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A Systematic Literature Review of Hybrid Multi-Criteria Decision-Making and Technique for Order Preference by Similarity to Ideal Solution Methods for Construction Material Supplier Selection

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ABSTRACT: Choosing the right supplier is critical in construction supply chain management, as it directly impacts cost, schedule, and material quality. This paper presents a systematic review of the integration of the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) with hybrid Multi-Criteria Decision-Making (MCDM) methods for building material supplier selection. Following the PRISMA procedure and quality assessment criteria adapted from CASP, JBI, and Kitchenham et al., only Scopus-indexed articles from 2020–2025 were considered. Out of 227 initial records, seven studies met all inclusion and quality criteria. Results showed increasing use of hybrid MCDM approaches, primarily in Asian contexts. Common weighting techniques included the Analytic Hierarchy Process (AHP), Best–Worst Method (BWM), and rough set theory, while advanced methods such as Rough–Dombi BWM, game-theoretic approaches, fuzzy–rough systems, and Entropy–G1 weighting were used to handle uncertainty and complex decision problems. Fuzzy-based representations, particularly Triangular Fuzzy Numbers, were widely employed, with evaluation criteria focused on cost, quality, risk, sustainability, and delivery performance. Hybrid MCDM–TOPSIS frameworks generally produced more consistent and structured decision outcomes. However, findings are limited due to the small number of studies. Key research gaps include insufficient empirical validation in developing-country contexts, limited incorporation of sustainability factors, and practical challenges related to data quality and computational complexity. Future research should prioritize real-world applications, integrate sustainability more thoroughly, and develop user-friendly decision-support tools for construction practitioners.

KEYWORDS: TOPSIS; hybrid MCDM; supplier selection; construction materials.

1. Introduction

Choosing the right suppliers was a critical aspect of supply chain management in the construction industry. Projects in this sector were typically complex, involved diverse resources, and were characterized by significant uncertainty. Selecting reliable and competent suppliers directly influenced project scheduling, cost control, and the overall quality of construction outcomes. In practical decision-making, supplier selection was rarely based on a single criterion; instead, it required the simultaneous consideration of multiple factors, including cost, quality, risk, sustainability, and delivery performance. Because such decisions were inherently complex, MCDM approaches were commonly employed to provide a more structured and transparent evaluation framework [1–3].

The Technique for Order Preference by TOPSIS was among the most widely used MCDM methods. Its popularity stemmed from its conceptual simplicity, computational efficiency, and ability to produce stable and consistent ranking results [4]. Compared with established methods such as the AHP, VIKOR, and the BWM, TOPSIS demonstrated strong competitiveness. Its frequent adoption did not necessarily reflect superiority over AHP or VIKOR but rather its intuitive structure and compatibility with other MCDM frameworks [5].

Despite this, Pramesti and Setiawan (2024) reported that although AHP- and fuzzy-based models were considered global standards, the application of hybrid TOPSIS in construction supplier selection remained limited [6]. This gap was noteworthy given the high stakes involved in procurement decisions. In construction projects, inappropriate supplier selection often triggered cascading effects, including schedule delays, quality deficiencies, and cost overruns, particularly because materials such as steel and cement constituted a substantial proportion of total project expenditures.

Recent years witnessed a significant shift toward methodological refinement, with hybrid MCDM configurations becoming increasingly prevalent. Advanced combinations such as AHP–TOPSIS [7] and BWM–TOPSIS [8–11], along with specialized integrations involving Rough Set Theory [12–14], were increasingly explored. These hybrid approaches strengthened decision-making robustness by better addressing uncertainty and complexity.

In parallel with these methodological developments, the rapid growth of digital tools—ranging from customized MATLAB implementations to open-source Python libraries such as PyTOPS—facilitated broader access to large-scale analytical capabilities. This advancement aligned with the broader trend toward digitalization and evidence-based decision-making in the construction industry.

Given the pace of these developments, it became necessary to critically examine how TOPSIS integrated with advanced hybrid frameworks, particularly in managing uncertainty and data variability inherent in real-world construction projects. This study contributed by systematically reviewing hybrid TOPSIS applications in supplier selection, aiming to bridge the gap between methodological development and practical technological implementation. Specifically, the study sought to (1) identify recent hybrid TOPSIS advancements, (2) examine their effectiveness in handling complex and uncertain data, (3) assess their practical adoption in construction contexts, and (4) highlight remaining research gaps within construction supply chain management.

2. Materials and Methods

At its core, this study employed a SLR to critically evaluate how TOPSIS had been integrated into hybrid MCDM frameworks. The objective was to synthesize existing evidence specifically related to its application in the high-stakes context of construction material supplier selection. The SLR approach was selected to ensure that the review process was transparent, systematic, and reproducible. The review protocol followed the PRISMA guidelines and was further strengthened by incorporating the SLR framework proposed by Kitchenham et al., together with quality assessment criteria adapted from CASP and JBI.

2.1. Review protocol and scope definition.

During the planning phase, the boundaries of the review were defined using the PICo framework, which focused on Population, Phenomenon of Interest, and Context to maintain a focused and relevant scope. This framework was applied to clearly delineate the review limits and ensure consistency throughout the study selection process. The specific components of the PICo framework used in this study are presented in Table 1. The population comprised studies related to supplier selection in the construction and building materials sectors. The phenomenon of interest concerned the application of TOPSIS and hybrid MCDM techniques, while the context involved construction material procurement supported by digital tools and decision-support systems.

