

## Multi-criteria decision making methods comparative analysis in Fuzzy Environment: Article review

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### Abstract

Multi criteria decision making (MCDM) appears to be a difficult decision-making (DM) technique involving both theoretical and practical elements. Many MCDM tools and procedures have recently been proposed in order to choose the most likely option. Due to the obvious wide range of MCDM programmes available in many fields, there may be a strong need to divide them into various regions and sub-areas. Manufacturing systems, supply chain issues, business and management, human resource management, power and safety, environmental science, and other programmes are just a few examples. This news letter also discusses the state of fuzzy multi-standards decision-making systems. Multi-criteria decision-making has been used in a variety of fields. Where several criteria have emerged, the MCDM approach aids in the choice of the best options. The optimum one may be determined by assessing the many scopes for the criteria. To use any multi-criteria decision-making methodology (figure1), assign weights to the criteria and then choose the better ones. This The article covers the evolution of several FMCDM techniques and approaches in depth. MCDM approaches are frequently integrated with other methodology to obtain more precise findings or to handle a specific class of issues and circumstances. Hybrid methods are a collection of multi-criteria decision-making approaches that have been merged (figure2).

### Abbreviations

FMDC	Fuzzy multi criteria decision making.
DM	Decision Making.
FAHP	Fuzzy Analytical Hierarchy Process.
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution.
VIKOR	vlsekriterijumska optimizacija i kompromisno resenje.
AHP	Analytical Hierarchy Process.
ANP	Analytical Network Process.
ELECTRE	Elimination And Choice Translating Reality.
PROMETHE	Preference Ranking Organization METHod for Enrichment Evaluation.
COPRAS	COMplex PROportional Assessment.
SMART	Simple Multi-Attribute Rating Technique.
BF	Bipolar Fuzzy.
CRITIC	CRiteria Importance Through Intercriteria Correlation.
MOORA	Multi-Objective Optimization on the basis of Ratio Analysis.
ARAS	Additive Ratio Assessment.
WASPAS	Weighted Aggregated Sum Product Assessment.
FUCOM	FULL Consistency Method.
SAW	Simple Additive Weighting.
DEMATEL	Decision-Making Trial and Evaluation Laboratory.
MABAC	multi-attributive border approximation area comparison.
GRA	Gray Relation analysis.

### 1. Introduction

This paper looks into the evolution of various MCDM approaches and their applications. Many judgments are made in your daily lives depending on a variety of factors; consequently, choices can be taken by weights assigned to multiple criteria and obtaining all of the weights through expert groups. Decision-making based on many criteria There in sciences, business, government, and engineering, multicriteria decision making (MCDM) was among the most extensively utilised decision approaches. By rendering the decision-making approach more explicit, reasonable, and efficient, MCDM approaches can help in improving the effectiveness of choices. Fast-changing technology on the

product end foreshadowed necessity manufacturing businesses to respond just as quickly. Because decision-making is now more difficult today, the selection decisions are complicated. Multi-criteria decision in the recent times, a variety of methodology have been widely used in numerous fields in these scenarios.

The decision-making theoretical approach is becoming a crucial methods for offering actual solutions to ambiguity problems in manufacturing procedures, especially in the fields of environmental sustainability and sustainable engineering. In previous decades, there a number of methodologies and systems have been formulated to solve problems in the fields of environmental

sustainability and sustainable engineering. Allocating weights for criteria would be a crucial step with most MCDM processes that has to be revisited. However, one of most difficult aspects with MCDM usually calculating appropriate weights of criteria. The entropy approach is used to determine the weight in an issue since the decision matrix for a set of candidate materials has a specific amount of information when using this methodology.

The entropy is dependent on a decision matrix that is predefined. Entropy is a measure of how much information there is in a system. uncertainty

expressed by a discrete probability distribution, with consensus that an increased availability indicates more ambiguity than a tightly packed one. fuzzy sets are a handy approach to dealing with unpredictability, ambiguity, and vagueness. Multiple criteria decision-making, group decision-making, forecasting, pattern recognition, and system optimization and control challenges have all seen increased use in recent years. These rules are converted into numerical equivalents by fuzzy systems. This makes the system designer's job and the computer's job easier, and it leads in much more accurate approximations of how systems act in the actual world.



Fig. (1) General Multi Criteria Decision Making (MCDM) process.

