Decision Making: Applications in Management and Engineering, Volume 8, Issue 1 (2025) 380-400

Decision Making: Applications in Management and Engineering

Journal homepage: www.dmame-journal.org
ISSN: 2560-6018, eISSN: 2620-0104

Integrating Multiple Criteria Decision-Making Techniques in Sustainable Supplier Selection: A Comprehensive Review

Haya Alastal, Ahmed Sharaf, Shahd Mahmoud, Ola Alsaidi, Zied Bahroun*

1 Department of Industrial Engineering, American University of Sharjah, P.O. Box 26666, Sharjah, United Arab Emirates

ARTICLE INFO

Article history:
Received 5 August 2024
Received in revised 19 December 2024
Accepted 7 March 2025
Available online 30 March 2025

Keywords:
Multiple Criteria Decision-Making (MCDM); Sustainable Supplier Selection; Fuzzy Sets; TOPSIS; Supply Chain Management; Environmental Sustainability; Strategic Sourcing

ABSTRACT

Amidst the increasing emphasis on sustainability and efficiency within global supply chains, this review explores the application of Multiple Criteria Decision-Making (MCDM) methods in optimising supplier selection across diverse sectors, including management, healthcare, manufacturing, and supply chain operations. Adopting a systematic approach, the study commences with a bibliometric analysis of the Scopus database to identify global research trends, influential contributors, key thematic areas, and patterns of collaboration in the utilisation of MCDM for sustainable supplier selection. Furthermore, a detailed content analysis examines the integration and comparative effectiveness of various MCDM techniques—such as TOPSIS, fuzzy logic, and hybrid algorithms—based on sustainability and efficiency criteria. The findings indicate that these methodologies enhance the precision of supplier evaluations and support strategic sourcing decisions, yielding both environmental and economic advantages. Additionally, the review highlights critical research gaps, including the incorporation of Artificial Intelligence (AI) into MCDM frameworks and the necessity of addressing social performance factors in supplier assessments. This study underscores the pivotal role of MCDM in aligning supplier selection processes with sustainable business strategies and provides recommendations for industry practitioners to implement adaptive MCDM models capable of responding to evolving sustainability benchmarks and stakeholder expectations. Moreover, it advocates for the establishment of policies and standards that encourage the adoption of advanced MCDM techniques in procurement practices, thereby fostering transparency, equity, and environmental stewardship. The insights presented aim to inform future research and facilitate practical applications, ultimately enhancing the strategic significance of MCDM in sustainable supplier selection across industries.

1. Introduction

The selection of appropriate suppliers constitutes a fundamental component of strategic supply chain management, as it significantly influences product quality, cost-effectiveness, and overall business performance [1]. A well-structured supplier selection process mitigates risks and fosters long-term, mutually beneficial partnerships with suppliers [2]. This process necessitates the

* *Corresponding author.*
E-mail address: zbahroun@aus.edu

https://doi.org/10.31181/dmame8120251243

evaluation of potential suppliers based on multiple criteria that align with organisational objectives and competitive strategies. Key considerations typically include reliability, financial robustness, and ethical standards, ensuring that selected suppliers adhere to the company's requirements and contribute to its strategic goals.

Amidst increasing regulatory pressures, heightened consumer awareness, and strengthened corporate sustainability commitments, the prioritisation of sustainable suppliers has become imperative for organisations aiming to enhance their environmental impact and long-term resilience. Structured decision-making methodologies, such as MCDM techniques, play a crucial role in this context by enabling firms to assess suppliers against a range of economic, environmental, and social parameters. Recent studies underscore the significance of sustainable supplier management, demonstrating that effective supplier selection not only facilitates regulatory compliance but also fortifies stakeholder relationships and enhances corporate reputation [3; 4]. This study is particularly relevant as it systematically examines the application of MCDM techniques, offering critical insights into their capacity to address the evolving sustainability requirements in supplier selection. In response to these challenges and opportunities, the review provides essential guidance for navigating the intricate, multi-criteria supplier selection process in alignment with contemporary sustainability imperatives.

Sustainability has become an increasingly significant criterion in supplier selection, complementing established factors such as reliability, financial stability, and ethical standards [5]. This shift reflects a broader emphasis on corporate social responsibility within business operations. Moreover, rising consumer awareness regarding sustainability influences purchasing decisions, compelling organisations to prioritise suppliers that adhere to environmental, social, and economic sustainability principles [6]. Sustainable supplier selection involves assessing and comparing suppliers based on their environmental impact and social responsibility to ensure alignment with sustainability objectives.

Despite widespread recognition of the need to integrate sustainability into supplier selection, organisations face substantial challenges in systematically evaluating and comparing suppliers based on sustainability alongside traditional considerations such as cost and quality. A primary difficulty arises from the absence of a standardised framework capable of addressing the diverse and often conflicting criteria associated with sustainable practices. This complexity not only complicates the decision-making process but also increases the risk of critical sustainability factors being overlooked due to the prevailing emphasis on cost-effectiveness and operational efficiency. Furthermore, the rapid evolution of sustainability standards and assessment metrics exacerbates these challenges, necessitating dynamic and adaptable decision-making methodologies to accommodate emerging sustainability demands and stakeholder expectations. In response to these issues, this study undertakes a systematic review of MCDM techniques, evaluating their effectiveness in supporting well-balanced and informed decision-making in the context of sustainable supplier selection.

To address the complexities inherent in supplier selection, this study draws upon multiple theoretical frameworks to emphasise the necessity and impact of advanced decision-making methodologies. Sustainability Theory underscores the importance of integrating environmental, social, and economic considerations into corporate decision-making processes. This perspective posits that long-term business viability depends on the sustainable management of both natural and human resources, a challenge that MCDM techniques help to address. By enabling organisations to systematically evaluate and incorporate sustainability criteria into supplier selection, MCDM methods facilitate decision-making that balances financial performance with sustainability imperatives [7].

Innovation Diffusion Theory (IDT) examines the dissemination of new ideas and technologies within a social system, tracing their adoption through specific communication channels over time. When applied to MCDM techniques in supplier selection, IDT provides insights into how these tools, as technological innovations, gain traction across industries due to their capacity to enhance decision accuracy and operational efficiency. The theory highlights the key determinants of MCDM adoption, including their demonstrable advantages over conventional methods, their compatibility with existing business values and practices, and the ease with which they can be integrated into established decision-making frameworks [8]. Together, these theoretical perspectives elucidate the intricacies of supplier selection while reinforcing the role of MCDM methodologies as effective instruments for optimising strategic sourcing and advancing sustainability within supply chain management.

MCDM techniques serve as highly effective tools for evaluating and ranking suppliers, providing a structured framework for decision-making that involves competing criteria. These methods enable a systematic and comprehensive assessment of alternative options [9]. Prominent MCDM approaches include the Analytic Hierarchy Process (AHP), the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), and various utility-based models. However, despite the growing body of research on the application of MCDM in sustainable supplier selection, a comprehensive review encompassing all relevant methodologies remains absent. This study seeks to address this gap by offering an extensive analysis of how MCDM techniques are employed for sustainable supplier selection across diverse industries.

