BILINGUAL PUBLISHING GROUP

Journal of Management Science & Engineering Research
https://journals.bilpubgroup.com/index.php/jmser

ARTICLE

A Comprehensive Guide to the COPRAS method for Multi-Criteria Decision Making

***Hamed Taherdoost*[1,2,3], *Atefeh Mohebi*[3*]**

[1] *Hamta Business Corporation, Vancouver V6E 0A7, British Columbia, Canada*
[2] *Q Minded | Quark Minded Technology Inc., Vancouver V5K 0B8, British Columbia, Canada*
[3] *Department of Arts, Communications and Social Sciences, University Canada West , Vancouver V6B 1V9, British Columbia, Canada*

Abstract

MCDM has been utilized as a proficient decision-making technique for numerous decades. Complex Proportional Assessment (COPRAS) method, a prominent technique in multi-criteria decision-making (MCDM) which offers a systematic and effective framework for evaluating alternatives and making informed choices. The versatility of COPRAS is demonstrated via case studies across various domains, such as engineering, business, and environmental management, showcasing its adaptability and robustness in providing solutions to diverse decision-making scenarios. There is a lack of a comprehensive guide and a reviewing of application, strengths, and limitation for this method in the literature. Therefore, this study aims to offer an in-depth understanding of the COPRAS approach, including its applications, advantages, and disadvantages. Additionally, it provides detailed guidance on how to utilize the COPRAS methodology for decision-making and real-life problems.

Keywords: Multi-Criteria decision making; COPRAS; Decision-making; Complex proportional assessment; Multi-criteria decision-making.

1. Introduction

Multi-Criteria Decision Making (MCDM) has evolved significantly since its inception, with a growing body of methodologies developed to address the complex nature of decision-making processes that

*CORRESPONDING AUTHOR:
atefeh.mohebi@ucanwest.ca | hamed.taherdoost@gmail.com

ARTICLE INFO
Received: 1 March 2024 | Revised: 15 April 2024 | Accepted: 16 April 2024 | Published Online: 23 May 2024
DOI: https://doi.org/10.30564/jmser.v7i2.6280

CITATION
Hamed Taherdoost, 2024. A Comprehensive Guide to the COPRAS method for Multi-Criteria Decision Making. Journal of Management Science & Engineering Research. 7(2): 1–14. DOI: https://doi.org/10.30564/jmser.v7i2.6280

involve multiple, often conflicting, criteria. Central to the field is the work of Hwang and Yoon [1], who introduced foundational methods for MCDM, and Triantaphyllou and Triantaphyllou [2], who provided a comparative study of MCDM methods, highlighting their application and theoretical underpinnings. The field of multicriteria decision making (MCDM) is employed to successfully address difficulties related to multicriteria decision making. These strategies are frequently employed in several domains of daily life as well as in professional contexts. Moreover, these methodologies, including the Analytic Hierarchy Process (AHP), the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), and the Complex Proportional Assessment (COPRAS) method, have been applied across various domains, demonstrating the versatility and robustness of MCDM techniques in facilitating decision-making [1,2]. Recent advancements in MCDM reflect a growing emphasis on integrating sustainability and environmental considerations into decision-making processes, showcasing the field's adaptability to contemporary challenges.

The "Complex Proportional Assessment" or COPRAS method was introduced by Zavadskas and Kaklauskas [3] and was utilized to assess the superiority of one option over another and enables the comparison of options [4]. This approach can be used to optimize criteria in an evaluation including multiple factors [5]. The COPRAS technique systematically rates and assesses options based on their importance and utility level [6]. This method is built on the premise of linear normalization, which allows for the direct comparison of diverse criteria by converting them into a common scale. Moreover, it incorporates the relative importance of each criterion into the decision-making process, enabling decision-makers to articulate and integrate their preferences and priorities into the analysis [7]. This method is commonly employed in decision-making scenarios with unclear outcomes [8]. It has undergone numerous advancements as a widely used approach for making decisions using multiple factors. Vahdani, Mousavi [9] created a novel COPRAS method using interval values to address the issue of robot selection. Turanoglu Bekar, Cakmakci [10] used the COPRAS technique with grey numbers theory to develop a decision support system for enhancing maintenance performance through the assessment of total productive maintenance (TPM) strategies. Mishra, Rani [11] introduced an expansion of the COPRAS method that can be applied to hesitant fuzzy sets for assessing service quality. Kumari and Mishra [12] demonstrated the application of multicriteria decision making using intuitionistic fuzzy sets to choose a green supplier.

The aim of this paper is twofold: to provide an in-depth exploration of the COPRAS method within the context of MCDM and to underscore its utility and efficiency through a review of its theoretical foundations, procedural details, and varied applications. By doing so, this study seeks to illuminate the unique attributes of COPRAS that contribute to its effectiveness as a decision-making tool, including its adaptability to different decision-making contexts and its capacity to handle complex decision problems with multiple criteria. Moreover, this study showcases the practical applications of COPRAS across various domains, demonstrating its capacity to facilitate decision-making in real-world scenarios. These applications not only testify to the method's versatility but also provide valuable insights into its operationalization and the potential challenges encountered in different decision-making environments. In conclusion, this study will be brought to a close with a final section summarizing our findings.

2. Application of COPRAS

COPRAS is one such MCDM method that has been used in different applications such as Neuroscience, Social Science, Energy, Mathematics and Engineering. **Figure 1** displays the distribution of research articles that utilize the COPRAS approach, categorized by subject area. This distribution is derived from the search results for "COPRAS", "MCDM" and "Complex Proportional Assessment" in the Scopus database, namely from papers that feature "COPRAS", "Complex Proportional Assessment" and "MCDM" in their title, abstract, or keywords. The results demonstrate the implementation of the COPRAS approach across various subject domains.