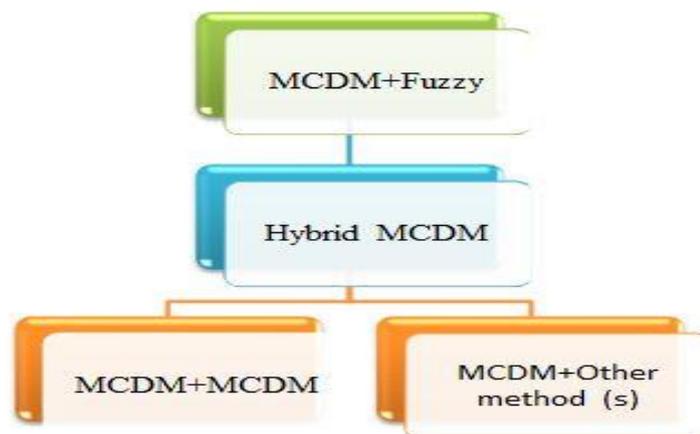


Fig. (2) Chart shows hybrid. method construction

Literature review

There are multiple decision criteria in most real-world situations. Techniques like MCDM have been developed to solve complex problems. The goal of MCDM is to determine overall preferences among several options. MCDM methods are used to outrank options or make a final decision that is in line with the goal. In this research paper, a fuzzy hybrid (MCDM) methodology is used to select employees. (FAHP) would be used to deal with a situation of dependency in regards to feedback among each measurement criteria. Finally, they're used to decide out which options are the best for people to choose from. using (TOPSIS). We combine the Fuzzy AHP & Fuzzy TOPSIS methodologies to create a more effective people selection system.

Table (1) research literature.

SN. NO.	Algorithm	WORK DONE	RESEARCHER(S)
1.	MCDM	It then looks at how MCDM has been used in 16 Australian case studies to see how ambiguity has been dealt with in practise. The findings show that when MCDM is used correctly, it may handle the uncertainties that arise from decision-makers' preferences and the employment of various approaches (epistemic uncertainty).	Razieh Mosadeghia , Jan Warnkenb , Rodger Tomlinsona and Hamid Mirfenderesk.
2.	Analytical Hierarchy Process.	This study employs the pair-wise weighting method (i.e. Analytical Hierarchy Process) to determine priorities for several criteria for converting urban commuters to public transportation. The primary poll was undertaken to gather data for defining public preferences for four parent criteria: reliability, comfort, safety, and cost, which were determined based on literature analysis and expert opinion.	Suresh Jain , Preeti Aggarwal , Prashant Kumar, Shaleen Singhal, Prateek Sharma.
3.	MCDM Methods.	Multi-criteria decision making analysis was created to represent complicated issues like this. This article looks at how 22 different techniques from this discipline were implemented in 11 different classes in the construction industry. The most important techniques are usually discussed, with their major advantages and disadvantages highlighted.	Daniel Jato-Espino , Elena Castillo-Lopez , Jorge Rodriguez-Hernandez , Juan Carlos Canteras-Jordana.
4.	AHP,ELECTRE, TOPSIS and COPRAS Methods.	The review delves into the multi-criteria procedures that are most commonly employed when evaluating the long-term viability of infrastructure developments.	I. Navarro Martínez, J.V. Martí Albiñana , V. Yepes Piqueras.
5.	AHP,ELECTRE, TOPSIS, PROMETHE And SMART Methods.	The purpose of the project is to look at (MCDM) models, analyse each approach, and perform a critical correlation to evaluate them from the perspective of a maintenance manager. Its first phase of the research examines how Techniques have been applied in different publications, while the second section develops a list of conditions for categorising different strategies.	Davood Sabaei, John Erkoyuncu , and Rajkumar Roy.
6.	BF-TOPSIS and BF-ELECTRE1.	The goal of this study is to develop new approaches for dealing with multi-criteria decision-making (MCDM) problems in which a decision maker's subjective input is expressed using bipolar fuzzy information.	M. A. Alghamdi , Noura Omair Alshehri, Muhammad Akram.
7.	Fuzzy-TOPSIS.	The TOPSIS approach is proposed for aggregating picture fuzzy information. To demonstrate the applicability of the proposed approach, we present several numerical examples of group decision-making problems.	Shahzaib Ashraf, Tahir Mahmood, Saleem Abdullah, Qaisar Khan.
8.	Fuzzy-MCDM.	This paper discusses some of the oldest and most recent applications of category in fuzzy multi-criteria decision-making.	Lazim Abdullah.
9.	(PF-ELECTRE I).	The goal of this work is to adapt the ELECTRE I method to the Pythagorean fuzzy ELECTRE I (PF-ELECTRE I) approach in a group decision-making setting, because the Pythagorean fuzzy set model is a better tool for capturing ambiguity and incompleteness in human judgments.	Muhammad Akram, Farwa Ilyas, Harish Garg.
10.	Fuzzy VIKOR.	This approach was created to tackle multiple criteria decision-making issues facing competing and non-commensurable criteria, with the assumption that compromising is acceptable for conflict resolution. In this study, the options were considered using the VIKOR technique in a fully fuzzy environment with fuzzy sets, and from all defined criteria.	G. Nilay Yücenur, Nihan Çetin Demirel.