Table 1. PICo framework used in the study.

Criteria	Description
Population	Studies addressing supplier selection within the construction sector and building-material industries.
Phenomenon of Interest	Application of TOPSIS and its integration with complementary MCDM techniques (e.g., AHP, VIKOR, BWM, Fuzzy, CRITIC).
Context	Decision-making processes in construction material procurement (e.g., cement, steel, concrete) and digital integration through MATLAB, Python, or Decision Support Systems.

2.2. Search strategy.

To identify the most recent and relevant research on hybrid MCDM–TOPSIS applications in construction procurement, the search strategy was confined to the Scopus database. Scopus was selected due to its extensive coverage and stringent indexing standards, particularly in the fields of engineering, construction management, and decision sciences. Although the inclusion of additional databases could have expanded the initial pool of studies, Scopus was considered sufficient to provide a high-quality and focused corpus of peer-reviewed literature aligned with the objectives of this SLR. The search process was conducted in three sequential stages: (1) keyword identification, (2) construction of Boolean search strings, and (3) final extraction of publications. The selected keywords and thematic groupings encompassing MCDM methodologies, construction-related applications, and digital decision-support tools, are presented in Table 2. Boolean operators (AND/OR) were applied to refine the search results, ensuring high relevance while excluding tangential or unrelated studies.

Table 2. List of keywords used for the search strategy.

Topic	Keywords
Decision-Making Methods (MCDM)	"TOPSIS", "AHP", "VIKOR", "BWM", "Fuzzy TOPSIS", "Hybrid MCDM", "Multi-criteria decision-making"
Construction Industry Context	"Construction industry", "construction materials", "supplier selection", "vendor evaluation", "building materials", "procurement"

Topic	Keywords
Digitalization and Technological Tools	“Python”, “MATLAB”, “decision support system”, “simulation”, “optimization”, “digital tools”, “AI integration”

2.3. Study selection process.

The study selection process was conducted in accordance with the PRISMA framework and involved multiple sequential screening stages. In the initial stage, all retrieved records were filtered by year of publication, language, and document type. Following this preliminary screening, titles and abstracts were reviewed to assess their relevance to construction procurement and MCDM applications. Articles that satisfied these initial criteria were subsequently subjected to a comprehensive full-text assessment. The specific inclusion and exclusion criteria used to refine the study selection are presented in Table 3. These criteria were strictly applied to ensure that the final synthesis included only peer-reviewed studies published between 2020 and 2025. In addition, the selection was restricted to articles written in English or Indonesian that employed empirical or applied MCDM–TOPSIS methodologies within the construction sector.

Table 3. Inclusion and exclusion criteria for study selection.

Criteria	Inclusion	Exclusion
Type of Publication	Peer-reviewed journal articles, conference proceedings	Editorials, opinion papers, non-scientific reports
Publication Year	2020–2025	Publications prior to 2020
Language	English or Indonesian	Other languages
Topic Relevance	Studies applying TOPSIS or other MCDM methods for construction supplier selection	Studies unrelated to MCDM or not addressing supplier selection
Approach	Empirical research, case studies, computational models using TOPSIS	Purely theoretical studies without application
Context Fit	Relevant to construction procurement or material supply chains	Irrelevant to the construction sector

2.4. Quality assessment.

Following study selection, a set of ten quality assessment questions adapted from CASP (2018), JBI (2020), and Kitchenham et al. was applied to evaluate the methodological rigor of the eligible studies. These questions addressed key aspects, including the clarity of research objectives, the appropriateness of the methodological design, the transparency of criteria weighting procedures, the robustness of case-study data, and the consistency between reported results and stated conclusions. The full set of quality assessment questions is presented in Table 4. Each study was scored using a three-point scale: 1 (Yes), 0.5 (Partially), and 0 (No). This approach enabled a consistent and systematic comparison of methodological quality across studies and ensured that only research meeting acceptable quality standards was included in the final synthesis.

Table 4. Quality assessment questions for evaluating selected studies.

No.	Quality Assessment Question
Q1	Is the research objective clearly stated and relevant to supplier selection or decision-making in construction?
Q2	Does the study present a specific problem statement supported by real industrial conditions or evidence?
Q3	Are the MCDM methods used (AHP, TOPSIS, BWM, FMEA, Entropy, Game Theory, etc.) described comprehensively and justified?

No.	Quality Assessment Question
Q4	Are the evaluation criteria and sub-criteria explicitly defined with theoretical or empirical justification?
Q5	Is the criteria-weighting approach (AHP, BWM, G1, Entropy, Fuzzy, Rough Set, etc.) transparently explained and reproducible?
Q6	Does the study use real case-study data or simulation data with clear sources?
Q7	Are the computational steps for TOPSIS or its variants (Fuzzy, Rough, Modified TOPSIS) sufficiently detailed and logically presented?
Q8	Are the results (supplier ranking, criteria weights, scenario analysis, performance outcomes) adequately interpreted and supported?
Q9	Does the study provide a meaningful discussion connecting the results with the research objectives?
Q10	Are the conclusions consistent with the findings and do they offer practical or theoretical contributions?