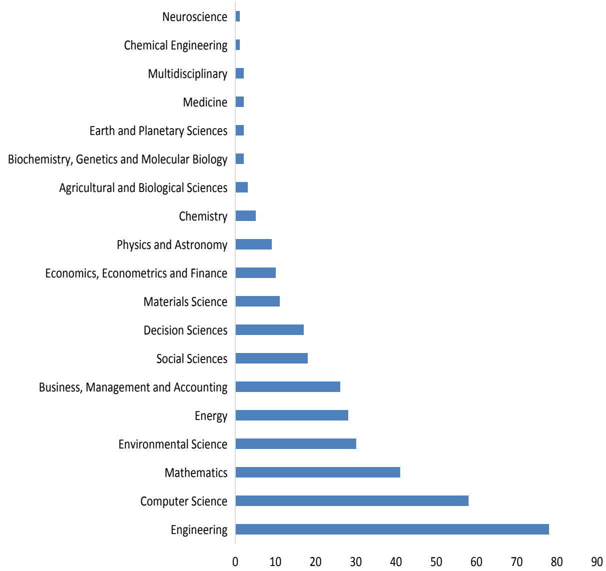

Figure 1. Application of COPRAS in various areas.

Based on the results obtained from the Scopus database, we'll explore in more detail how the COPRAS approach is uniquely utilized and valued in these fundamental domains, beginning with Engineering, then delving into its implications in Mathematics, on to Energy, then Business, Management and Accounting and ultimately examining its influence in the Social Sciences.

2.1. Engineering

The COPRAS approach is commonly used in engineering for complicated decision-making situations such as project evaluation, material selection, and infrastructure construction. Engineers use COPRAS to evaluate different materials, technologies, or designs by considering many factors like cost, durability, environmental effect, and performance efficiency. COPRAS is used in civil engineering to choose the most sustainable construction materials by assessing their lifespan environmental impact in addition to traditional factors such as cost and strength. **Table 1** provides a detailed summary of the different applications of the COPRAS technique in Engineering, demonstrating its effectiveness in solving complicated multi-criteria decision-making challenges. It also emphasizes other approaches used in combination with COPRAS.

Table 1. Application of COPRAS in Engineering.

Author	Application of Problem	Respondents	Methods
[13]	This study integrates COPRAS and ANP methods under interval-valued intuitionistic fuzzy environments for evaluating healthcare risks, illustrating its application in a hospital service setting.	Cross-functional team members, including employees and patients in a hospital service setting, serve as the primary data source for the risk assessment.	IVIF-COPRAS and IVIF-ANP
[14]	This study identifies and evaluates risks in urban natural gas projects in Shiraz, focusing on human resources threats. The study employs interviews, questionnaires, and case studies' information to gather data.	HSE experts, construction industry supervisors, and contractors involved in natural gas supply projects. Total respondents: 140 experts.	ANP and COPRAS
[15]	The study examines the management of autonomous vehicles in mixed traffic by introducing a decision support system that utilizes T2NN and COPRAS methodology to provide policymakers with several control options.	Not applicable (The study is based on theoretical models and does not involve primary research with human respondents.)	T2NN-Entropy-COPRAS
[16]	The paper focuses on the selection of optimal sites for women's universities in West Bengal, India, incorporating various uncertainties related to site selection. It utilizes trapezoidal neutrosophic numbers and multi-criteria decision-making tools like AHP, TOPSIS, and COPRAS for evaluating and ranking potential sites.	Experts such as transportation engineers, architects, environmental engineers, civil engineers, geologists, environmental experts, and municipal officials were consulted for their opinions on different criteria corresponding to various locations.	AHP, TOPSIS, COPRAS
[17]	The paper presents an extended COPRAS approach for selecting optimal renewable energy sources (RES) within a Fermatean fuzzy set context. It introduces a novel Fermatean fuzzy Archimedean copula-based Maclaurin symmetric mean operator and new similarity measures to enhance decision-making in uncertain environments.	Not applicable, as the study focuses on theoretical development and application of a novel method rather than collecting data from respondents.	Fermatean fuzzy-COPRAS method integrated with Archimedean copula-based Maclaurin

2.2. Mathematics

COPRAS is essential in mathematics for enhancing decision-making models through a systematic method for managing various criteria. It is utilized for creating algorithms that can analyze extensive datasets to find the best solutions. Mathematical models that include COPRAS aid in simplifying intricate situations by breaking them down into manageable criteria, making it easier to analyze and compare different options. **Table 2** presents a comprehensive overview of selected publications on various applications of the COPRAS methodology in Mathematics, in addition to descriptions and the methodologies employed in the papers.

Table 2. Application of COPRAS in mathematics.

Author	Application of problem	Respondents	Methods
[18]	Text classification feature selection using ridge regression and COPRAS method for ranking features. Tested on ten real-world text datasets to demonstrate superiority over existing methods.	Simulation on ten real-world text datasets.	An Intergration of COPRAS
[19]	The paper proposes a task-based fuzzy integrated multi-criteria decision-making (MCDM) approach for selecting shopping malls, considering universal design criteria. It aims to enhance decision-making for shopping mall selection by incorporating universal design principles to cater to a wider range of consumer needs, including those with disabilities.	Experts acting as consumers to evaluate shopping malls based on tasks related to universal design criteria.	Fuzzy DEMATEL, R-MOORA, Fuzzy COPRAS
[20]	This study focuses on identifying and prioritizing risk factors in train collisions using fuzzy logic approaches. It aims to enhance safety management in the railway sector by evaluating critical risk factors contributing to collisions, with a case study on the collision near the Haft Khan Station.	Railway industry experts, including academics, technical, and management experts, were surveyed to gather their opinions on risk factors contributing to train collisions.	Fuzzy COPRAS, Fuzzy DEMATEL
[21]	The paper introduces a novel entropy measure in the context of Complex Spherical Fuzzy Sets (CSFS) and applies it to the COPRAS method for multi-criteria group decision-making (MCGDM), focusing on strategic supplier selection to enhance trading company efficiency.	Not applicable (methodological research)	Entropy Method and COPRAS
[22]	The study introduces a novel approach integrating AHP and COPRAS methods with Interval-Valued Pythagorean Fuzzy (IPF) logic for supplier selection. This aims to enhance decision-making under uncertainty and complexity in selecting suppliers.	The study focuses on the application of the method rather than collecting data from respondents.	Interval-Valued Pythagorean Fuzzy AHP (IPF-AHP) and Interval-Valued Pythagorean Fuzzy COPRAS (IPF-COPRAS)

2.3. Energy

The energy sector benefits from the COPRAS approach in renewable energy projects, energy efficiency studies, and energy source selection. The COPRAS technique improves decision-making in the energy sector by offering a formal framework to assess and compare various energy alternatives. By employing COPRAS, stakeholders may methodically evaluate the various features of renewable energy projects, including solar, wind, and hydroelectric power. This method enables a thorough assessment that encompasses economic and technical feasibility, as well as environmental implications and sustainability standards. COPRAS integrates multiple factors to enhance decision-making by allowing stakeholders to choose energy sources that are cost-effective, technically possible, ecologically responsible, and sustainable. The multi-criteria analysis guarantees that energy projects are in line with the overarching objectives of sustainability and efficiency, which are essential for progressing towards a more beneficial to the environment energy future. Several papers have been chosen to demonstrate the advantages of the COPRAS approach in the relevant subject (**Table 3**).

