature Review on MCDM approaches

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**Abstract:** The Multi-Criteria Decision-Making (MCDM) method is the most commonly used method for solving decision making problems in real world applications. The MCDM method is becoming increasingly popular for resolving decision-making problems in variety of fields. Multi-Criteria Decision-Making methods ranking the alternatives, alternatives are ranked based on their values in satisfying the criteria. There are numerous MCDM approaches that support the decision-making process and used for solving the decision-making problems, such as Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Analytical Hierarchy Process (AHP), Weighted Sum Method (WSM), VIKOR (VIseKriterijumska Optimizacija I Kompromisno Resenje means multi-criteria optimization and compromise solution, in Serbian) etc. which are used in business and other areas. The MCDM approach has several applications to solve the real-world problems such as marketing, human resources, transportation, investment project etc. This paper presents a literature survey on different multi-criteria decision-making approaches to solve decision-making problems in various field. The objective of this paper is to analyze the most prevalent MCDM techniques applied in real-world applications. This paper will explore the literature of earlier research papers. It was found that TOPSIS, AHP, VIKOR and hybrid approaches are most frequently used in real-world application.

*Keywords:* *Multi-Criteria Decision-Making (MCDM), Multi-Criteria, Decision-Making Problems, MCDM Approaches.*

## I. Introduction

The most common problem in business and other real-world issues is the decision-making process, and as communication technologies are used more frequently in commercial settings, decision-making scenarios are becoming more complex. The focus of decision-makers for problem solutions is on multi-criteria decision-making processes. Multi-Criteria Decision-Making (MCDM) approaches ranking the alternatives, alternatives are ranked based on their value in satisfying the criteria. MCDM has several applications to solve real-world problems such as marketing, human resources, transportation, investment project, etc.

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MCDM method is the most feasible decision-making method to handle a various criterion and alternative simultaneously, select an alternative that is fulfill our criteria. MCDM is the most widely used in the area of business, academics, engineering etc. to predicting ranks. Every company hopes to expand and generate more revenue. To choose the best option that meets the investment goals, it is crucial to evaluate the results with different investment possibilities. Multi-Criteria analysis can be utilized to rank potential investment projects using many factors might help investors make better decision and reach their investment goals [1]. The best way for analyzing data based on several criteria is multi-criteria decision-making (MCDM). There are numerous MCDM strategies including COPRAS (Complex Proportional Assessment), TOPSIS, AHP, WSM and others, that deliver the desired outcomes. The MCDM approaches are used to analyze complicated problems involving various criteria or strategies and to support various solutions in order to select the best or most appropriate solutions. There are certain distinguishing characteristics, including the number of numerous inconsonant and incompatible criteria, the various measurement units between the criteria, and the presence of equally dissimilar alternatives [2].

The advantage of MCDM is its capability to simultaneously take into account several criteria with variable relevance weight. Every MCDM challenge typically involves a number of options and a set of standards for judging those options. The performance of each alternative is represented by a numeric number, and these values are used to rank the alternatives. In earlier research, it was suggested a strategy for business success employing multi-criteria decision-making approaches ranking to identify successful businesses based on several factors [3].

## II.    Related Work

A lot of research on MCDM approaches, to ranking alternatives based on various criteria. There is numerous previous research paper on different MCDM approaches which are used to solve decision-making problems in various field. In order to choose the best company from the group of companies, the writers research MCDM methodologies. Kung et al. [4] have suggested the optimal investment strategy based on the analysis of data from financial reports and the use of the fuzzy MCDM method.

Türegün N. [5] compared the entropy-based TOPSIS and VIKOR techniques to analyze the stock performance outcome and presented a model as suggestion to the tourism companies for evaluating financial performance outcome. Gupta et al. [6] have presented an MCDM model to rank the performance of sectors in the Indian stock market. To identify the best performing sectors for investments, build a hybrid ranking technique that performs a relative ranking of the NSE (National Stock Exchange) sectoral indexes. Gupta et al. [7] have reviewed a three-stage model (Perceptual Map-Data Envelopment Analysis-COPRAS) that integrates market performance with the fundamental complement in an MCDM framework to provide a comprehensive approach to understanding the performance of the stocks.