2.5. Data extraction and synthesis.

Data extraction was done for all studies that met the quality evaluation level. The extracted information encompassed bibliographic details, the employed MCDM and weighting methodologies, the application context within construction supply chains, the evaluation criteria utilized, and the principal findings pertaining to supplier ranking and decision performance. Then, the extracted data were put together using qualitative and descriptive methods to find patterns in the methods used, the most common analytical tactics, and the research gaps that keep coming up in the literature.

2.6. Analytical approach.

Due to the small number of research that fit the criteria (n = 7), the analysis mostly used simple statistical approaches like frequency counts and proportional distributions instead of more advanced bibliometric methods. This strategy is good for finding patterns and methodological trends in the current body of research without making unduly broad conclusions that would need a bigger sample size. The synthesis results are the basis for the theme analysis that is spoken about in the Results and Discussion section.

3. Results and Discussion

3.1. Literature search results.

The PRISMA standards were followed exactly during the research selection procedure, which included the steps of identifying, screening, assessing eligibility, and finally including. This organized methodology makes sure that the methods are clear and makes it easier to repeat the review process. Comparisons between industrialized and developing countries should be regarded as exploratory rather than conclusive, given the restricted sample size (n = 7). Consequently, the identified discrepancies provide informative insights into regional research methodologies rather than statistically sound classifications. The percentages in this section are only meant to be descriptive, so be careful when you read them. The initial literature search in the Scopus database revealed 227 publications. After then, these records went through several filtering processes, such as publication year, language, document type, topical significance, availability of full texts, and methodological quality. Figure 1 illustrates the PRISMA flow diagram that depicts the step-by-step selection process. It indicates that just seven studies met all of the inclusion and quality criteria, thus they were kept for further study.

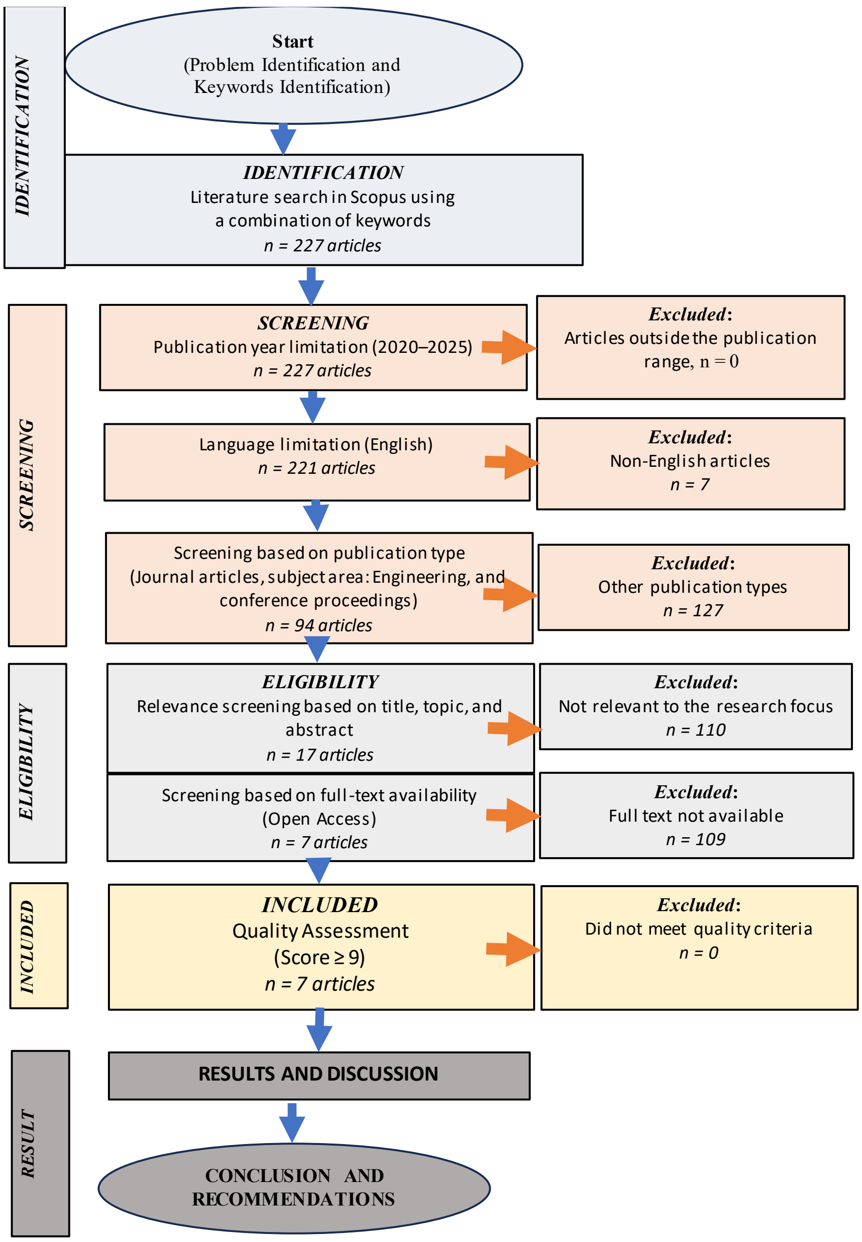

Figure 1. PRISMA flow diagram of the study selection process.