Table 3. Application of COPRAS in Energy.

Author	Application of Problem	Respondents	Methods
[23]	The study utilizes entropy, SWARA, and CORPRAS methodologies to optimize supplier selection in the fuel cell and hydrogen sector, focusing on uncertainty and erroneous information.	It implies the involvement of experts and stakeholders in the FCH industry for evaluating suppliers based on the proposed method.	SWARA, COPRAS, Entropy Method
[24]	The research explores the optimization of Best Available Techniques (BATs) to enhance cleaner production in the textile sector, using a case study from an integrated residential facility.	It involves a comprehensive process involving authorized personnel (managers, employees, operators), experts-consultants, and academicians from the relevant facility for the evaluation of BATs.	PROMETHEE, TOPSIS, VIKOR, ARAS, and COPRAS
[25]	The study is conducted on smart grid technologies that support renewable energy for decentralized energy investment projects using a hybrid picture fuzzy rough decision-making approach. It emphasizes the critical role of research and development and cost in selecting smart grid technologies.	It involves a comprehensive process that includes experts or stakeholders in the energy sector for the evaluation of technologies.	Multi Stepwise Weight Assessment Ratio Analysis (M-SWARA) and COPRAS and Picture Fuzzy Rough Sets (PFRSs)
[26]	The research evaluates clean energy technologies in Jiangsu Province, China, by comparing five Multi-Criteria Decision-Making (MCDM) methods: SAW, TOPSIS, ELECTRE, VIKOR, and COPRAS. The goal is to choose the most suitable renewable energy solution according to a specific set of criteria.	It involves the application of MCDM methods to evaluate clean energy technologies, suggesting an analysis based on expert inputs or predefined criteria.	SAW, TOPSIS, ELECTRE, VIKOR, and COPRAS
[27]	The study assesses post-disaster and emergency gathering spaces in Ankara's Gölbaşı district through Multi-Criteria Decision-Making Techniques to pinpoint appropriate locations for efficient catastrophe management. The article assesses clean energy technologies in Jiangsu Province, China, utilizing five MCDM approaches to determine the best appropriate solution according to particular criteria.	It implies the involvement of experts or stakeholders in disaster management for the evaluation of assembly areas.	AHP, TOPSIS , COPRAS and BORDA

2.4. Business, accounting and management

COPRAS in business, accounting, and management involves strategic planning, financial analysis, and resource optimization, going beyond basic decision-making. Businesses can assess and prioritize alternatives using various financial indicators such as cash flow, return on investment, and cost-benefit analysis in a systematic manner. Accounting helps evaluate the feasibility of financial strategies, investment choices, and risk management methods. Management applications involve integrating several factors to aid decision-making processes in areas such as performance appraisal, supplier selection, and project management. This comprehensive method guarantees conformity with corporate objectives, enhancing effectiveness, profitability, and enduring expansion. **Table 4** discusses specific research publications utilizing COPRAS methodologies in the relevant field.

2.5. Social science

The COPRAS technique in the social sciences improves policy and social program analysis by considering several variables such societal benefits, economic costs, implementation feasibility, and public approval. The framework allows for a systematic evaluation of the many implications of policy options, considering both quantitative and qualitative

Table 4. Application of COPRAS in business, accounting and management.

Author	Application of Problem	Respondents	Methods
[28]	The research presents a new Multiple Criteria Group Decision Making (MCGDM) framework for COVID-19 immunization techniques. It utilizes an extended fuzzy set method to assist in intricate and uncertain decision-making processes.	A panel of six Decision Experts (DEs) was involved in the study, assessing six criteria for prioritizing four groups for vaccination.	(COPRAS) method under a Picture Fuzzy Environment (PFE)
[29]	The research presents a novel hybrid simulation-based assignment approach for assessing airlines using several service quality metrics. This method aims to improve decision-making in assessing airline services by using multiple variables to more accurately represent service quality.	The study involved 58 experts in the evaluation process, providing their opinions on 28 criteria related to airline service quality. These experts are considered as decision-makers in the multi-criteria decision-making (MCDM) process.	TOPSIS, COPRAS, WASPAS, and EDAS
[30]	This paper explores the application of various MCDM methods for risk assessment in PPP projects, specifically focusing on Iranian highway projects. It aims to identify the most effective method for assessing and prioritizing risks.	The study involved experts in construction and risk management, including project managers, construction managers, and other professionals, who provided insights and evaluations of the risks.	SWARA, COPRAS, FANP, FAHP, FTOPSIS, SAW, and EDAS
[31]	The study investigates barriers to ML implementation for accident analysis in the Indian oil industry, aiming to identify and analyze these barriers to improve safety measures.	10 experts from the oil industry, including professionals with expertise in ML and accident analysis, were consulted to gather insights and validate the findings.	Delphi, DEMATEL, COPRAS
[32]	Evaluation and selection of coal transportation companies using a novel fuzzy SWARA-COPRAS approach. This study focuses on improving decision-making under uncertainty in the context of coal transportation in China.	Experts in coal transportation, who provided insights and evaluations of the criteria and alternatives for transportation companies.	SWARA, COPRAS

elements in a balanced manner. This strategy facilitates the prioritizing of interventions based on their effectiveness in addressing social concerns, ensuring that resources are given to efforts with the highest social returns. COPRAS assists policymakers and researchers in conducting a detailed and thorough evaluation to better match social interventions with community needs and values. This leads to more fair and successful results in the formulation of social policies and programs. **Table 5** discusses the research paper selection using the COPRAS approach in the discipline of Social Science.