This research contributes to existing scholarship by presenting an up-to-date systematic review of MCDM applications in sustainable supplier selection, offering critical insights to inform both theoretical development and practical implementation. The review explores several key questions: How are MCDM techniques applied in sustainable supplier selection across different industries? What are the primary advantages and challenges associated with these methods? What research gaps persist regarding MCDM techniques in this context? Finally, how can future studies address these gaps to refine supplier selection processes? The analysis identifies several key issues, including the increasing need to integrate Artificial Intelligence (AI) into MCDM frameworks, the necessity of incorporating social performance assessments alongside environmental and economic criteria, and the limited research on the long-term implications of MCDM applications for sustainability. Additionally, the potential of real-time data analytics in enhancing MCDM processes remains underexplored.

This study underscores the critical role of MCDM in aligning supplier selection with sustainable business strategies. By systematically reviewing existing methodologies, it provides practical insights to guide future research and support real-world applications across multiple industries. The integration of MCDM techniques into supplier selection enhances decision accuracy, strengthens strategic sourcing, and advances sustainability initiatives. These improvements are instrumental in fostering more resilient and responsible supply chains. This study offers valuable insights for key stakeholders involved in supply chain management and sustainability. For industry practitioners, particularly procurement and supply chain managers, the findings present a structured framework for incorporating sustainability into supplier selection, facilitating more informed and balanced decision-making in alignment with corporate social responsibility objectives. Additionally, this comprehensive review provides significant contributions to academics and researchers in decision sciences and sustainable supply chain management by identifying existing research gaps and suggesting directions for future inquiry. Furthermore, policymakers may leverage the insights from this study to develop guidelines that promote the adoption of MCDM techniques, thereby fostering sustainable practices across diverse industries.

The structure of this paper is as follows: The first section outlines the methodology employed in conducting the review. The subsequent section presents the findings of the bibliometric analysis, highlighting key trends and notable contributions within the field. This is followed by an in-depth content analysis that examines the application of various MCDM techniques in sustainable supplier selection across multiple industries. The paper concludes with a discussion summarising the key findings, exploring their implications for future research, and providing practical recommendations.

2. Methodology

This study employs a structured and rigorous review process, adhering to the PRISMA framework to ensure clarity, precision, and consistency in the identification and analysis of relevant literature [10; 11]. The methodology integrates bibliometric and content analysis, enabling both quantitative and qualitative examinations of citation patterns, keyword distributions, and thematic classifications across a broad spectrum of studies. Although this research relies on secondary data obtained from existing literature, the analytical approach yields valuable, data-driven insights into emerging trends, key contributors, and evolving themes within the field. The review process is systematically organised into four distinct phases, each playing a crucial role in facilitating a comprehensive exploration of the subject and identifying significant research gaps to inform future investigations.

2.1 Literature Retrieval

This study adopted a systematic and structured approach to data collection, with the literature review primarily based on the Scopus database. Scopus was selected due to its extensive repository of peer-reviewed publications and its capacity to encompass both well-established and emerging research domains [11]. The platform's advanced search functionalities and comprehensive coverage facilitated a rigorous and in-depth review, ensuring the inclusion of the most pertinent and up-to-date studies on the subject. The search strategy was meticulously designed, incorporating a combination of specific keywords such as "multi," "criteria," "decision," "making," "sustainable," "green," "supplier," and "selection." This method extended beyond basic keyword matching to encompass searches within titles, abstracts, and keyword fields, enabling the identification of significant linkages between MCDM methodologies and sustainable supplier selection. The systematic approach yielded a dataset of 741 scholarly articles, serving as the foundation for the subsequent analysis.

2.2 Literature Screening Process

The selection and screening of literature were conducted systematically in accordance with the PRISMA framework, which is widely recognised for enhancing the transparency and reproducibility of systematic reviews [10]. The initial search retrieved 741 publications from the Scopus database. Following the removal of duplicate entries, 426 studies remained. Each publication was then meticulously evaluated based on its relevance, with consideration given to publication date and alignment with the research objectives. To ensure the inclusion of recent and high-quality studies, the review was limited to research published from 2020 onwards, refining the dataset to 222 articles. A subsequent in-depth relevance assessment led to the exclusion of 143 papers, resulting in a final selection of 79 studies deemed most pertinent to this review. Figure 1 illustrates the filtering process, highlighting the structured and systematic approach undertaken to identify high-quality and relevant literature.

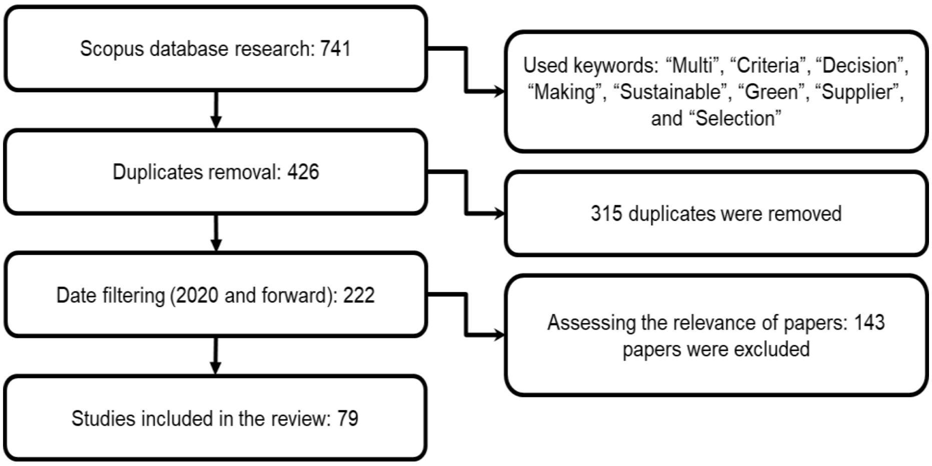
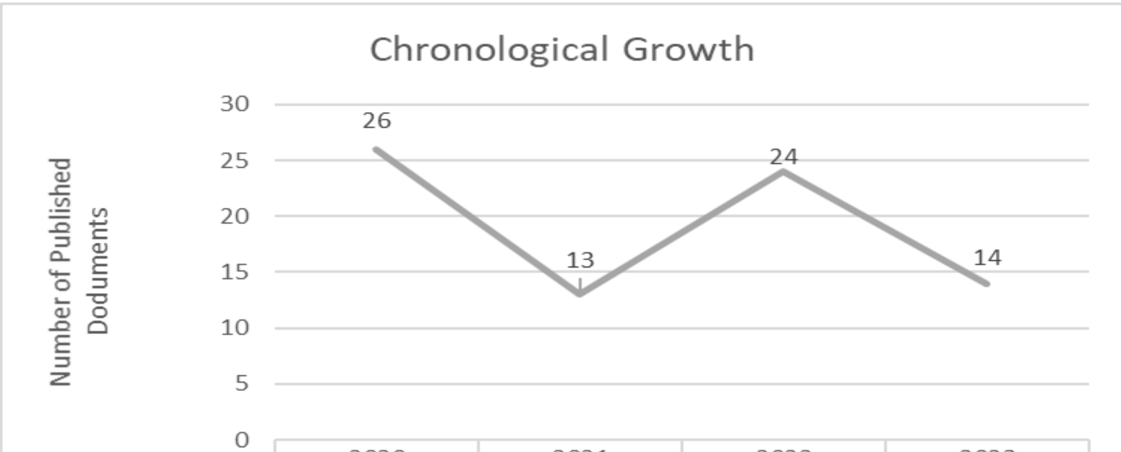