3.2. Selection of eligible studies.

Adhering to the SLR framework, we identified seven peer-reviewed publications that directly investigate the challenges of supplier selection using MCDM strategies across construction and related sectors. A comprehensive summary of these works detailing authorship, publication years, and primary methodologies, is provided in Table 5. Each selected study offered sufficient granularity regarding MCDM frameworks, evaluation criteria, weighting protocols, and final ranking outcomes, ensuring they were robust enough for a high-quality synthesis. This rigorous filtering process ensured that the final dataset specifically targeted the intersection of industrial complexity and decision-making logic. A concise breakdown of these papers, including authorship, publication year, and primary methodologies, is provided in Table 5. Crucially, each selected study offered a high level of detail regarding its weighting procedures, assessment criteria, and final ranking outcomes. This depth of data ensured that all seven publications were rigorous enough to support a comprehensive synthesis of the current landscape.

Table 5. Summary of selected studies for the review.

No.	Authors	Title of the Article
1	[15]	Green Supplier Evaluation in E-Commerce Systems: An Integrated Rough–Dombi BWM–TOPSIS Approach
2	[16]	Evaluation Model for Emergency Material Suppliers in Emergency Logistics Systems Based on Game Theory–TOPSIS Method
3	[17]	Optimization of Benefit Distribution in Green Supply Chain for Prefabricated Buildings Based on TFN–TOPSIS–Banzhaf Cooperative Game Theory
4	[18]	A Decision Support System for Sustainable Supplier Selection Problem: Evidence from a Radiator Manufacturing Industry
5	[19]	Selecting an Optimal Scenario for Addressing Supplier Selection Problem by Considering Sustainable Scheduling: A Hybrid Approach
6	[20]	Sustainable Suppliers Evaluation in the Waste Management Sector: The Case of a Leading Sicilian Enterprise
7	[21]	Research on Supplier Selection Based on Improved AHP–TOPSIS Method

3.3. Analysis of selected literature.

To ensure the synthesis remained both rigorous and systematic, we organized the findings from our seven core studies into five thematic dimensions: publication patterns, research focus, methodological frameworks, primary contributions, and the extent of technological integration. This structured approach does more than just categorize data; it provides a strategic lens through which to view the shifting research landscape, making it easier to pinpoint exactly where current MCDM supplier selection literature falls short. A geographical breakdown of the data shows a clear concentration of research in Asia, which accounts for an overwhelming 85.7% of the analyzed papers. The significant output from nations like China, Iran, Malaysia, and India highlights a robust regional drive toward digitizing supply chain logistics and decision-making processes. In contrast, only a single study emerged from Europe (14.3%), indicating a significant disparity in research output between these regions, despite the topic's global relevance. Looking at the timeline, we can see a gradual uptick in academic interest, peaking in 2025. While the years 2020, 2022, and 2023 each produced only a single relevant study, the recent surge suggests that hybrid decision-making is becoming a focal point for researchers.

Our thematic breakdown reveals that a striking 85.71% of the literature focuses exclusively on hybrid MCDM frameworks for supplier selection [15–17, 19–21]. These studies rarely rely on TOPSIS in isolation; instead, they integrate it with methodologies such as AHP, Fuzzy AHP, Rough Sets, BWM, or FUCOM to refine ranking precision and navigate the "gray areas" of data ambiguity. In contrast, only a minor fraction (14.29%) applies these tools to production scheduling or broader optimization tasks. This overwhelming preference for hybrid models signals a definitive industry departure from rigid, "one-size-fits-all" methodologies in favor of more versatile and resilient decision-making systems.

Geographically, the data confirms that Asia has become the dominant center for this research, contributing 85.7% of the reviewed papers. The high volume of output from China, Iran, Malaysia, and India points to a massive regional investment in digitized supply chain logistics. Meanwhile, Europe is represented by just a single study (14.3%), uncovering a stark disparity in research momentum between the two regions, a surprising find given the global scale of construction procurement challenges. The spatial and chronological evolution of these publications is mapped out in Figure 2.

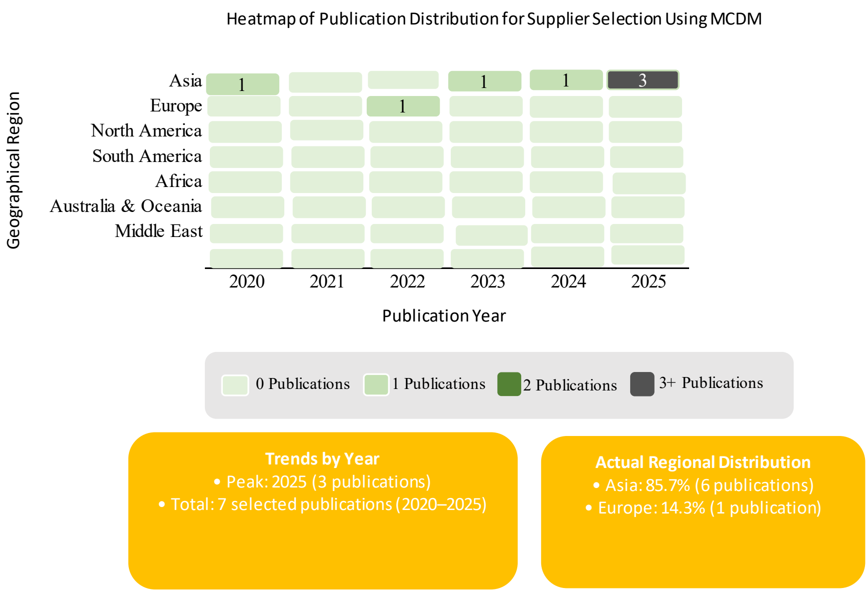

Figure 2. Heatmap of publication trends by year and geographic region.