The COPRAS technique is a versatile and effective multi-criteria decision-making tool used in numerous areas to address difficult decision-making challenges. It is commonly utilized in construction for project prioritization, in environmental management for resource allocation and waste management, in supply chain management for vendor selection and logistics optimization, in the energy sector for selecting the best energy sources, in healthcare for evaluating services, and in education for enhancing decision-making processes. COPRAS's versatility in many decision-making situations highlights its significance in strategic and operational management, making it an essential tool for firms seeking to enhance results across multiple criteria. COPRAS can be customized to suit different sectors, enabling well-informed decision-making that considers all pertinent considerations. **Table 6** provides a detailed summary of the numerous uses of the COPRAS approach in several study fields, demonstrating its widespread application in solving complicated multi-criteria decision-making challenges.

3. Advantages and disadvantages of copras technique

As we mentioned in the previous section, COPRAS Method is one of the popular MCDM meth-

Table 5. Application of COPRAS in social science.

Author	Application of problem	Respondents	Methods
[33]	The investigation introduces a methodology for choosing simulation tools for renewable energy systems in university teaching. The study tackles the issue of selecting the most suitable software for teaching renewable energy courses through the application of Multi-Criteria Decision-Making (MCDM) methods.	The study primarily involves expert opinions. It involves experts in the field of renewable energy were consulted to evaluate and rank different software tools.	Fuzzy Entropy, Fuzzy VIKOR, Fuzzy COPRAS
[34]	This study introduces the Proximity Indexed Value (PIV) method, a new Multi-Criteria Decision-Making (MCDM) strategy for ranking and choosing e-learning websites. The method is praised for its simplicity and effectiveness in reducing rank reversal issues when compared to other MCDM methods.	It utilizes illustrative examples previously solved by researchers using different MCDM methods for validation.	AHP, COPRAS, VIKOR
[35]	This research provides a Multi-Criteria Decision-Making (MCDM) model designed for sustainable decision-making in managing facilities of municipal residential complexes. The goal is to improve sustainability practices in the management of municipal buildings, with an emphasis on the EU and former Soviet Republic environments.	The study used a survey of 63 residents of social housing and engaged a group of 43 national level experts, including certified construction engineers, maintenance managers, and researchers, for evaluating and ranking different criteria related to social housing.	AHP, COPRAS, WASPAS
[36]	The study concentrates on choosing e-commerce technology adoption techniques for Indonesian small and medium enterprises (SMEs) utilizing the DTOE framework. The goal is to determine the most effective strategic way to improve e-commerce usage in these businesses, taking into account technological, organizational, and environmental aspects.	The study collected data through online surveys from experts based in Jakarta, Indonesia, including SME and digital economy researchers, e-commerce business leaders, and retail SME industry players, to obtain a comprehensive view from academics and industry practitioners.	Integrated DEMATEL-ANP, COPRAS
[37]	The paper presents a decision-making method that combines generalized fuzzy information to choose zero- and low-carbon materials in building, with the goal of promoting sustainability and minimizing environmental harm.	It involves experts in the field of construction and sustainability were consulted to evaluate and select materials based on various criteria.	CIRTIC, COPRAS

Table 6. Application of COPRAS in specific areas.

Author	Description	Research area
[38]	The study implements the COPRAS method as a decision support system for selecting the best sales marketing personnel at PT. Alfa Scorph, underlining the method's practicality in human resource management and performance evaluation.	Human Resource Management and Marketing
[39]	The research proposes a COPRAS-based decision-making strategy aimed at optimizing the selection of cluster heads in wireless sensor networks, highlighting the method's applicability in telecommunications.	Telecommunications
[40]	This study conducts a comparative analysis of European countries' management capabilities within the construction sector amid a crisis, utilizing the COPRAS method to assess and rank national performance.	Construction Management
[41]	This paper demonstrates the use of the COPRAS method for supplier selection in the supply chain, emphasizing its strategic importance in procurement and logistics management.	Supply Chain Management
[42]	It applies an improved COPRAS method for the selection of rapid prototyping systems, focusing on the method's adaptability in manufacturing technology evaluation.	Manufacturing Technology
[43]	In a comprehensive study, Mousavi-Nasab and Sotoudeh-Anvari combine TOPSIS, COPRAS, and DEA to address material selection problems, underscoring the method's integrative potential in materials engineering.	Materials Engineering
[44]	This study applies the COPRAS method coupled with imprecise data handling to select the most viable investment projects, showcasing the flexibility of COPRAS in financial decision-making under uncertainty.	Finance and Investment
[45]	This paper explores the integration of neuromorphic sets with the COPRAS method to advance multi-criteria decision-making processes, contributing to the field of decision sciences.	Decision Sciences
[46]	This study presents an integrated approach that combines intuitionistic dense fuzzy Entropy, COPRAS, and WASPAS for selecting manufacturing robots, showcasing the method's synergy with other MCDM tools in robotics.	Robotics and Manufacturing

ods such that the COPRAS technique evaluates the impact of both positive and non-benefit factors separately to establish the relative importance of the options. This is then used to select the optimum option through quantitative utility analysis. Furthermore, it has both advantages and disadvantages. COPRAS provides several advantages compared to other decision-making systems. It evaluates the most and least favorable solutions for further assessment, maintaining brief and straightforward computations, resulting in faster processing [47]. It ranks and evaluates options progressively based on their significance and level of applicability. **Table 7** contrasts the merits of the COPRAS method, including simplicity and adaptability, with its possible limitations, such as subjectivity in criterion weighting and difficulties in handling complicated scenarios, offering valuable insights for academics and practitioners.

Table 7. Mertis and demerits of COPRAS method.