Fig. 1. Filtering Process

The academic interest in MCDM within the context of green supplier selection can be assessed through the volume of publications over the past four years, as depicted in Figure 2. The number of publications peaked in 2020, reaching 26 studies, likely driven by a heightened global emphasis on sustainability in response to the economic and environmental challenges arising from the COVID-19 pandemic. This increase in research underscores a growing recognition of sustainability in supply chain management as a critical component of competitive advantage. The subsequent decline to 13 publications in 2021 may be attributed to a shift in academic priorities, as the evolving impact of the pandemic necessitated a focus on crisis management and supply chain adaptation strategies. Consequently, research related to MCDM, and green supplier selection temporarily decreased. However, in 2022, publication numbers rebounded to 24, indicating renewed scholarly and practical interest, likely stimulated by the recovery of industrial activities and the application of insights gained from earlier disruptions. This resurgence suggests a concerted effort to reintegrate sustainability into supply chain strategies, leveraging MCDM techniques to enhance decision-making. The slight decrease to 14 publications in 2023 may reflect the maturation of the field, with a shift in emphasis from the quantity of research to its depth and applicability. This trend indicates that scholars are increasingly focusing on the practical implementation of MCDM in green supplier selection across various industries, moving beyond purely theoretical explorations. It demonstrates a growing refinement of methodologies to address the complexities of sustainable supply chain management more effectively.



	2020	2021	2022	2023
Documents	26	13	24	14

Fig. 2. Chronological Growth Graph

2.3 Bibliometric Analysis

The bibliometric analysis was conducted using VOSviewer, a specialised tool designed for the construction and visualisation of bibliometric networks [12]. This analysis involved mapping citation structures, co-authorship linkages, and keyword associations to identify influential studies, key contributors, and collaborative research networks within the field. Various bibliometric indicators, such as citation frequency, author affiliations, and commonly co-occurring keywords, were systematically quantified to highlight leading contributions and prevailing research trends. Adhering to established best practices for bibliometric studies Donthu et al. [13], VOSviewer facilitated the development of visual networks that illustrate emerging themes and evolving patterns within the literature. This approach provided a comprehensive contextualisation of MCDM applications in sustainable supplier selection, offering deeper insights into the intellectual landscape of the field.

2.4 Content Analysis

The content analysis was conducted manually, employing a structured methodology to systematically organise and evaluate the selected literature without the aid of specialised software [14; 15]. Each study was categorised according to key dimensions, including the specific MCDM technique utilised (e.g., AHP, TOPSIS, fuzzy logic), the sector of application (e.g., manufacturing, healthcare), and the sustainability criteria considered (economic, environmental, or social). This classification framework facilitated the identification of recurring themes and enabled a detailed examination of how MCDM methods are implemented in sustainable supplier selection. A thorough review of each study allowed for the recognition of methodological patterns, practical applications, and existing research gaps. This systematic, hands-on approach to content analysis provided insights into the adaptability of various MCDM techniques in addressing sustainability challenges within supply chains. By grouping the studies into overarching themes and sub-themes, a comprehensive understanding was developed regarding both the theoretical foundations and practical applications of MCDM in sustainable supplier selection. Furthermore, this approach contributed to identifying potential avenues for future research.

3. Bibliometric Analysis

This section presents a bibliometric analysis aimed at identifying collaborative networks and dominant themes within the field of sustainable supplier selection. By analysing co-occurrence maps of countries, institutions, and keywords, this study highlights influential contributors and prevailing research trends that define contemporary scholarly discourse and shape future directions in the field.

3.1 Co-Occurrence Map Based on Countries

This section presents a co-occurrence map illustrating the geographic distribution and collaborative networks among countries engaged in research on sustainable supplier selection. By visualising these interconnections, the analysis identifies key contributors and assesses their influence on the global research landscape. It highlights the most active nations and explores the nature of international cooperation, providing insights into how research partnerships contribute to advancements in sustainability. Figure 3 offers a network visualisation of co-authorship patterns among countries, showcasing global collaboration trends. China emerges as a pivotal contributor, maintaining extensive research partnerships with nations such as Iran, India, and the United States, underscoring its strategic emphasis on international cooperation in sustainability research. Likewise, India demonstrates strong research linkages with Turkey, Germany, and the United Kingdom, reflecting its engagement with European expertise to enhance sustainability initiatives.

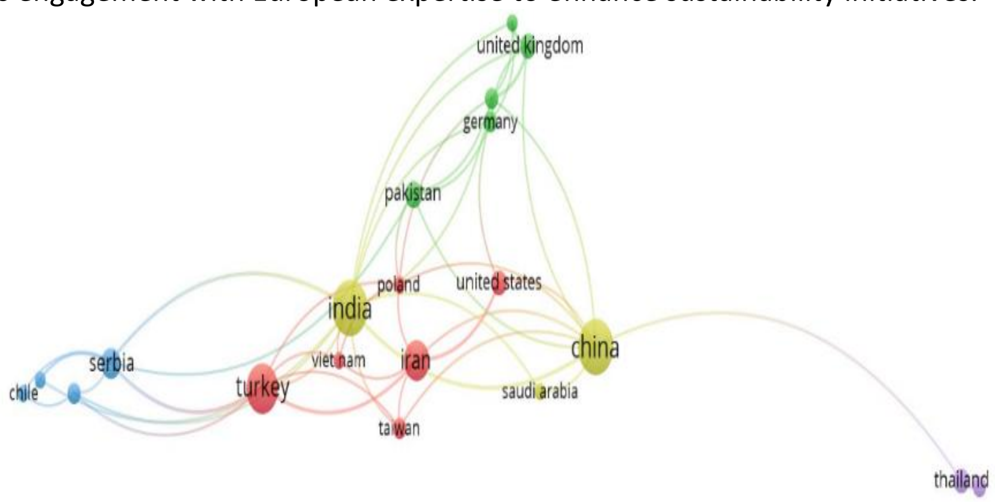


Fig. 3. Network visualization of countries co-Authorship

3.2 Co-Occurrence Map Based on Keywords

This section presents a co-occurrence map of keywords extracted from bibliometric data on MCDM applications in sustainable supplier selection. By utilising VOSviewer, similar terms were consolidated through a thesaurus, enhancing the clarity and interpretability of the visual representation. This methodological refinement enables a more precise identification of dominant research themes, prevailing trends, and interconnections within the field. Following thesaurus integration, the total number of keywords was reduced from 572 to 537, with further refinement yielding a final set of 54 keywords appearing at least twice. The resulting network visualisation (Figure 4) highlights the most frequently used terms and their interrelationships. Core keywords such as "decision making," "sustainability," "supplier selection," and "sustainable supplier selection" feature prominently, signifying their central role in the research domain.