11.	(WASPAS),TOPSIS and FUZZY-AHP.	To ensure the accuracy of the results, a statistical analysis is performed. Both techniques of multi-criteria analysis were effective, with TOPSIS being a little more restrictive in its performance score assigning. Synthetic fibres, as well as fibres with high tensile strength and elastic modulus, were found to be appropriate options.	Carlos J. Slebi-Acevedo, Pablo Pascual-Muñoz, Pedro Lastra-González and Daniel Castro-Fresno.
12.	Fuzzy-Delphi ,Fuzzy-AHP,Fuzzy-TOPSIS.	The study's fuzzy multiple-criteria approach enables for both quantitative and qualitative data, making the ambiguous decision-making process more objective and analytical. The study emphasises the significance of "proper scale" and how the priority order of technologies varies across expert domains.	Manoj Govind Kharat, Shankar Murthy, Sheetal Jaisingh Kamble, Rakesh D. Raut, Sachin S. Kamble, Mukesh Govind Kharat.
13.	FAHP-TOPSIS, FAHP-VIKOR, FAHP-ELECTRE, and FAHP-PROMTHEE	In the sugar business, multi-criteria decision-making techniques for solving the problem of pipe material selection. The four approaches utilised to choose the best option among several materials are FAHP-TOPSIS, FAHP-VIKOR, FAHP-ELECTRE, and FAHP-PROMTHEE.The effectiveness and adaptability of the VIKOR approach are investigated by comparing the ranking performance of several MCDM methods.	L. Anojkumar , M. Ilankumaran , V. Sasirekha.
14.	FAHP-TOPSIS.	In a fuzzy environment, little research has been done on this subject. For wind power plant site selection in Vietnam, a hybrid Fuzzy Analytic Hierarchy Process (FAHP) and The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) has been created. In the early stages of this study, an FAHP model is developed for calculating the weight of each potential wind power plant location based on qualitative and quantitative parameters. In the final stage, a TOPSIS is used to rank all possible solutions.	Chia-Nan Wang , Ying-Fang Huang , Yu-Chien Chai , and Van Thanh Nguyen.
15.	FAHP,Fuzzy VIKOR.	Because of the features of the assessment process, fuzzy logic is used. Experts used fuzzy AHP to evaluate the criteria weights, and fuzzy VIKOR to evaluate the e-government websites of a set of selected EU countries as a multi-criteria decision making (MCDM) technique, and a ranking was produced.	Serhat Burmaoglu, Yigit Kazancoglu.
16.	SWARA and Multi-MOORA.	Because numerous results from engine tests and studies are achieved, determining the availability of the best suited alternative fuel is difficult. The criteria weights are computed using SWARA (Step-Wise Weight Assessment Ratio Analysis) from multi-criteria decision-making models, and MULTIMOORA (Multi-Objective Optimization on the Basis of Ratio Analysis) is ranked from best to worst according to fuel properties.	Sinan Erdogan and Cenk Sayin.
17.	DANP with PROMETHEE.	The goal of this paper is to use a hybrid multi-criteria decision-making model that combines DEMATEL based on ANP (DANP) and Preference Ranking Organization METHod for Enrichment Evaluations to select the optimal GMP based on dimensions and relevant factors. A methodological framework for evaluating GMP is given, and it is evaluated in an individual case industrial located in the southern region of India, which is the major manufacturer of pneumatic tires and tubes.	Kannan Govindana , Devika Kannanb and Madan Shankar.
18.	Fuzzy-[AHP with TOPSIS], Fuzzy-[AHP with WASPAS] and Fuzzy-[AHP with MABAC].	The top four green supplier selection criteria, according to AHP studies, are "environmental management system," "pollution control," "quality," and "green image." Furthermore, the consistency test was used to ensure that the expert's input was consistent, and sensitivity analysis was used to assess the approach's 'robustness.' The findings show that the fuzzy hybrid approaches used achieve common green supplier ranks.	Shubham Guptaa , Umang Sonia, Girish Kumar