Advantages	Disadvantages
Simplicity and ease of understanding, making it accessible to users with varying levels of expertise.	Reliance on subjective weighting of criteria, which can introduce bias based on the decision-maker's judgments.
Ability to handle both quantitative and qualitative criteria, facilitating comprehensive decision-making.	Limited in handling extremely complex decision-making scenarios with a vast number of criteria and alternatives.
Incorporates the relative importance of criteria, allowing for customized weighting based on decision-maker preferences.	Does not explicitly account for uncertainty or variability in criteria values, which may affect decision outcomes.
Effective for ranking and selecting alternatives in diverse fields, demonstrating versatility and applicability.	Comparative performance heavily depends on the chosen criteria and their weights, requiring careful selection and justification.
Effective for ranking and selecting alternatives in diverse fields, demonstrating versatility and applicability.	May not be as widely known or used as other MCDM methods, potentially limiting available resources and case study references.

The Complex Proportional Assessment (COPRAS) method is a recognized multi-criteria decision-making (MCDM) approach with proven efficacy in various fields. However, it has certain limitations that may impact its application. To mitigate these disadvantages, researchers have developed several strategies. One approach involves adopting hybrid methods that combine COPRAS with other decision-making frameworks like the Analytic Hierarchy Process (AHP) [48] or the Best-Worst Method (BWM) [49] to derive weights more systematically, thus reducing subjectivity. To address uncertainty in criteria evaluation, extensions of COPRAS have been proposed, incorporating fuzzy sets, stochastic models providing a more nuanced assessment under ambiguous conditions [50].

4. COPRAS technique step-by-step

The COPRAS method establishes a direct and proportional relationship between the significance and utility degree of alternatives and the criteria, including their weights and values, that effectively define the alternatives [51]. Also, this technique involves a systematic process of sequencing and evaluating options based on their relevance and utility. This strategy chooses the optimal decision by considering both the best and worst-case scenarios. Therefore, the features explored for COPRAS are its compensating nature, the independence of attributes, and the conversion of qualitative attributes into quantitative ones. The steps presented in the **Figure 2** are described in detail.

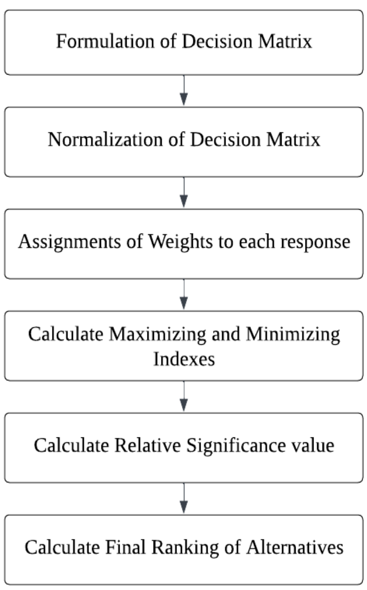

Figure 2. COPRAS Approach Process.

Step 1. Formulation of Decision Matrix

First, we need to construct the decision matrix based on the information from the decision makers which is shown in equation (1).

$$X = \begin{bmatrix} r_{11} & \cdots & r_{1j} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{nj} & \cdots & r_{mn} \end{bmatrix}_{m\times n} ;\ i = 1, \ldots, m,\ j = 1, \ldots, n \tag{1}$$

According to the matrix of equation (1), r_{ij} is the element of decision matrix for ith alternative in jth attribute. Also, decision makers provide the weight of the attributes $[w_1, w_2 \ldots, w_n]$.

Step 2. The Normalized Decision Matrix

Normalize the decision matrix from the previous step as depicted in equation (2).

$$r_{ij}^* = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}}; \qquad j = 1, \ldots, n \tag{2}$$

Here, r_{ij}^* indicates the normalized value of the decision matrix of *i*th alternative in *j*th attribute.

Step 3. The Weighted Normalized Decision Matrix

Equation (3) is utilized to calculate the values of the weighted normalized decision matrix.

$$\hat{r}_{ij} = r_{ij}^*. w_j; \qquad i = 1, \ldots, m, \qquad j = 1, \ldots, n \tag{3}$$

Where W_j is the weight of attribute $[w_1, w_2 \ldots, w_n]$.

Step 4. The Maximizing and Minimizing Indexes

The maximizing and minimizing indices for each attribute are determined based on whether the attributes are negative or positive, using equation (4) and (5).

$$S_{+i} = \sum_{j=1}^{g} \hat{r}_{ij}; \qquad i = 1, \ldots., m \tag{4}$$

$$S_{-i} = \sum_{j=g+1}^{n} \hat{r}_{ij}; \qquad i = 1, \ldots., m \tag{5}$$

Where g represents the number of positive attributes and n–g represents the number of negative attributes. S_i describes the maximum and minimizing indices of the ith attribute based on its type.

Step 5. The relative significance value

The importance of each alternative is determined using either equation (6) or equation (7).

$$Q_i = S_{+i} + \frac{min_i S_{-i} \sum_{i=1}^{m} S_{-i}}{S_{-i} \sum_{i=1}^{m} \frac{min_i S_{-i}}{S_{-i}}} \tag{6}$$

$$Q_i = S_{+i} + \frac{\sum_{i=1}^{m} S_{-i}}{S_{-i} \sum_{i=1}^{m} \frac{1}{S_{-i}}} \tag{7}$$

Step 6. The final rating of alternatives

The alternatives are ordered based on their relative importance values in descending order, with the highest final value receiving the first rank.

5. Discussion

Our research delves into the complexities of the Complex Proportional Assessment (COPRAS) method in multi-criteria decision-making, revealing a detailed perspective on its capabilities and areas of use. This section critically examines COPRAS, exploring its wide applicability in several fields, addressing its limitations, and considering future improvements for methodology. We intend to analyze the fundamental characteristics, difficulties, and changing significance of the method in aiding well-informed, sophisticated decision-making processes.

5.1. Versatility and applicability

The widespread use of the COPRAS technique in various fields such as engineering, healthcare, and energy highlights its adaptability and effectiveness in tackling a wide range of decision-making issues. Its capacity to manage both quantitative and qualitative criteria enables a thorough examination, making it a beneficial tool for different stakeholders. The adaptation of this method showcases its resilience and its ability to assist decision-making in industries aiming to incorporate multi-dimensional criteria into their evaluation processes.