Figure 4 depicts keyword relationships and their frequency of occurrence. Distinct clusters represent thematic areas: the red cluster links "decision making" with methodologies such as AHP, the green cluster associates' "sustainability" with environmental and social considerations, while the blue cluster connects "sustainable supplier selection" with industrial approaches like Industry 4.0 and goal programming. Strong interconnections between "decision making" and "sustainability" highlight their integration within supplier selection processes. Peripheral keywords, including "pharmaceutical industry" and "iron and steel industry," indicate niche and emerging areas of investigation. The visualisation underscores the significance of interdisciplinary and integrated approaches in advancing sustainable supplier selection, offering insights into current research trajectories and potential avenues for future exploration.

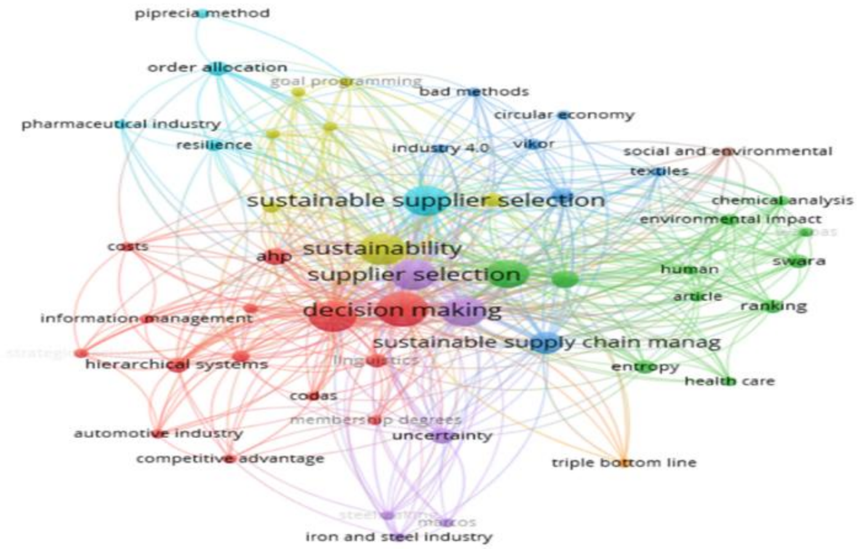


Fig. 4. Network visualization of keywords co-Authorship.

3.3 Analysis of Article Sources in MCDM Research

This section provides a comprehensive analysis of the collected studies on MCDM in sustainable supplier selection, examining them through multiple lenses. The dataset has been systematically classified into four primary categories: industry type, document type, MCDM methodologies employed, and the intended purpose of the studies. This multidimensional approach aims to identify patterns and trends across various domains, illustrating the diverse applications of MCDM principles. By encompassing a wide spectrum of industries, research methodologies, and objectives, the analysis offers a holistic perspective on the current research landscape, demonstrating how MCDM enhances and streamlines supplier selection processes.

Figure 5 visualises the application of MCDM techniques across different industries, underscoring their adaptability and effectiveness. Supply chain management emerges as the predominant area, with 23 studies, reflecting significant research efforts aimed at optimising supplier selection, logistics, and overall operational performance—an essential focus given the complexity of global supply chains. Management and manufacturing follow, with 12 and 9 studies, respectively, highlighting the role of MCDM in resource allocation, process optimisation, and strategic decision-making. Notably, the manufacturing sector employs these methodologies to improve efficiency, sustainability, and competitiveness. Additional significant applications of MCDM techniques are evident in healthcare (7 studies), construction (7 studies), and cold supply chains (4 studies), where they facilitate complex decision-making processes. Within healthcare, MCDM contributes to enhanced supplier selection and resource allocation, whereas in construction and cold supply chains, these methodologies assist in reconciling competing criteria. Furthermore, a growing interest is observed in industries such as electronics, oil and gas, automotive, electric vehicles, pharmaceuticals, iron and steel, and agriculture, each represented by 2–3 studies. This trend underscores the increasing recognition of MCDM's capacity to address multifaceted challenges while advancing sustainability objectives. The extensive application of MCDM techniques across diverse industries highlights their adaptability and broad relevance. Irrespective of the sector, these methodologies provide structured frameworks for resolving intricate decision-making issues. Figure 5 offers a visual representation of the significant research focus on supply chain management, management, and manufacturing, while also identifying emerging opportunities in other sectors.

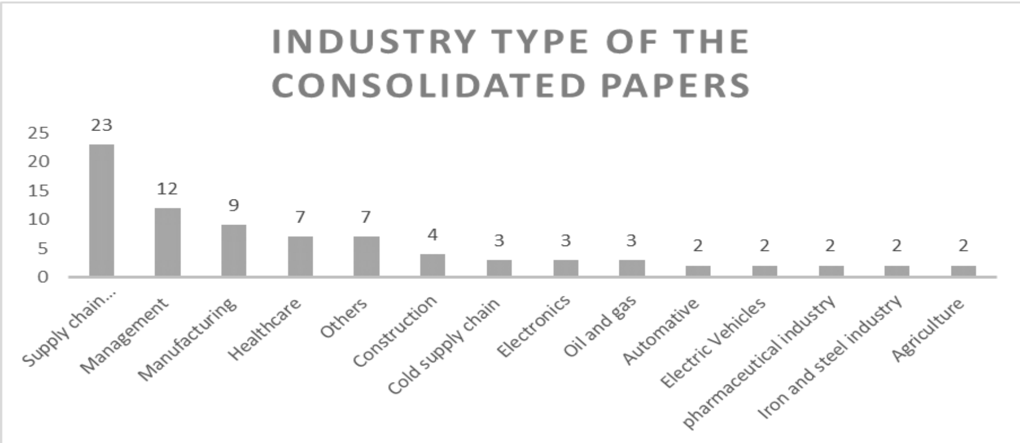


Fig. 5. Industry Applications of MCDM Principles

Figure 6 presents a comprehensive summary of the document types included in the reviewed studies on MCDM for sustainable supplier selection. The analysis reveals that journal articles constitute the predominant category, with 69 out of 79 studies falling within this classification. Accounting for 87.3% of the total, this prevalence underscores the academic community's inclination towards disseminating research through peer-reviewed journals, which are widely regarded as authoritative and impactful channels for scholarly communication.