Looking at the timeline, we can see a gradual uptick in academic interest, peaking in 2025. While the years 2020, 2022, and 2023 each produced only a single relevant study, the recent surge suggests that hybrid decision-making is becoming a focal point for researchers. Only a small fraction (14.29%) shifts the focus toward production scheduling or broader optimization. This heavy lean toward hybrid models marks a clear industry transition away from "one-size-fits-all" tools and toward more adaptable, resilient decision-making frameworks. Figure 3 provides a comprehensive breakdown of the thematic distribution within the current literature. Beyond the specific topics, our methodological evaluation uncovers a significant degree of diversity in how data is processed and interpreted across the studies. While standalone TOPSIS still accounts for 38.89% of the analyzed studies—proving that many researchers still value it as a fast, reliable, and straightforward tool—the tide is clearly turning. Hybrid methodologies now make up the majority at 61.11%, reflecting a significant shift toward integrated approaches that can handle more complex decision-making scenarios [22, 23].

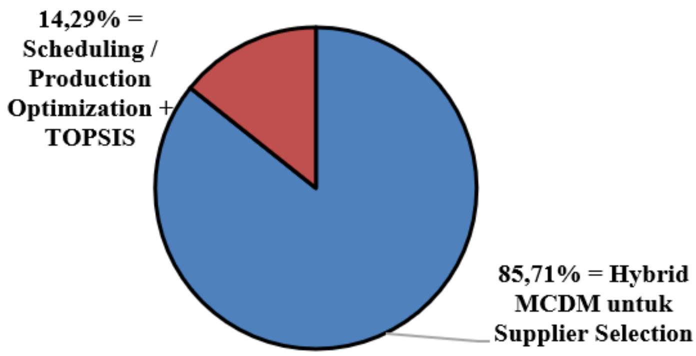

Figure 3. Distribution of main research themes.

Weighting techniques, specifically AHP–TOPSIS [21], its improved variants, and BWM–TOPSIS [15], accounted for 11.11% of the reviewed literature. Their continued use underscored their reliability for researchers requiring a highly systematic approach to criteria prioritization [24–26]. Fuzzy logic–based integrations, such as TFN–TOPSIS [17], along with combinations incorporating Failure Mode and Effects Analysis (FMEA) or LP Metric techniques, also represented 11.11% of the reviewed studies [27–29]. More advanced hybrid models, including Rough–Dombi BWM–TOPSIS [15], Game Theory–TOPSIS [16], and Entropy/G1-based weighting approaches, appeared in 5.56% of the studies, indicating a growing research interest in enhancing decision robustness [30–32]. Figure 4 illustrates these methodological distributions.

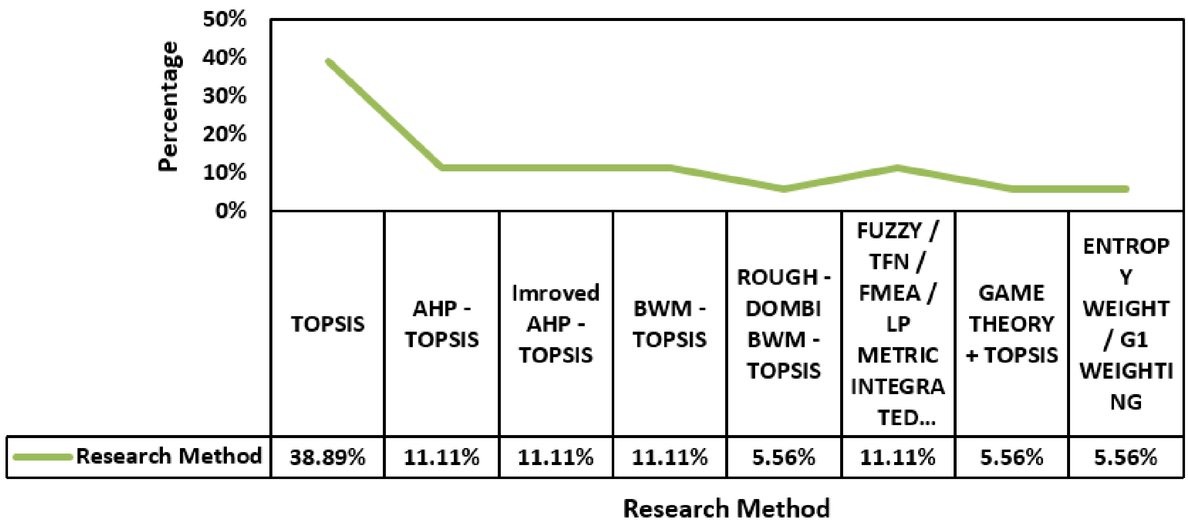

Figure 4. Classification of research methods used in selected studies.