5.2. Limitations and methodological advancements

COPRAS provides a systematic decision-making method, however its use of subjective criterion weighting could lead to biases that may impact the impartiality of the outcome. Exploring hybrid models that combine COPRAS with other decision-making frameworks shows potential for improving its accuracy and reliability. The capacity to incorporate other approaches can help counterbalance its shortcomings, providing a more well-rounded and sophisticated decision-making tool.

5.3. Innovation within the COPRAS framework

Recent progress in combining COPRAS with fuzzy logic and other probabilistic models has improved its ability to manage uncertainty, demonstrating the method's development. The changes enhance decision-making in ambiguous conditions and broaden the method's application to more complicated scenarios. Methodological improvements guarantee that COPRAS stays pertinent and efficient in handling the complexities of contemporary decision-making environments.

5.4. Future directions and research opportunities

The ongoing advancement of COPRAS, with methodological advancements and its use in new areas, offers extensive possibilities for future research. Exploring how it might be used with new technology and decision-making approaches could enhance its usefulness and efficiency. The advancement of COPRAS will play a crucial role in providing advanced tools to address the intricate aspects of modern decision-making difficulties as the processes become more complex.

6. Conclusion

The COPRAS method is a significant contribution to multi-criteria decision-making (MCDM), providing a thorough, effective, and adaptable approach for assessing and prioritizing options. This discussion explores the consequences of our findings, considering the method's use in other industries, its integration with other MCDM techniques, and potential areas for further research.

The COPRAS method's versatility is demonstrated by its implementation in several disciplines like engineering, healthcare, and energy management, highlighting its adaptability in complicated decision-making situations. The method's capacity to integrate both qualitative and quantitative criteria into a single assessment framework demonstrates its usefulness in aiding informed decisions. Furthermore, this study's examination of COPRAS in various situations reaffirms its suitability and offers a useful manual for stakeholders to use the method proficiently.

The research shows shortcomings in the COPRAS framework, namely concerning the subjective weighting of criteria, which could lead to biases impacting the decision-making process. This revelation indicates a crucial requirement for additional methodological breakthroughs to improve the objectivity and dependability of evaluations based on COPRAS. Hybrid models combining COPRAS with other decision-making frameworks may provide a solution by allowing a more systematic and balanced approach to criteria weighting and evaluation.

The talk focuses on the methodological advancements in the COPRAS framework, emphasizing the development of hybrid and advanced models to overcome its constraints. The advancements, such as incorporating fuzzy sets and other probabilistic models, are designed to address uncertainty and ambiguity in decision-making. These innovations enhance the method's strength and broaden its suitability for intricate and unpredictable decision-making scenarios.

The potential of COPRAS in enabling sustainable and strategic decision-making across different industries is still substantial in the future. The ongoing development of the method, by integrating new technology and interdisciplinary approaches, offers promising prospects for future research. Improving the analytical capabilities, reducing biases, and enhancing adaptability of the COPRAS method are essential for advancing the field of MCDM and ensuring its relevance and effectiveness in addressing future decision-making challenges.

This research highlights the crucial importance of the COPRAS method in furthering Multiple Criteria Decision Making (MCDM). This work contributes to the greater conversation on decision-making procedures by emphasizing its uses, examining its shortcomings, and proposing ways to improve its methodology. The COPRAS approach remains crucial for decision-makers dealing with complicated decision-making environments due to its established effectiveness and potential for advancement.

Author Contributions

Conceptualization, H.T.; methodology, H.T. and A.M.; formal analysis, H.T.; resources, A.M.; writing—original draft preparation, A.M.; writing—review and editing, H.T.; visualization, A.M. and H.T.; supervision, H.T. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare that they have no conflicts of interest in this work.

Funding

This research received no external funding.

References

[1] Hwang, C.-L., Yoon, K., 2012. Multiple attribute decision making: methods and applications a state-of-the-art survey. Springer Berlin, Heidelberg: Berlin.
DOI: https://doi.org/10.1007/978-3-642-48318-9

[2] Triantaphyllou, E., 2000. Multi-criteria decision making methods. Springer, Boston, MA: Boston.
DOI: https://doi.org/10.1007/978-1-4757-3157-6_2

[3] Zavadskas, E.K., Kaklauskas, A., Šarka, S., 1996. The new method of multicriteria evaluation of projects. Technological and Economic Development of Economy. 1(3), 131–139. Available from: https://etalpykla.vilniustech.lt/handle/123456789/128479

[4] Zavadskas, E.K., Kaklauskas, A., Vilutiene, T., 2009. Multicriteria evaluation of apartment blocks maintenance contractors: Lithuanian case study. International Journal of Strategic Property Management. 13(4), 319–338.
DOI: https://doi.org/10.3846/1648-715X.2009.13.319-338

[5] Podvezko, V., 2011. The comparative analysis of MCDA methods SAW and COPRAS. Engineering Economics. 22(2), 134–146.
DOI: http://dx.doi.org/10.5755/j01.ee.22.2.310

[6] Kaklauskas, A., Zavadskas, E.K., Naimavičienė, j., et al., 2010. Model for a complex analysis of intelligent built environment. Automation in construction. 19(3), 326–340.
DOI: https://doi.org/10.1016/j.autcon.2009.12.006

[7] Zavadskas, E.K., Turskis, Z., Kildienė, S., 2014. State of art surveys of overviews on MCDM/MADM methods. Technological and Economic Development of Economy. 20(1), 165–179.
DOI: https://doi.org/10.3846/20294913.2014.892037

[8] Ghorabaee, M.K., Amiri, M., Sadaghiani, J.S., et al., 2014. Multiple criteria group decision-making for supplier selection based on COPRAS method with interval type-2 fuzzy sets. The International Journal of Advanced Manufacturing Technology. 75(5), 1115–1130.
DOI: https://doi.org/10.1007/s00170-014-6142-7

[9] Vahdani, B., Mousavi, S.M., Tavakkoli-Moghaddam, R., et al., 2014. Robot selection by a multiple criteria complex proportional assessment method under an interval-valued fuzzy environment. The International Journal of Advanced Manufacturing Technology. 73(5), 687–697.
DOI: https://doi.org/10.1007/s00170-014-5849-9