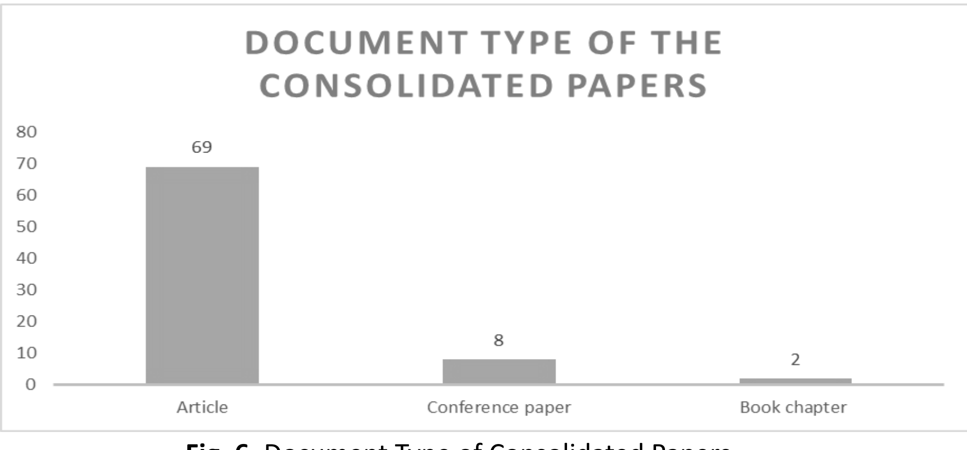


Fig. 6. Document Type of Consolidated Papers

Figure 7 presents various MCDM methods in sustainable supplier selection, illustrating their adaptability. The largest category, "Other," encompasses 25 papers on less common or hybrid methods, reflecting the field's innovation. AHP-TOPSIS appears in 10 papers, highlighting its systematic approach, while another 10 papers focus solely on TOPSIS for its reliability. Fuzzy analytical methods feature in 7 papers, addressing uncertainty in supplier selection. The BWM Method and SWARA-WASPAS each appear in 5 papers, offering robust weighting frameworks. VIKOR, cited in 4 papers, balances conflicting criteria, while FANP, CODAS, hesitant fuzzy methods, and DEMATEL appear in 2–3 papers each for specialised tasks. This diversity underscores the complexity of sustainable supplier selection and the need for tailored tools. The frequent use of AHP, TOPSIS, and fuzzy methods affirms their reliability and adaptability.

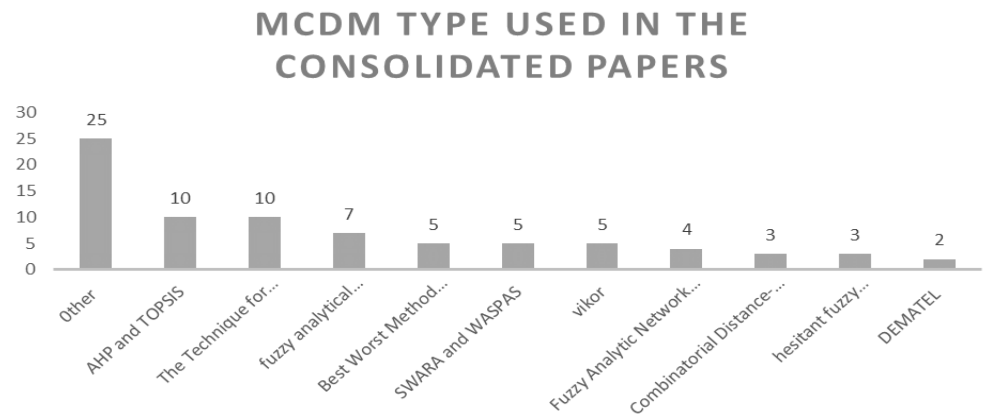


Fig. 7. Types of MCDM Methods in Sustainable Supplier Selection.

Figure 8 illustrates the objectives of MCDM studies on sustainable supplier selection, highlighting diverse research focuses. Forty papers propose new methodologies, emphasising innovation to enhance decision-making. Researchers refine existing methods and introduce novel techniques to address complexities in this domain. Nineteen papers focus on developing frameworks, providing structured models to standardise supplier selection across industries. This underscores the need for practical tools to streamline decision-making. Eleven papers integrate qualitative and quantitative approaches, combining theoretical and empirical research to validate MCDM techniques. Additionally, six papers are classified as case studies. These studies offer practical insights by applying MCDM methods to real-world supplier selection challenges, demonstrating their effectiveness through case studies. Such studies provide detailed examples and valuable lessons. Three papers fall under the "other" category, encompassing reviews, theoretical discussions, or exploratory research. This diversity reflects the broad scope of MCDM research. Figure 9 highlights the strong emphasis on developing methodologies and frameworks, alongside qualitative and quantitative approaches. The inclusion of case studies underscores the balance between theoretical innovation and practical application, advancing MCDM for sustainable supplier selection.

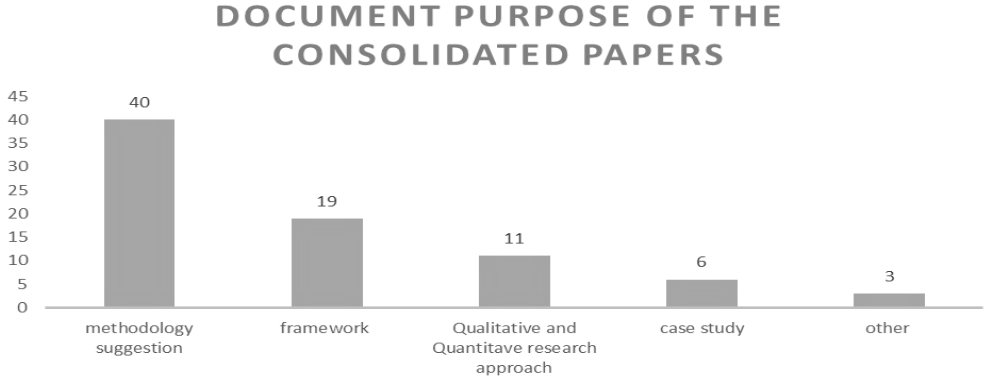


Fig. 8. Research Purposes in MCDM for Sustainable Supplier Selection

4. Content Analysis

This section provides an in-depth analysis of the application of MCDM techniques in sustainable supplier selection across various industries, including management, supply chain, healthcare, and manufacturing. It explores the different MCDM tools employed, summarises key findings, and discusses limitations identified in the literature. By systematically categorising and examining the reviewed studies, this section highlights the scope and impact of MCDM applications, uncovering trends and insights that contribute to the refinement and advancement of sustainable supplier selection methodologies.

4.1 MCDM for Sustainable Supplier Selection in Management

This section explores MCDM techniques for sustainable supplier selection in management. Table 1 summarises diverse methodologies addressing green performance, cost efficiency, preference differences, and uncertainty. Key approaches include deterministic multi-period models, hybrid algorithms, and multi-phase decision-support frameworks. Techniques such as hesitant fuzzy sets, TOPSIS, and intuitionistic fuzzy models mitigate subjective bias, enhance accuracy, and manage uncertainty. Findings confirm MCDM's effectiveness in balancing environmental and economic goals, making it ideal for large-scale green supplier selection. Hybrid algorithms and fuzzy models excel in handling uncertainty and incorporating expert input, while multi-phase frameworks integrate social, environmental, and economic objectives for a holistic approach. However, gaps remain, including limited integration of social performance metrics, a lack of supplier selection combined with routing optimisation, and underexplored AI applications in MCDM. Addressing these through targeted research, including longitudinal studies, could enhance MCDM's strategic value. Future research should focus on integrating social objectives, leveraging AI, and optimising cost-emission trade-offs.