19.	F-ANP,F-TOPSIS AND F-ELECTRE.	It is significantly more complicated due to the multi-criteria nature and the existence of both qualitative and quantitative components.This research provides a fuzzy hybrid multicriteria decision-making strategy that allows both qualitative and quantitative elements to be considered. This paper is unusual in that it uses a combination of Fuzzy ANP, Fuzzy TOPSIS, and Fuzzy ELECTRE approaches, proposes an MCDM methodology for sniper selection, and applies these techniques to an actual instance.	Mehmet Kabak , Serhat Burmaoglu , Yigit Kazançoglu.
20.	Fuzzy-[GRA with VIKOR].	To deal with the evaluation of service reliability issues in international airports, a new fuzzy MCDM approach is presented. An efficient algorithm was used to solve this model, which took into account the decision-attitude maker's and/or preference for customer ratings on weights and performance ratings for each criterion. The findings of this study showed that this strategy is a good way to deal with MCDM challenges involving subjective qualitative attribute assessments in a fuzzy environment.	Ming-Shin Kuo , Gin-Shuh Liang.
21.	TOPSIS, VIKOR and ELECTRE Method.	This research uses four MCDM approaches - WSM, VIKOR, TOPSIS, and ELECTRE - to compare and rank renewable energy sources (RES) for power generation in Taiwan. The relevance of each criterion for RES ranking is determined using the Shannon entropy weight approach. Then, for quantitative evaluation, four MCDM approaches are used to rank all available RE options. In all assessment criteria, efficiency comes first, trailed by job creation, operating, and servicing costs, according to the weights results obtained.	Hsing-Chen Leea , Ching-Ter Chang.
22.	Fuzzy-VIKOR.	Site selection is a complex multi-criteria decision-making (MCDM) problem that necessitates the examination of several potential solutions as well as opposing quantitative and qualitative criteria. The ratings and weights for the selection criteria are evaluated in this paper using linguistic variables, which can be written as trapezoidal fuzzy numbers. The fuzzy decision matrix is transformed into crisp values using the ordered weighted averaging operator, which takes into account the decision maker's attitude. The extended Visekriterijumska optimizacija I KOMpromisno Resenje (VIKOR) technique is used to determine the prioritized ranking of alternatives while choosing the optimal site.	Hu-Chen Liu,Jian-Xin You,Yi-Zeng Chen ,Xiao-Jun Fan.
23.	Fuzzy-VIKOR.	The VIKOR method was created to solve multiple criteria decision making (MCDM) problems with conflicting and non-commensurable (different units) criteria, assuming that compromising is acceptable for conflict resolution, the decision maker wants the closest solution to the ideal, and the alternatives are evaluated using all established criteria. The ratings in this paper are evaluated using linguistic values.and their respective weights These linguistic evaluations can be expressed as fuzzy trapezoidal or triangular shapes.numbers. Then, using fuzzy sets theory and the VIKOR approach, a hierarchy MCDM model is proposed.cope with the supply chain system's supplier selection issues The use of a numerical example is suggested.exemplify how the suggested paradigm can be used.	Amir Sanayei , S. Farid Mousavi , A. Yazdankhah.