[10] Bekar, E.T., Cakmakci, M., Kahraman, C., 2016. Fuzzy COPRAS method for performance measurement in total productive maintenance: a comparative analysis. Journal of Business Economics and Management. 17(5), 663–684.
DOI: https://doi.org/10.3846/16111699.201

6.1202314

[11] Mishra, A.R., Rani, P., Pardasani, K.R., 2019. Multiple-criteria decision-making for service quality selection based on Shapley COPRAS method under hesitant fuzzy sets. Granular Computing. 4(3), 435–449. DOI: https://doi.org/10.1007/s41066-018-0103-8

[12] Kumari, R., Mishra, A.R., 2020. Multi-criteria copras method based on parametric measures for intuitionistic fuzzy sets: application of green supplier selection. Iranian Journal of Science and Technology, Transactions of Electrical Engineering. 44(4), 1645–1662. DOI: https://doi.org/10.1007/s40998-020-00312-w

[13] Wang, L.E., H.C. Liu, M.Y. Quan, 2016. Evaluating the risk of failure modes with a hybrid MCDM model under interval-valued intuitionistic fuzzy environments. Computers and Industrial Engineering. 102, 175–185. DOI: https://doi.org/10.1016/j.cie.2016.11.003

[14] Balali, A., Valipour, A., Edwards, R., et al., 2021. Ranking effective risks on human resources threats in natural gas supply projects using ANP-COPRAS method: case study of Shiraz. Reliability Engineering and System Safety. 208, 107442. DOI: https://doi.org/10.1016/j.ress.2021.107442

[15] Gokasar, I., Simic, V., Deveci, M., et al., 2023. Alternative prioritization of freeway incident management using autonomous vehicles in mixed traffic using a type-2 neutrosophic number based decision support system. Engineering Applications of Artificial Intelligence, 2023. 123, 106183. DOI: https://doi.org/10.1016/j.engappai.2023.106183

[16] Alzahrani, F.A., Ghorui, N., Gazi, K.H., et al., Optimal Site Selection for Women University Using Neutrosophic Multi-Criteria Decision Making Approach. Buildings, 2023. 13(1), 152. DOI: https://doi.org/10.3390/buildings13010152

[17] Mishra, A.R., Rani, P., Saha, A., et al., 2022. Fermatean fuzzy copula aggregation operators and similarity measures-based complex proportional assessment approach for renewable energy source selection. Complex and Intelligent Systems. 8(6), 5223–5248. DOI: https://doi.org/10.1007/s40747-022-00743-4

[18] Mohanrasu, S.S., Janani, K., Rakkiyappan, R., 2023. A COPRAS-based Approach to Multi-Label Feature Selection for Text Classification. Mathematics and Computers in Simulation. In Press, Corrected Proof. DOI: https://doi.org/10.1016/j.matcom.2023.07.022

[19] Can, G.F., Delice, E.K., 2018. A task-based fuzzy integrated MCDM approach for shopping mall selection considering universal design criteria. Soft Computing. 22(22), 7377–7397. DOI: https://doi.org/10.1007/s00500-018-3074-4

[20] Hasheminezhad, A., Hadadi, F. , Shirmohammadi, H., 2021. Investigation and prioritization of risk factors in the collision of two passenger trains based on fuzzy COPRAS and fuzzy DEMATEL methods. Soft Computing. 25(6), 4677–4697. DOI: https://doi.org/10.1007/s00500-020-05478-3

[21] Aydoğdu, E., et al., 2023. A Novel Entropy Measure with its Application to the COPRAS Method in Complex Spherical Fuzzy Environment. Informatica (Netherlands). 34(4), 679–711.

[22] Erdebilli, B., Yilmaz, I., Aksoy, T., et al., 2023. An Interval-Valued Pythagorean Fuzzy AHP and COPRAS Hybrid Methods for the Supplier Selection Problem. International Journal of Computational Intelligence Systems. 16(1), no. 124. DOI: https://doi.org/10.1007/s44196-023-00297-4

[23] Alipour, M., Hafezi, R., Rani, P., et al., 2021. A new Pythagorean fuzzy-based decision-making method through entropy measure for fuel cell and hydrogen components supplier selec-

tion. Energy. 234, 121208.
DOI: https://doi.org/10.1016/j.energy.2021.121208

[24] Simsek, E., et al., 2022. Use of multi-criteria decision models for optimization of selecting the most appropriate best available techniques in cleaner production applications: A case study in a textile industry. Journal of Cleaner Production. 335, 130311.
DOI: https://doi.org/10.1016/j.jclepro.2021.130311

[25] Dinçer, H., Demirel, Y.E., Ozturk, E., et al., 2022. Analysis of renewable-friendly smart grid technologies for the distributed energy investment projects using a hybrid picture fuzzy rough decision-making approach. Energy Reports. 8, 11466–11477.
DOI: https://doi.org/10.1016/j.jclepro.2021.130311

[26] Effatpanah, S.K., Ahmadi, M.H., Aungkulanon, P., et al., 2022. Comparative Analysis of Five Widely-Used Multi-Criteria Decision-Making Methods to Evaluate Clean Energy Technologies: A Case Study. Sustainability (Switzerland). 14(3), 1403.
DOI: https://doi.org/10.3390/su14031403

[27] Atmaca, E., Aktaş, E., Öztürk, H.N., 2023. Evaluated Post-Disaster and Emergency Assembly Areas Using Multi-Criteria Decision-Making Techniques: A Case Study of Turkey. Sustainability (Switzerland). 15(10), 8350.
DOI: https://doi.org/10.3390/su15108350

[28] Almulhim, T., Barahona, I., 2023. An extended picture fuzzy multicriteria group decision analysis with different weights: A case study of COVID-19 vaccine allocation. Socio-Economic Planning Sciences. 85, 101435.
DOI: https://doi.org/10.1016/j.seps.2022.101435

[29] Ghorabaee, M.K., Amiri, M., Zavadskas, E.K., et al., 2017. A new hybrid simulation-based assignment approach for evaluating airlines with multiple service quality criteria. Journal of Air Transport Management. 63, 45–60.
DOI: https://doi.org/10.1016/j.jairtraman.2017.05.008