Table 1
Application of MCDM in Sustainable Supplier Selection in Management

Author	Year	Focus of the Study	Key Findings
Hamdan et al. [16]	2023	Green supplier selection and order allocation with environmental and economic criteria.	Suggested a heuristic approach for large-scale applications.
Zhang et al. [17]	2022	Green supplier selection using preference differences and incomplete information.	TOPSIS-based method ensures consistency and selects the best supplier.
Rao et al. [18]	2022	Hybrid algorithm using green manufacturing standards.	Enhances collaboration and sustainability in production.
Eghbali-Zarch et al. [19]	2023	Fuzzy framework for criteria and alternatives evaluation.	Highlights criteria like responsiveness and sustainability.
Hezam et al. [20]	2023	Intuitionistic fuzzy preference model for triple bottom line attributes.	Effectively incorporates expert knowledge and uncertain data.
Liaqait et al. [21]	2022	Multi-phase framework integrating social, environmental, and economic goals.	Optimized goals in a multi-modal supply chain network.
Zhong et al. [22]	2022	Multi-criteria group decision-making for supplier selection and order allocation.	Combined best-worst method, TODIM, and Pareto optimization.
Deniz [23]	2020	Debiasing strategies in MCDM techniques.	Improved accuracy by addressing cognitive biases.
Aslani et al. [24]	2021	Grey MCDM framework for global supplier selection.	Identified sustainability criteria and ranks suppliers.
Cao [25]	2020	Picture fuzzy decision-making model with fractional programming.	Evaluated green suppliers using TOPSIS and distance measures.
Ma et al. [26]	2020	Group decision-making in hesitant fuzzy linguistic environments.	Combined multi-criteria methods for practical sustainable development.

4.2 MCDM for Sustainable Supplier Selection in Supply Chains

This section examines MCDM techniques in sustainable supplier selection within supply chain management. Table 2 summarises methodologies addressing agility, sustainability, durability, and uncertainty, integrating both established and innovative approaches to enhance decision-making and efficiency. Findings highlight the dual benefits of environmental and economic improvements. Intuitionistic fuzzy AHP, TOPSIS, and hybrid models effectively manage green supplier selection challenges by addressing uncertainty and preference differences. For instance, Kumar et al. [27] developed a framework for sustainable supply chain indicators in the automobile industry. Peng et al. [28] used an extended VIKOR-based framework to assess economic, environmental, and social criteria. Multi-phase models and hybrid algorithms provide comprehensive supplier evaluation, incorporating general and industry-specific criteria. Erdogan and Tosun [29] combined SWARA and WASPAS in a hybrid model for the electronics industry, ensuring sustainability alignment through sensitivity analysis. Despite advancements, gaps remain. The effects of regional differences and company size on supplier selection are underexplored. Future research should focus on scalable models and greater adoption of emerging technologies like IoT, blockchain, and AI to enhance traceability, transparency, and predictive capabilities in sustainable supply chains.

Table 2.
Application of MCDM in Sustainable Supplier Selection in Supply Chains

Author	Year	Focus of the Study	Key Findings
Rouyendegh et al. [30]	2020	Green supplier selection focusing on lean, agile, and sustainable criteria.	Enhanced supplier evaluation and selection for diverse challenges.
Kumar et al. [27]	2022	Framework for sustainable supply chain indicators.	Improved sustainability in global supply chains and enhances collaboration in the automobile industry.
Peng et al. [28]	2020	Integrated framework-using VIKOR for supplier selection.	Evaluated economic, environmental, and social criteria comprehensively.
Erdogan and Tosun [29]	2020	Hybrid model using SWARA and WASPAS for supplier selection.	Provided robust tools for ranking suppliers, validated through sensitivity analysis.
Alkan and Kahraman [31]	2023	Multi-criteria model using intuitionistic fuzzy sets.	Addressed conflicting parameters and enhances uncertainty management.

4.3 MCDM for Sustainable Supplier Selection in Healthcare

This section examines the application of MCDM techniques in sustainable supplier selection within the healthcare sector. Table 3 summarises methodologies addressing uncertainties, multiple attributes, and sustainability goals, focusing on green performance, agility, durability, and sustainability. Findings highlight the importance of integrating sustainability into supplier evaluations. Methods like hesitant fuzzy sets and extended LINMAP effectively manage uncertainties, enhancing evaluation reliability. For instance, Chakraborty and Saha [32] employed Fermatean fuzzy models for healthcare waste management, aiding in waste treatment technology selection. Similarly, Stević et al. [33] developed the MARCOS method, incorporating economic, social, and environmental criteria into supplier evaluation.

Table 3.
Application of MCDM in Sustainable Supplier Selection in Healthcare

Author	Year	Focus of Study	Key Findings
Chakraborty and Saha [32]	2023	Healthcare waste management using Fermatean fuzzy models.	Highlighted the role of MCDM in selecting waste treatment technologies.
Nayeri et al. [34]	2023	Fermatean fuzzy environment for waste management in India.	Introduced FFBM and FFWBM operators for robust evaluation of healthcare waste technologies.
Stević et al. [33]	2020	MARCOS method for evaluating healthcare suppliers.	Comprehensive approach addressing economic, social, and environmental criteria.
Remadi and Frikha [35]	2020	Green supplier evaluation using IFS-FlowSort method.	Successfully addressed uncertainty and ambiguity in sorting suppliers for pharmaceuticals.

Hybrid algorithms and multi-step models effectively manage complex scenarios, ensuring reliable decision-making. Hybrid algorithms and fuzzy models excel in managing uncertainties while incorporating expert insights. Multi-phase frameworks further enhance this by integrating social, environmental, and economic dimensions, providing a comprehensive sustainability approach.

4.4 MCDM for Sustainable Supplier Selection in Manufacturing

This section examines the application of MCDM techniques in sustainable supplier selection within the manufacturing industry. Table 4 summarises diverse approaches addressing complexities across industries such as textiles, aluminium cans, home appliances, additive manufacturing, and plastics. Key methods include BWM, VIKOR, AHP, fuzzy AHP, and TOPSIS. For instance, Kusi-Sarpong et al. [36] combined BWM and VIKOR to prioritise technological infrastructure and organisational culture in textile manufacturing, while [37] applied AHP to evaluate digital, resilient, and sustainable supply chains in Industry 4.0. Ambilkar et al. [38] utilised fuzzy AHP and VIKOR to assess supplier performance under uncertainty in the aluminium cans industry. Advanced models, such as BWM-MARCOS and fuzzy Delphi with neutrosophic BWM, demonstrated high efficiency and practical applicability in sourcing strategies and resilience enhancement, as shown in and [38] for additive manufacturing and home appliances sectors. Findings emphasise the benefits of integrating sustainability into supplier selection, offering comprehensive evaluation tools under uncertain conditions. Techniques like fuzzy DEMATEL-VIKOR, used by [39], and MARCOS methods, applied by [40], reduce uncertainty and provide unbiased insights for strategic planning. Multi-objective frameworks further support supplier evaluation, order allocation, and overall supply chain optimisation.