The primary contributions of the selected papers can be classified into four areas. The most important contributions are the creation of hybrid MCDM frameworks for choosing suppliers (33.33%) and the use of MCDM approaches in real-world case studies (33.33%) [18, 20]. These results underscore the equilibrium between methodological innovation and practical application. Furthermore, 26.67% of the papers contribute by enhancing weighting strategies, including Entropy, Rough Set Theory, TFN modeling, or game-theoretic weighting structures [16, 17]. A much smaller fraction of the literature—roughly 6.67%—extends the use of these models to scheduling or production optimization [19]. The thematic distribution of these contributions is visually summarized in Figure 5.

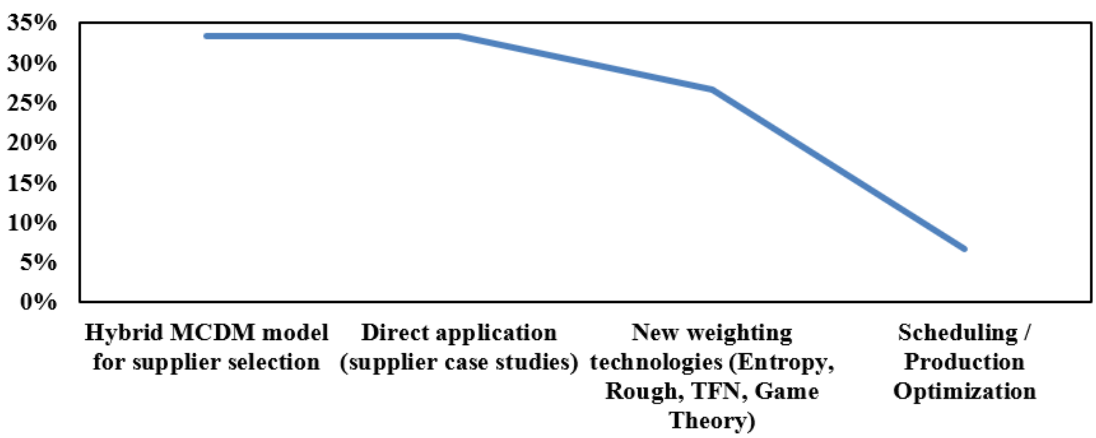

Figure 5. Distribution of primary research contributions.

Modern MCDM research is increasingly defined by its deep integration of advanced technology. It is evident that uncertainty management has moved to the forefront of the field, with nearly 58.33% of the literature now dominated by methodologies such as Fuzzy logic, Rough Set Theory, and Triangular Fuzzy Numbers (TFN). This high percentage underscores a widespread shift toward sophisticated computational tools designed to handle the 'gray areas' of decision-making [15, 17]. In contrast, traditional frameworks like classical AHP or standalone TOPSIS now appear in only 25% of the studies, signaling a gradual departure from purely conventional models [21]. Meanwhile, a smaller but significant portion of the literature (16.67%) has begun incorporating Game Theory and Entropy-based weighting. This trend points toward an increasing appetite for analytical frameworks that are more strategic and data-intensive [16]. The overall depth of this technological integration is mapped out in Figure 6.

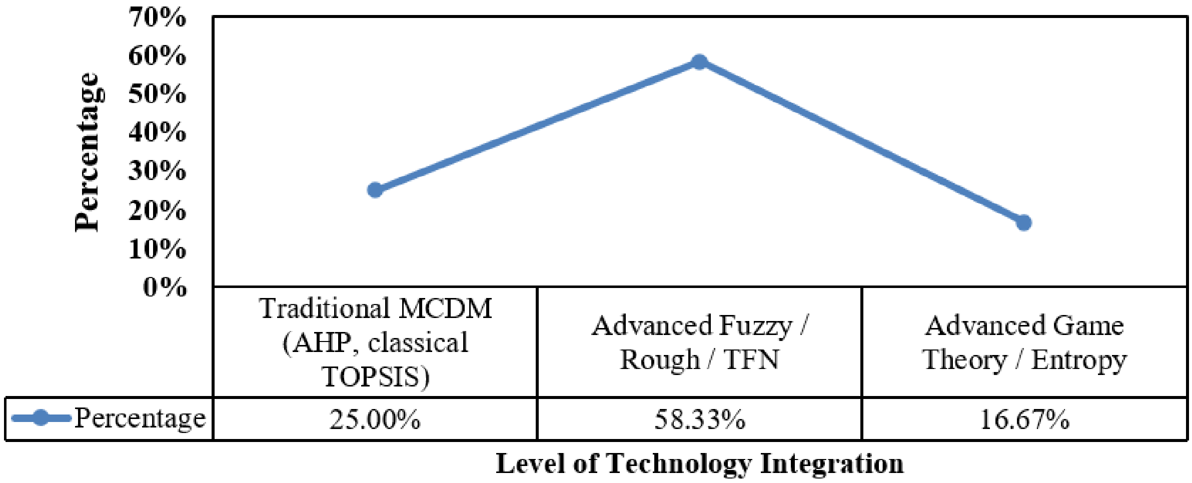

Figure 6. Level of technological integration in MCDM studies.