[30] Valipour, A., Sarvari, H., Tamošaitiene, J., 2018. Risk assessment in ppp projects by applying different mcdm methods and comparative results analysis. Administrative Sciences. 8(4), 80.
DOI: https://doi.org/10.3390/admsci8040080

[31] Gangadhari, R.K., Khanzode, V., Murthy, S., et al., 2023. Modelling the relationships between the barriers to implementing machine learning for accident analysis: the Indian petroleum industry. Benchmarking. 30(9), 3357–3381.
DOI: https://doi.org/10.1108/BIJ-03-2022-0161

[32] Xiang, Z., Naseem, M.H., Yang, J., 2022. Selection of coal transportation company based on fuzzy swara-copras approach. Logistics. 6(1), 7.
DOI: https://doi.org/10.3390/logistics6010007

[33] Ighravwe, D.E., Babatunde, M.O., Mosetlhe, T.C., et al., 2022. A MCDM-based framework for the selection of renewable energy system simulation tool for teaching and learning at university level. Environment, Development and Sustainability. 24(11), 13035–13056.
DOI: https://doi.org/10.1007/s10668-021-01981-1

[34] Khan, N.Z., Ansari, T.S.A., Siddiquee, A.N., et al., 2019. Selection of E-learning websites using a novel Proximity Indexed Value (PIV) MCDM method. Journal of Computers in Education. 6(2), 241–256.
DOI: https://doi.org/10.1007/s40692-019-00135-7

[35] Klumbytė, E., Raimondas Bliūdžius, Milena Medineckienė, et al., 2021. An MCDM model for sustainable decision-making in municipal residential buildings facilities management. Sustainability (Switzerland). 13(5), 2820.
DOI: https://doi.org/10.3390/su13052820

[36] Bening, S.A., Dachyar, M., Pratama, N.R., et al., 2023. E-Commerce Technologies Adoption Strategy Selection in Indonesian SMEs Using the Decision-Makers, Technological, Organizational and Environmental (DTOE) Framework. Sustainability (Switzerland). 15(12), 9361.
DOI: https://doi.org/10.3390/su15129361

[37] Krishankumar, R., Mishra, a.r., Cavallaro, F.,

et al., 2022. A New Approach to the Viable Ranking of Zero-Carbon Construction Materials with Generalized Fuzzy Information. Sustainability (Switzerland). 14(13), 7691. DOI: https://doi.org/10.3390/su14137691

[38] Alwali Daini Udda, S., H. Nelly Astuti, F. Fadlina, 2020. Sistem Pendukung Keputusan Pemilihan Sales Marketing Terbaik di PT. Alfa Scorph Menggunakan Metode COPRAS. 2(1), 62–68.

[39] Sengathir,J., Priya, M.D., Nithiavathy, R., 2023. COPRAS-Based Decision-Making Strategy for Optimal Cluster Head Selection in WSNs. 537–549. DOI: https://doi.org/10.1007/978-981-19-8825-7_46

[40] Kildienė, S., Kaklauskas, A., Zavadskas, E.K., 2011. COPRAS based comparative analysis of the European country management capabilities within the construction sector in the time of crisis. Journal of Business Economics and Management. 12(2), 417–434. DOI: https://doi.org/10.3846/16111699.2011.575190

[41] Madić, M., Markovi, D., Radovanovi, M., 2014. Application of COPRAS method for supplier selection. The Fifth International Conference Transport and Logistics-TIL 2014, Proceedings. 247161370.

[42] Makhesana, M.A., 2015. Application of improved complex proportional assessment (COPRAS) method for rapid prototyping system selection. Rapid Prototyping Journal. 21(6), 671–674. DOI: https://doi.org/10.1108/RPJ-03-2014-0027

[43] Mousavi-Nasab, S.H., Sotoudeh-Anvari, A., 2017. A comprehensive MCDM-based approach using TOPSIS, COPRAS and DEA as an auxiliary tool for material selection problems. Materials and Design. 121, 237–253. DOI: https://doi.org/10.1016/j.matdes.2017.02.041

[44] Popovic, G., Stanujkic, D., Stojanovic, S., 2012. Investment project selection by applying COPRAS method and imprecise data. Serbian Journal of Management. 7(2), 257–269. DOI: https://doi.org/10.5937/sjm7-2268

[45] Romualdas, B., Z. Edmundas Kazimieras, K. Artūras, 2019. Application of neutrosophic set to multicriteria decision making by copras. viXra, 2019.

[46] Swethaa, S., Augustin, F., Kaabar, M.K., 2023. An integrated intuitionistic dense fuzzy Entropy-COPRAS-WASPAS approach for manufacturing robot selection. Advances in Mechanical Engineering. 15(3), 168781322311602–168781322311602. DOI: https://doi.org/10.1177/1687813223116026

[47] Chaurasiya, R., Jain, D., 2022. Pythagorean fuzzy entropy measure-based complex proportional assessment technique for solving multi-criteria healthcare waste treatment problem. Granular Computing. 7(4), 917–930. DOI: https://doi.org/10.1007/s41066-021-00304-z

[48] Goswami, S.S., Behera, D.K., 2023. Developing Fuzzy-AHP-Integrated Hybrid MCDM System of COPRAS-ARAS for Solving an Industrial Robot Selection Problem. International Journal of Decision Support System Technology (IJDSST). 15(1), 1–38. DOI: https://doi.org/10.4018/IJDSST.324599

[49] Mahdiraji, H.A., Arzaghi, S., Stauskis, G. et al., 2018. A hybrid fuzzy BWM-COPRAS method for analyzing key factors of sustainable architecture. Sustainability. 10(5), 1626. DOI: https://doi.org/10.3390/su10051626

[50] Mardani, A., Devi, S., Alrasheedi, M., et al., 2023. Hybrid Intuitionistic Fuzzy Entropy-SWARA-COPRAS Method for Multi-Criteria Sustainable Biomass Crop Type Selection. Sustainability. 15(10), 7765. DOI: https://doi.org/10.3390/su15107765

[51] Kaklauskas, A., et al., 2006. Selection of low-e windows in retrofit of public buildings by applying multiple criteria method COPRAS: A Lithuanian case. Energy and buildings. 38(5), 454–462. DOI: https://doi.org/10.1016/j.enbuild.2005.08.005