Despite progress in the field, sustainability-related criteria such as waste management and product life cycles remain underexplored, limiting the comprehensiveness of supplier evaluations. A more integrated approach that equally considers environmental, economic, and social dimensions is necessary to enhance decision-making. Additionally, emerging technologies such as IoT, blockchain, and AI are underutilised, despite their potential to improve transparency, efficiency, and data-driven decision-making in sustainable supplier selection. Furthermore, there is a lack of long-term studies assessing the sustained impact of MCDM frameworks on sustainability, highlighting the need for future research to address these gaps.

Table 4.
Application of MCDM in Sustainable Supplier Selection in Manufacturing

Author	Year	Focus of Study	Key Findings
Kusi-Sarpong et al. [36]	2023	BWM and VIKOR methods for textile manufacturing.	Prioritized technological infrastructure and circular economy implementation.
Chaouni Benabdellah et al. [37]	2022	AHP for Industry 4.0 supplier selection.	Evaluated criteria like digital, resilient, and sustainable supply chains.
Zandkarimkhani et al. [41]	2022	Fuzzy AHP and VIKOR for aluminum cans industry.	Addressed supplier evaluation under uncertainty using interval numbers.
Ambilkar et al. [38]	2023	Fuzzy Delphi and neutrosophic BWM for additive manufacturing.	Enhanced resiliency and sustainability evaluation.
Sulistyoningarum et al. [42]	2020	BWM, TOPSIS, and MOLP for plastic manufacturing.	Optimized cost and sustainability in supplier selection and order allocation.
Tavakkoli-Moghaddam et al. [39]	2020	Fuzzy DEMATEL-VIKOR for cloud manufacturing.	Proposed a revenue-sharing contract framework for supplier-client coordination.
Chakraborty et al. [40]	2020	D numbers and MARCOS for iron and steel.	Reduced uncertainty and provides unbiased supplier evaluations.
Jain et al. [43]	2020	Fuzzy AHP and TOPSIS for sustainability in iron and steel industry.	Developed a supplier performance index for sustainability.

4.5 MCDM for Sustainable Supplier Selection in the Chemical Industry

This section examines the application of MCDM techniques in sustainable supplier selection within the chemical industry, including palm oil production, oil and gas, mining, and chemical engineering. Table 5 outlines methodologies that integrate sustainability criteria into supplier evaluation frameworks. Key approaches include AHP, TOPSIS, and hybrid models to address industry-specific challenges. For instance, Gahona-Flores and Juárez-Rubio [44] integrated AHP and TOPSIS to enhance supplier management in copper mining. In the oil and gas sector, Jermsittiparsert et al. [45] employed FANP and Electre, prioritising quality and contract commitment. Similarly, Ortiz-Barrios et al. [46] combined Fuzzy AHP, FDEMATEL, and TOPSIS to assess forklift filter suppliers, identifying quality as the most critical criterion. Other studies, such as Wu et al. [47], developed hybrid MCDM frameworks to tackle ecological protection and regulatory challenges in the chemical industry. Oey et al. [48] evaluated palm oil suppliers using AHP and TOPSIS, focusing on sustainability and environmental impact.

These studies demonstrate the effectiveness of MCDM methods in enhancing sustainable supplier selection. By incorporating sustainability and environmental factors, these frameworks support competitive decision-making. Hybrid models combining multiple MCDM techniques provide comprehensive supplier evaluations, ensuring robust purchasing strategies. Despite significant progress, notable gaps persist. Many existing approaches are not industry-specific and primarily emphasise environmental and economic factors, often neglecting social responsibility. Future research should adopt a more integrated approach, addressing environmental, financial, and social sustainability. Additionally, the complexity of current models hampers scalability and practical implementation. Simplifying these frameworks while maintaining their effectiveness is crucial for broader adoption.

Table 5
Application of MCDM in Sustainable Supplier Selection in the Chemical Industry

Author	Year	Focus of Study	Key Findings
Gahona-Flores and Juárez-Rubio [44]	2022	Sustainable supplier selection in copper mining using AHP and TOPSIS.	Enhanced decision-making and supplier management, addressing subjectivity in purchasing.
Jermsittiparsert et al. [45]	2021	Framework for supplier selection in oil and gas using FANP and Electre.	Quality and contract commitment ranked as top priorities, showing framework efficiency.
Ortiz-Barrios et al. [46]	2021	Fuzzy AHP, FDEMATEL, and TOPSIS for forklift filter supplier selection.	Quality emerged as the most crucial criterion for supplier evaluation.
Wu et al. [47]	2021	Hybrid MCDM for ecological protection and regulatory compliance.	Helped manager's select sustainable suppliers while maintaining competitiveness.
Oey et al. [48]	2020	Evaluated palm oil suppliers using AHP and TOPSIS.	Shortlisted top suppliers based on sustainability and environmental impact criteria.

4.6 MCDM for Sustainable Supplier Selection in Electronics and Automotive Sectors

This section examines the application of MCDM techniques in sustainable supplier selection within the electronics and automotive industries. Table 6 summarises methodologies incorporating fuzzy AHP, TOPSIS, DEA, SWARA, WASPAS, DEMATEL, and grey relational analysis, alongside advanced techniques such as linear programming and double hierarchy hesitant linguistic term sets to enhance decision-making precision. Key studies demonstrate the effectiveness of these methods. Chai et al. [49] compared fuzzy MCDM techniques for battery supplier selection, recommending fuzzy VIKOR for reliability. Gupta [50] developed a framework using fuzzy AHP and TOPSIS for sustainability decisions in the automobile industry. Izadikhah and Farzipoor Saen [51] applied a new DEA model to rank suppliers, distinguishing between efficient and inefficient ones in an automotive case. Wang et al. [52] utilised triangular fuzzy entropy and MULTIMOORA for battery supplier selection in electric vehicles, proving its feasibility. Similarly, Bhayana et al. [53] developed a two-phase optimisation model combining DEMATEL and grey relational analysis, demonstrating its effectiveness in an electronics company case study.

Findings highlight the importance of integrating sustainability into supplier selection, addressing criteria such as environmental impact, cost efficiency, and quality. Techniques like fuzzy AHP and hybrid models offer robust solutions for strategic planning and operational efficiency. However, gaps persist. Research lacks regional comparisons, which could reveal geographical variations in sustainability priorities. The influence of company size on sustainable supply chains remains underexplored. Additionally, model complexity limits scalability for large-scale implementation. Simplifying frameworks while preserving effectiveness will be crucial for wider adoption, enhancing the strategic depth and practical utility of MCDM applications in these industries.