Pramanik et al. [8] have presented a comparative analysis compared the 5 MCDM techniques i.e., EDAS (Evaluation based on Distance from Average Solution), ARAS (Additive Ratio Assessment), MABAC (Multi-Attributive Border Approximation Area Comparison), COPRAS (Complex Proportional Assessment) and MACROS (Measurement Alternatives and Ranking) with different criteria and set of alternatives for selection of resources in mobile crowd computing. Compared the MCDM techniques to select the best one which is solve the decision making problem based on various criteria. Gayatri and

Chetan [9] discussed on "Comparative Study of Different Multicriteria Decision Making Methods", includes the six MCDM techniques i.e., TOPSIS, PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation), VIKOR, SAW (Simple Additive Weighting), AHP (Analytical Hierarchy Process) and WPM (Weighted Product Method) and described the strength and weakness of MCDM techniques. Kanwar et al. [10] Computed the correlation based criteria weight and ranking the alternatives to identify top-k alternative based on MCDM approcah i.e., weighted TOPSIS.

Haddad et al. [11] have discussed on HSE (Health, Safety, and Environment), In a case study where a fuzzy-TOPSIS model was used to choose a supplier for an operations and maintenance contract of floating production storage and offloading with a focus on HSE aspects for supplier prioritization. Naveed et al. [12] reviewed, the Analytical Hierarchy Process can help determine which success criteria are most important for the cloud enterprise resource planning (CERP) system success and failure. Evaluation of these elements can assist businesses in monitoring and managing an effective CERP system. Liu Zongsheng [13] has presented a Financial Management Assessment Model based on Analytical Hierarchical Process. The assessment factors include three different parts i.e., elemental work, personal management and structural establishment. The model appreciates the correct financial management assessment.

Kecek et al. [14] have analyzed the TOPSIS and MOORA (multi-objective optimization on the basis of ratio analysis) methods to solving the problem of decision making in laptop selection, determine the effective criteria that help in laptop selection. Baczkiewicz and Aleksandra [15] have presented an approach based on MCDM techniques in the area of e-commerce to select the best headphone model. The approach includes MCDM techniques i.e., TOPSIS, COMET (Characteristics Objects Method), PROMETHEE II and VIKOR, to evaluate the alternatives and solve the decision-making problems. Daghouri et al. [16] studied the MCDM approaches and determine the use of MCDM techniques to assess the effectiveness of the information system. Compare the six most widely used multi-criteria decision-making approaches in a real-world application. These techniques are Weighted Product Method (WPM), Weighted Sum Method (WSM), Simple Multi-Attribute Ranking (SMART), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Analytical Hierarchy Process (AHP), and Revised AHP. Agarwal et al. [17] studied various MCDM methods for selecting and evaluating suppliers, and then assess the supplier selection methodology based on inputs from the operational and functional levels. There are many factors to consider while evaluating the supplier selection approach, such as delivery performance, quality, pricing and reliability. Zulqarnain et al. [18] have discussed TOPSIS and the application of the TOPSIS method for the best automotive car selection using hypothetical data.

## MCDM Approaches

MCDM has two classes, i.e., Multiple Attribute Decision Making (MADM) and Multiple Objective Decision Making (MODM). In MODM, the decision space is continuous for example, mathematical programing problem with multiple objective functions. The MADM is focused on the problem of discrete decision space. In the discrete decision space problems, the set of decision alternatives has predetermined [19]. For ranking multiple alternatives based on several criteria, the multi-criteria decision-making method is considered as extremely reliable methodology.

MCDM methods have been applied in different areas such as supply chain management and logistics, human resources, engineering design and manufacturing systems, marketing management, health and safety, classification and clustering problems and stock exchange, etc. [20]. The MCDM approaches determine the best optimal solution for a problem and provide the uniqueness based on criteria.

There are the following MCDM approaches which are used in previous research papers for ranking the alternatives and solving the decision-making problems.

**Analytical hierarchy process (AHP)**

The Analytical Hierarchy Process (AHP) is the most popular method for solving decision-making problems in actual conditions. AHP was developed by Saaty in 1980, based on a hierarchical structure and it is robust and helpful tool used to calculate weights for criteria and determine the ranks of alternatives. This tool is effective for controlling multi-criteria decision-making. One of the most complete systems for making decisions with multiple criteria is the analytical hierarchy process because it allows for the formulation of the issue as a hierarchical structure and a mixture of qualitative and quantitative criteria [21].

In order to analyze method selection, Duleba et al. [22] suggested a multi-criteria decision-making strategy employing the grey theory. A genuine transportation problem is studied using an extended analytical hierarchy process (AHP) model, which combine the benefits of the traditional AHP and the grey theory for the precise estimation of the commuting mode weight coefficient. Canco et al. [23] have analyzed a particular decision-making problem and proposed a new application to use decision-making techniques under real-world circumstances. It focuses on a decision-making process based on the Analytical Hierarchy Process, a technique that can be used to ensure success in the area of business.

**Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)**

TOPSIS is an MCDM approach to identify an alternative solution that is closest to the positive ideal solution and farthest to the negative ideal solution [24]. The TOPSIS was developed by Hwang and Yoon in 1981. It is the best method for addressing rank reversal issues and the number of steps is the same regardless of the number of attributes. It also has many advantages, including being simple to process, easy to use, and programmable, easy for decision making using positive and negative ideal solutions, useful for numerical and qualitative data, well-organized, systematic process, and very large flexibility. The disadvantages of the TOPSIS method are the use of Euclidian distance, which does not take into account the correlation of attributes, the normalization of the decision matrix, where each criterion's normalization measure typically derives from a small gap between the achieved measures and the ranking reversal problem (the final ranking can change when new alternatives are included in the model) [25].

TOPSIS has been employed in numerous field such as supply chain management, logistic design, business and marketing management, human resources management, engineering, manufacturing system, environmental management and water resource management [26]. Bulgurcu and B.K. [27] provided a methodology to evaluate and compare the financial performance of companies listed on the Istanbul Stock Exchange. These companies were investigated and evaluated in terms of financial ratio and the financial performance score of these companies was evaluated using the TOPSIS approach.

## Simple Additive Weighting Method (SAW)

A multicriteria decision-making approach commonly referred to as the "summing up method" is the simple additive weighting method. The result of SAW is that multiplying the rating by the weight of each attribute yields the final score for a given criteria. A normalized decision matrix is necessary for the simple additive weighting approach in order to compare it with all other available MCDM methods [28]. Vafaei et al. [29] have evaluated the impact of normalization techniques such as Max, Max-Min, Sum, and Vector using a simple additive weighting method, to show that the assessment framework is valid and to offer a better approach for the given case study.

## VIKOR

Opricovic and Tzeng created the VIKOR (VIseKriterijumska Optimizacija I Kompromisno Resenje means multi-criteria optimization and compromise solution, in Serbian) approach in 2004 for multi-criteria optimization in complex systems. A discrete decision-making problem with various units and varying criteria is solved using the VIKOR method as an MCDM method. This approach focuses on rating and selecting from a list of alternatives to find a compromise solution for a problem with competing requirements, which can assist the decision-makers in arriving at a final conclusion. The VIKOR approach is useful for multi-criteria decision making, especially when the decision maker is unable to communicate his preference at the outset of system design [30].

Zimonjić et al. [31] explained how to use compromise ranking, or multi-criteria analysis, to evaluate investment plans and compare them to alternatives based on dynamic financial evaluation indicators. The VIKOR technique can be used to identify the best and most effective project.

## Multi-Objective Optimization on The Basis of Ratio Analysis (MOORA)

The MOORA method was developed by Brauers and Zavadskas [32] in 2006, it is a MCDM method that can be applied to solve complex decision-making problems. It is a well-known and effective method for selecting the alternative that is most appropriate and acceptable given the circumstances at hand. Multi-criteria or multi-attribute optimization, also referred to as multi-objective optimization on the basis of ratio analysis (MOORA), is the process of simultaneously optimizing two or more competing attributes under specific restrictions [14].

To improve evaluation and selection methodology and offer an alternative way by using the multi-objective optimization on the basis of ratio analysis (MOORA) method. In order to resolve various selection problems in a supply chain setting, explored the applicability of MOORA, a multi-criteria decision-making approach. This approach can be used in a wide variety of complicated and conflictual supply chain environments such as choosing a warehouse, supplier, product and process design etc. [33]. Pérez-Domínguez et al. [34] have suggested an analysis and evaluation for the maintenance system by using the metric data gathered through the process. It might help the management to take into account the best decisions with regards to each machine.

## Complex Proportional Assessment (COPRAS)

Complex Proportional Assessment (COPRAS) is a multi-criteria decision-making method developed by Zavadskas, Sarka, and Kaklauskas in 1994 to determine the rank of alternatives. This is commonly utilized in engineering field complications for project appraisal and selection. The fundamental goal of the

COPRAS technique is to rank each alternative by considering the particular weights of each criterion [35]. Vujičić et al. [36] studied the COPRAS method to determine the optimum option for selecting compact fluorescent lamps (CFLs) using decision-making method (COPRAS). This methodology aids decision-makers in developing comprehensive understanding of issues and adopting appropriate solutions.