3.4. Differences in supplier selection practices between developed and developing countries.

Figure 7 highlights a clear divergence in how MCDM methodologies are applied across different economic landscapes. In industrialized nations, the research leans heavily toward sophisticated hybrid models, such as AHP–TOPSIS, Fuzzy–TOPSIS, and Entropy-based weighting. These sophisticated frameworks often go hand-in-hand with high-level digital environments like MATLAB, Python, and custom-built Decision Support Systems. Although such methods undoubtedly refine the precision and impartiality of the selection process, they present a steep learning curve, demanding not only high-fidelity data but also a level of computational mastery that is not always accessible. On the other hand, the literature coming out of developing economies typically leans toward more accessible analytical tools, with conventional AHP–TOPSIS and fundamental Fuzzy–TOPSIS serving as the backbone of most studies. In these settings, the evaluation process is still heavily anchored to the 'classic' metrics of cost, quality, risk, and delivery. Consequently, broader environmental and sustainability-driven criteria are frequently relegated to the background, often due to the immediate pressure of operational survival and resource constraints. This methodological simplicity is frequently a byproduct of practical constraints, such as limited access to specialized analytical software, a shortage of technical expertise, and inconsistent data record-keeping, all of which can compromise the overall reliability of the decision-making process.

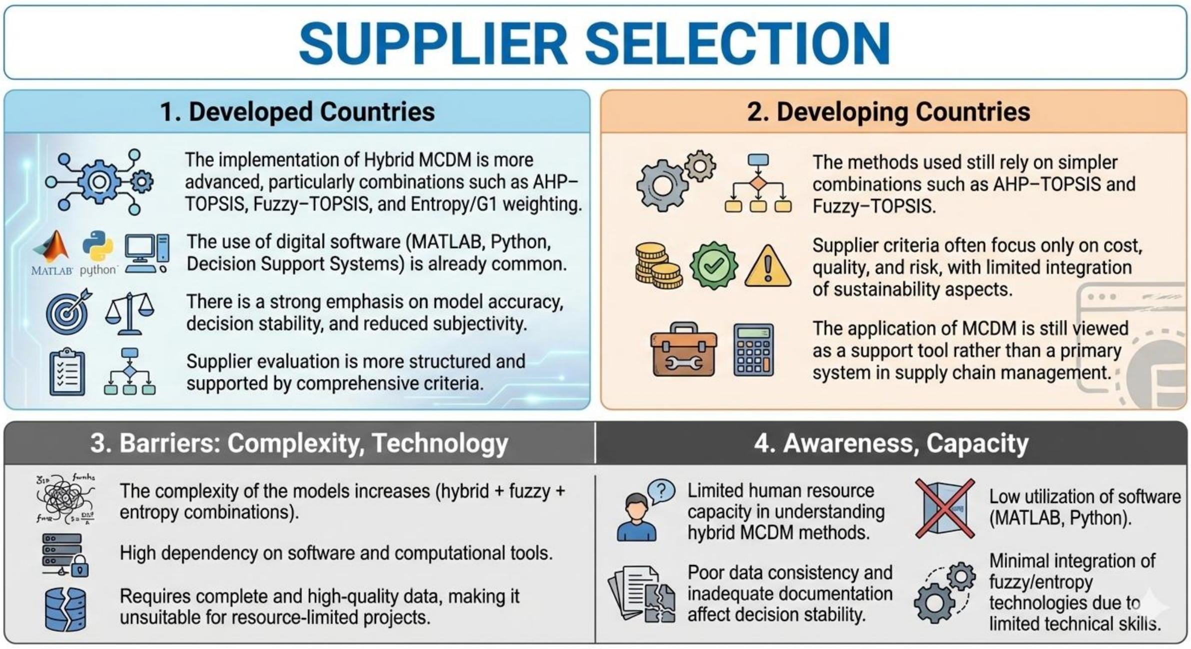

Figure 7. Barriers and technological adoption differences between regions.

3.5. Conceptual hybrid MCDM framework for supplier selection.

Figure 8 shows a conceptual framework that brings together the main results of the seven research that were analyzed. This paradigm shows how input factors, hybrid MCDM mechanisms, and output dimensions are related to each other in the process of choosing a supplier.