24.	Fuzzy- Analytical Hierarchy Process.	With the help of the case manufacturing manager into (AHP) in a fuzzy environment, the vital barrier was identified, and among those common barriers, the important barrier was discovered with the help of the case production manager into an (AHP) findings demonstrate that financial restrictions are the most significant impediment to CSR adoption in the Indian textiles industry, which is subsequently confirmed by comments from case industry managers. This research gives sociological and scientific insights, acknowledges limitations, and proposes a method that can be expanded in the future if other components are added.	Lixin Shen , Kannan Govindan and Madan Shankar.
25.	(TIFNs),(ANP), (PROMETHEE).	The MCDM approach is typically used in the areas of management and energy. A decision framework integrating triangular intuitionistic fuzzy numbers (TIFNs), (ANP) and (PROMETHEE) is designed and developed for both the site location of wind power generation stations, keeping in view the effective implementation of offshore wind power and the absence of meaningful coastal management (OWPS).	Yunna Wu a,b , Yao Tao , Buyuan Zhang a,b , Shiman Wang , Chuanbo Xu , Jianli Zhou.
26.	(BOCR) and Analytic Process Network.	The strategy calls for identifying and removing impediments to renewable energy utilisation. It is built on the foundation of two models: the Benefit, Opportunity, Cost, and Risk (BOCR) and the Analytic Network Process (ANP) models. The mutual weight of strategic factors such as technology, economy, energy vulnerability, security, global effects, and human wellbeing is used in the analysis. We discovered that solar energy would be Iran's preferred renewable energy source using the integrated model.	Reza Alizadeh , Leili Soltanisehat , Peter D. Lund b , Hamed Zamanisabzi.
27.	(FUCOM), COPRAS, (ARAS), (WASPAS), (SAW), (MABAC).	This study propose a hybrid MCDM model to assess and suppliers evaluating in a building company's sustainable supply chain. A set of 21 criteria covering all aspects of sustainability were used to evaluate and select suppliers. FUCOM was used to calculate the weight values of criteria, although the alternatives were assessed using a modern rough COPRAS technique. Already before considering the role of criteria and assessing the alternatives, the rough Dombi aggregator was used for collating in group decision-making.	Bojan Matić , Stanislav Jovanović , Dillip Kumar Das , Edmundas Kazimieras Zavadskas , Željko Stević , Siniša Sremac and Milan Marinković.
28.	Fuzzy- MULTIMOORA method.	Therefore in study, the risk factors & of there weights are regarded as input sets and assessed with fuzzy linguistic terms. As a result, for evaluating the risk of component failures, a novel probability impact model application of fuzzy number theory as well as the MULTIMOORA methodology is introduced. To demonstrate the potential uses and benefits of the proposed fuzzy FMEA, an experimental case of avoiding newborn abduction is presented. The article's principal conclusions are the proposed technique for assessing and grading failure modes, as well as its application to the avoidance of newborn abduction, which is a terrible situation for a medical facility.	Hu-Chen Liu , Xiao-Jun Fan a , Ping Li , Yi-Zeng Chen.
29.	fuzzy- ANP and (FROV).	This research presents a fuzzy-MCDM strategy that incorporates fuzzy predicted utility values theory and fuzzy-MCDM. The implementation of the proposed technique was illustrated using a real-world hypermarkets selection problem. Based on the expert discussions, the measurement items for retail location choices were identified. A network was then constructed for the fuzzy- ANP method. The financial dimension represented in the suggested approach was generated using the fuzzy real option value for each choice. Finally, the perceived importance of the criteria was determined, as well as the satisfaction ranking of the options.	A. Cagri tolga, fatih tuysuz, cengiz kahraman.

30.	Fuzzy-TOPSIS.	Because many messages are restricted by fuzzy preference regards, fuzzy numbers comparison and accumulation based on fuzzy preference relation are important issues in the fuzzy extension of TOPSIS to calculating distance values among choices and ideal (or anti-ideal) solution or rank attainable choices. However, calculating a fuzzy preference connection on a pair-wise comparison is frequently too difficult. For computing euclidean distance among choices and ideal (or anti-ideal) solution, or finding relative proximity coefficients of alternatives, To get around the problem, we use a relative fuzzy decision matrix improved from a fuzzy preference relation TOPSIS has a fuzzy extension. TOPSIS seems to have a fuzzy augmentation, and we use a relative fuzzy decision matrix improved from a fuzzy preference relation.	Yu-Jie Wang.
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#### A review of the literature on GAPS

The above literature survey, reveals that little work is done on the application of hybrid MCDM in fuzzy. It is really an advanced technique of MCDM. Few researchers have used the hybrid MCDM for ranking techniques in the field of fuzzy but very little in the case of FMCDM. hybrid FMCDM is not explored yet.

#### Conclusion

Following a review of the literature, it was discovered that the reason for choosing the decision-making method is briefly described in almost all of it. Also, a gap in the general overview for choosing a decision-making method based on decision-maker preference has been identified. Although this paper can help industries select a technique for using hybrid FMCDM to improve their decision efficiency and effectiveness based on their policies and preferences, it can also fill a gap in the literature by providing a general overview of various decision making methods. When considering the application FMCDM, keep the following points in mind:

1. In decision-making cases, many researchers worked on hybrid MCDM modelling, however the hybrid models were always AHP or ANP hybrid models. Rather than creating AHP or ANP hybrid models with other MCDM methods, hybrid models of other MCDM methods can be created to combine the effectiveness of various methodologies while reducing the risk of final decision errors.
2. Implementation of a hybrid multi-criteria decision-making strategy that combines two Methodology to address the problem in a rational order.
3. Comparing the results of the hybrid MCDM technique with benchmarked problems to test its performance.
4. Application of the hybrid MCDM technique with real case study.
5. Calculation of criteria weight by mathematical method.

6. After developing Hybrid multi-criteria decision-making strategy use a Software that solves any problem within consistent ranking process.

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