**Evaluation based on Distance from Average Solution (EDAS)**

EDAS stands for Evaluation based on Distance from Average Solution, it was presented by Keshavarz Ghorabaee et al. [37] in the year of 2015. EDAS method is related to the distance from average solution, first measure the PDA and NDA that is positive distance from average and negative distance from average respectively. This metric can demonstrate the variations between each alternative and the average solution. Higher values of PDA (Positive Distance Average) and lower values of NDA (Negative Distance Average) are used to evaluate the alternatives.

M. Ghorabaee et al. [38] extend the EDAS method to deal with the fuzzy MCDM problems. Performed an analysis using various simulated criteria weights to show how the ranking results will remain valid and stable when the criteria weights are modified. Sensitive study demonstrate that the suggested fuzzy strategy is stable under various weights of criteria and performs well in a fuzzy environment.

**III.     Conclusion and Future work**

In this paper, we study different multi-criteria decision-making approaches to solve decision making problems in numerous fields. Multi-Criteria decision-making (MCDM) technique is one of the most usable decision-making methods that determines the optimal alternative by considering several criteria in the selection procedure. It is the most feasible decision-making method to handle various criteria and alternatives simultaneously and select an alternative that is fulfill our criteria. MCDM is the most widely used in the areas of business, academics, engineering etc. to predict ranks. There is various earlier research on multi-criteria decision-making methods in different fields that provide the appropriate results. The MCDM techniques have many advantages such as ranking, sorting, selecting, weight calculation, prioritizing, etc., and help in the overall assessment. This paper briefly explains the different MCDM techniques that were used in previous research papers for solving decision-making problems and ranking the alternatives. It was found that TOPSIS, AHP, VIKOR and hybrid approaches are most frequently used in real-world application. In the future, we will extend the MCDM approache and propose an approach for identification and ranking on large datasets using multi-criteria decision-making method.

**REFERENCES**

[1]  A. B. A. I. &. Š. S. Puška, "Model for investment decision making by applying the multi-criteria analysis method," Serbian Journal Management, 13(1), pp. 7-28, 2018.

[2]  E. Triantaphyllou, "Multi-criteria decision-making methods: A comparative study," in Springer, Boston, MA, 2000.

[3]  S. A. A. G. K. H. &. T. T. P. Alrababah, "Comparative analysis of MCDM methods for Product Aspect Ranking: TOPSIS and VIKOR," in In 2017 8th International Conference on Information and

Communication Systems (ICICS), 2017.

[4] J. Y. C. T. N. &. K. C. M. Kung, "A fuzzy MCDM method to select the best company based on financial report analysis," in IEEE International Conference on Fuzzy Systems (FUZZ-IEEE 2011), 2011.

[5] N. Türegün, "Financial performance evaluation by multi-criteria decision-making techniques.," in Heliyon, 8(5), e09361, 2022.

[6] D. P. A. &. D. T. K. Gupta, "A multi-criteria decision making approach to rank the sectoral stock indices of national stock exchange of India based on their performances," National Accounting Review, pp. 272-292, 2021.

[7] S. B. G. B. M. &. B. S. Gupta, "Portfolio Selection using DEA-COPRAS at risk-return interface based on NSE (India)," International Journal of Innovative Technology and Exploring Engineering (IJITEE), pp. 4078-4086, 2019.

[8] P. K. D. B. S. P. S. M. D. &. C. P. Pramanik, "A Comparative Analysis of Multi-Criteria Decision-Making Methods for Resource Selection in Mobile Crowd Computing," Symmetry, 2021.

[9] V. a. M. C. Gayatri, Comparative study of different multi-criteria decision-making methods, 2013.

[10] P. M. R. &. T. B. Kanwar, "Correlation Based Muti-Criteria Feature Weighting for Identification of Top-k Investors and Companies," in In 2019 9th International Conference on Advances in Computing and Communication (ICACC), 2019.

[11] A. N. d. C. B. B. d. A. L. S. H. A. &. S. C. A. Haddad, "Application of Fuzzy-TOPSIS Method in Supporting Supplier Selection with Focus on HSE Criteria: A Case Study in the Oil and Gas Industry," 2021.

[12] Q. N. I. S. Q. M. R. N. M. A. A. M. R. M. A. A. &. F. S. Naveed, "Evaluating and Ranking of Critical Success Factors of Cloud Enterprise Resource Planning Adoption Using MCDM Approach," 2021.

[13] L. Zongsheng, "Application of analytical hierarchy process technology in financial management assessment," in The 2nd International Conference on Computer and Automation Engineering (ICCAE), Singapore, 2010.

[14] G. a. F. D. Kecek, A comparative analysis of TOPSIS and MOORA in laptop selection, 2016, pp. 1-9.