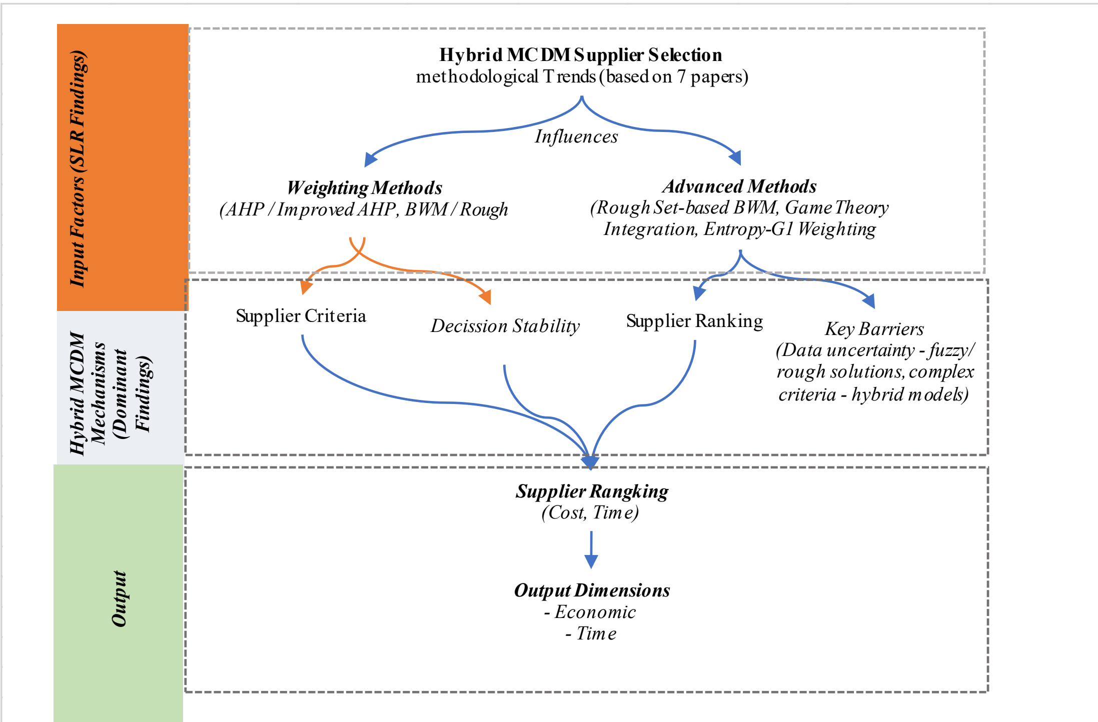

Figure 8. Conceptual hybrid MCDM framework for supplier selection.

The input layer stresses the relevance of criteria-weighting methods such AHP, Improved AHP, BWM, and Rough Set Theory, which are the main parts of hybrid decision models [15, 21]. Rough Set–BWM, Fuzzy–Rough combinations, Game Theory, and Entropy–G1 weighting are some of the more complex strategies that make these models better at handling data uncertainty and making supplier assessments more stable [16, 17].

There are four primary parts to the mechanism layer: figuring out the criteria for supplier rating, making decisions more stable, using hybrid ranking methods, and recognizing methodological problems. Key challenges identified in the literature range fromdata ambiguity and the rising complexity of hybrid models to a heavy reliance on computational tools, barriers that are particularly acute in resource-constrained environments. At the core of our findings, two primary dimensions emerge: cost efficiency and time performance. These elements dominate current supplier rankingresearch, reflecting the critical economic and operational weight ofprocurement decisions.This conceptual framework offers significant insights for both theory and practice. Theoretically, it clarifies the complex relationship between weighting techniques and advanced analytics inhybrid MCDM systems.More importantly, it exposes a persistent gap in the literature: the lack of sustainability-focused criteria, despite their increasing urgency in modern construction supply chains.On a practical level, the framework provides a blueprint for firms to move toward objective, evidence-based assessment systems. However, its success remains tied to a "trifecta" of technical expertise, data integrity, and appropriate software tools. Future research should prioritize empirical validation in emerging markets, a more aggressive integration of ESG (Environmental, Social, and Governance) metrics, and the development of intuitive decision-support tools specifically designed for the construction sector.

4. Conclusions

This systematic review synthesized current research on the integration of Hybrid MCDM and TOPSIS within the specific context of construction procurement.By evaluating seven targeted studies published between 2020 and 2025, we identified several prevailing methodological shifts and emerging analytical patterns.The results suggest that hybrid MCDM–TOPSIS frameworks facilitate more structured and transparent supplier evaluations, particularly when combined with fuzzy, rough, or entropy-based logic to dampen data volatility.However, given the relatively narrow sample of available literature, these findings should be interpreted as an indicative baseline rather than a definitive industry standard.Theoretically, this work enriches existing SLRs by narrowing the focus to hybrid frameworks specifically tailored for the construction sector, bridging the gap between general decision theory and specialized material procurement needs.From a practical perspective, the suggested conceptual framework provides practitioners with assistance in choosing suitable weighing procedures, handling uncertainty, and incorporating digital tools into supplier evaluation processes.There are a few holes in the research, such as the lack of real-world examples in developingcountries, the inconsistent use of sustainability criteria, and the practical problems that comewith having todeal with a lot of data and complicated calculations.Future research should concentrate on enhancingempirical validation, fortifying the incorporation of sustainability factors, and creating decision-support systems that are availableto practitioners with diverse levels of technical proficiency.

Author Contributions

Fransiscus Xavirius Rizky Suryoaji Wibowo contributed to the conceptualization, formulation of research questions, data collection, article screening, quality assessment, and drafting of the initial manuscript. Nectaria Putri Pramesti led the methodological design, supervised the systematic review process, validated the analysis, refined the interpretation of results, and conducted the final review and editing of the manuscript. Both authors contributed equally to the development of the research framework and approved the final version of the manuscript for publication.

Data Availability Statement

All data used in this study were obtained from publicly accessible scholarly databases, primarily Scopus. The datasets generated and analyzed during the review, including search strings, inclusion–exclusion matrices, and quality assessment results, are available from the corresponding author upon reasonable request. No proprietary or confidential data were used in this study.

Competing Interest

All authors should disclose any financial, personal, or professional relationships that might influence or appear to influence their research.

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