[15] A. Baczkiewicz, "MCDM based e-commerce consumer decision support tool," in 25th International conference on knowledge based and intelligent information & engineering system, 2021.

[16] A. M. K. &. Q. M. Daghouri, "Multi criteria decision making methods for information system selection: A comparative study," in International Conference on Electronics, Control, Optimization and Computer Science (ICECOCS), 2018.

[17] P. S. M. M. V. B. M. &. S. V. Agarwal, "A review of multi-criteria decision making techniques for supplier evaluation and selection," in International journal of industrial engineering computations, 2011.

[18] R. M. S. M. A. N. D. F. &. A. B. Zulqarnain, "Application of TOPSIS method for decision making," in International Journal of Scientific Research in Mathematical and Statistical Sciences, 2020.

[19] E. S. B. S. S. N. &. R. T. Triantaphyllou, Multicriteria decision making: an operations research

approach, 1998.

[20] M. &. J. A. K. Panda, "TOPSIS in Multi-Criteria Decision Making: A Survey," in In 2018 2nd International Conference on Data Science and Business Analytics (ICDSBA), 2018.

[21] H. Taherdoost, "Decision Making Using the Analytic Hierarchy Process (AHP): A Step by Step Approach," International Journal of Economics and Management Systems, 2017.

[22] S. Ç. Y. M. S. &. E.-K. D. Duleba, Application of grey analytic hierarchy process to estimate mode choice alternatives: A case study from Budapest., 2022.

[23] I. K. D. &. I. T. Canco, AHP, a Reliable Method for Quality Decision Making: A Case Study in Business, 2021.

[24] G. W. Wei, "Extension of TOPSIS method for 2-tuple linguistic multiple attribute group decision making with incomplete weight information," pp. 623-634, 2010.

[25] E. K. M. A. T. Z. J. A. &. N. K. M. Zavadskas, "Development of TOPSIS method to solve complicated decision-making problems—An overview on developments from 2000 to 2015," International Journal of Information Technology & Decision Making, pp. 645-682, 2016.

[26] M. O. S. K. Y. M. &. I. J. Behzadian, A state-of the-art survey of TOPSIS applications, 2012.

[27] B. K. Bulgurcu, "Application of TOPSIS technique for financial performance evaluation of technology firms in Istanbul Stock Exchange market," Procedia-Social and Behavioral Sciences, vol. 62, pp. 1033-1040, 2012.

[28] A. &. S. R. Cahyapratama, "Application of Analytic Hierarchy Process (AHP) and Simple Additive Weighting (SAW) methods in singer selection process," in International Conference on Information and Communications Technology (ICOIACT), 2018.

[29] N. R. R. A. &. C.-M. L. M. Vafaei, "Assessing Normalization Techniques for Simple Additive Weighting Method," Elsevier, pp. 1229-1236, 2022.

[30] M. K. H. M. &. S. K. Sayadi, "Extension of VIKOR method for decision making problem with interval numbers," Applied Mathematical Modelling, 2009.

[31] E. Z. S. &. Đ. M. Kastratović, Application of VIKOR method in ranking the investment projects., 2017.

[32] W. K. &. Z. E. K. Brauers, "The MOORA method and its application to privatization in a transition economy," Control and cybernetics, 35(2), pp. 445-469, 2006.

[33] B. B. B. S. B. &. S. S. Dey, "A MOORA based fuzzy multi-criteria decision making approach for supply chain strategy selection," International Journal of Industrial Engineering Computations, pp. 649-662, 2012.

[34] L. M. K. S. P. L. O. &. D. M. C. Pérez-Domínguez, "Application of the MOORA method for the evaluation of the industrial maintenance system," Journal of Physics, 2018.

[35] A. J. S. S. R. &. F. K. Patel, "Comparative study of MCDM techniques COPRAS and TOPSIS for selection of electric motorcycles," in Proceedings of the 2020 IEEE 7th International Conference on Industrial Engineering and Applications (ICIEA), Bangkok, Thailand , 2020.

[36] M. B. M. &. P. M. Vujičić, "Application of COPRAS MCDM method for choosing the best compact

fluorescent lamp," in International Scientific Conference, University of Kragujevac, 2016.

[37] M. Z. E. K. O. L. &. T. Z. Keshavarz Ghorabaee, "Multi-criteria inventory classification using a new method of evaluation based on distance from average solution (EDAS)," pp. 435-451, 2015.

[38] M. K. Z. E. K. A. M. &. T. Z. Ghorabaee, "Extended EDAS method for fuzzy multi-criteria decision-making: an application to supplier selection," International journal of computers communications & control, pp. 358-371, 2016.