Table 6.
Application of MCDM in Sustainable Supplier Selection in Electronics and Automotive Sectors

Author	Year	Focus of Study	Key Findings
Chai [49]	2023	Compared four fuzzy MCDM techniques for battery supplier selection.	Recommended fuzzy VIKOR for comprehensive and reliable decisions.
Gupta [50]	2022	Framework for sustainable supplier selection in the automobile industry using fuzzy AHP and TOPSIS.	Aided businesses in making strategic, sustainability-focused decisions.
Izadikhah [51]	2020	New DEA model for ranking automotive suppliers.	Successfully distinguished between efficient and inefficient suppliers.
Wang [52]	2021	Sustainable battery supplier selection using fuzzy entropy and MULTIMOORA.	Demonstrated feasibility in electric vehicle applications.
Bhayana [53]	2021	Two-stage optimization model using DEMATEL and gray relational analysis.	Confirmed effectiveness in electronics company case.
You et al,[54]	2020	Model for supplier selection and order allocation using advanced linguistic and MOLP methods.	Demonstrated applicability and efficiency in the electronics industry.

4.7 MCDM for Sustainable Supplier Selection in Food, Cold Supply Chains and Agriculture

This section examines the application of MCDM techniques in sustainable supplier selection for the food industry, cold supply chains, and agriculture. Table 7 summarises methodologies employing hybrid models to address sustainability challenges, focusing on the Triple Bottom Line approach, which integrates economic, environmental, and social dimensions. Notable studies showcase diverse approaches. Ada [55] combined Fuzzy Analytic Network Process (FANP) and fuzzy VIKOR to evaluate agri-food suppliers, ensuring balanced sustainability considerations. Yazdani et al. [56] developed a multi-tier model incorporating SWARA, LBWA, D-numbers, and MARCOS-D, validated through a WineSol Corporation case study. Khan and Ali [57] examined renewable resources as key drivers for sustainable cold chain suppliers in developing regions, using ISM and fuzzy VIKOR. Puška et al. [58] applied interval fuzzy logic to mitigate supplier information asymmetry, prioritising economic and social criteria over environmental concerns. Segura et al. [59] introduced a hybrid MAUT-PROMETHEE approach for food supplier evaluation, integrating factors such as food safety and corporate social responsibility.

Findings underscore the significance of hybrid models in supplier evaluation. Techniques like fuzzy VIKOR and interval fuzzy logic effectively manage uncertainties, while case studies validate their real-world applicability. The integration of multiple MCDM methods enhances adaptability and decision-making across various contexts. Despite progress, several gaps persist. The integration of real-time data remains limited, restricting adaptability to evolving sustainability criteria. Empirical studies testing these models under diverse conditions are scarce, and their long-term impacts remain underexplored. Additionally, AI is underutilised, despite its potential to enhance decision-making through dynamic, data-driven solutions. Future research should focus on developing scalable, holistic models that comprehensively address economic, environmental, and social dimensions, ensuring broader applicability and practical relevance.

Table 7
Application of MCDM in Sustainable Supplier Selection in Food, Cold Supply Chains, and Agriculture

Author	Year	Focus of Study	Key Findings
Ada [55]	2022	FANP and fuzzy VIKOR for sustainable agri-food supply chains.	Proposed a hybrid method addressing economic, environmental, and social sustainability.
Yazdani et al. [56]	2022	Multi-tier supplier selection for food supply chains using SWARA and MARCOS-D.	Validated in a WineSol Corporation case study, highlighting applicability in uncertain conditions.
Khan and Ali [57]	2021	Sustainable cold supply chains focusing on renewable resources.	Identified renewable resources as key drivers for sustainability in cold supply chains.
Puška et al. [58]	2021	Interval fuzzy logic for evaluating agricultural suppliers.	Prioritized economic and social criteria, addressing information asymmetry effectively.
Segura et al. [59]	2020	Hybrid MAUT-PROMETHEE approach for food supplier selection.	Enabled ranking based on food safety, product strategy, and corporate social responsibility.

4.8 MCDM for Sustainable Supplier Selection in Construction

This section examines the application of MCDM techniques for sustainable supplier selection in the construction industry. Table 8 summarises methodologies employing fuzzy EDAS, ELECTRE II, AHP, TOPSIS, dominance-based rough set analysis, and interval-valued probabilistic linguistic term sets (IVPLTS). Advanced approaches, including the integration of Z-numbers and case-based reasoning (CBR), enhance precision and practical decision-making. Key studies highlight the effectiveness of these techniques. Polat and Bayhan [60] utilised the fuzzy EDAS method to select energy-efficient HVAC systems, successfully reducing energy consumption and greenhouse gas emissions. Tu et al. [61] introduced an HFLT-Z-h-ELECTRE II approach to manage vague information and group consensus in supplier selection. Singh et al. [62] developed a dominance-based rough set analysis method to enhance decision transparency and credibility. Marzouk and Sabbah [63] combined AHP and TOPSIS to incorporate social sustainability considerations in supplier prequalification, while [64] proposed the IVPLTS-CBR model to manage uncertainty and cluster building suppliers effectively. Findings underscore the importance of MCDM models in addressing key supplier evaluation criteria, including energy efficiency, environmental impact, and social responsibility. Frameworks such as those proposed by [61; 63] emphasise the need to integrate social and environmental considerations into construction practices, while [60; 64] demonstrate the utility of advanced models in handling uncertainty and improving supplier evaluation processes.

Table 8.
Application of MCDM in Sustainable Supplier Selection in Construction

Author	Year	Focus of Study	Key Findings
Polat and Bayhan [60]	2022	Fuzzy EDAS for energy-efficient HVAC system selection.	Reduced energy consumption and greenhouse gas emissions, validated for green shopping centers.
Tu et al. [61]	2023	HFLT-Z-h-ELECTRE II for sustainable material supplier selection.	Managed vague information and expert consensus through group decision-making models.
Singh et al. [62]	2023	Dominance-based rough set analysis for supplier selection.	Enhanced transparency and credibility in decision-making with ranking rules for construction.
Marzouk and Sabbah [63]	2021	AHP-TOPSIS for socially sustainable supplier prequalification.	Evaluated suppliers against social sustainability attributes through structured interviews.
Li and Chen [64]	2022	IVPLTS-CBR for clustering building suppliers.	Managed uncertainty effectively, offering consistency and practicality over traditional methods.

Despite these advancements, several research gaps remain. The long-term effects of MCDM applications on supplier performance and overall sustainability are not well understood. The integration of real-time data analytics, essential for adapting to dynamic construction project conditions, remains underdeveloped. Additionally, cultural and socio-economic factors are often overlooked, underscoring the need for region-specific models to accommodate diverse construction practices. While methods such as IVPLTS-CBR have enhanced uncertainty management, the incorporation of predictive analytics for anticipating supplier risks remains underexplored. Addressing these gaps would significantly enhance the strategic value and practical applicability of MCDM in the construction industry.

5. Conclusion and Policy Implications

This review provides a comprehensive examination of MCDM techniques in sustainable supplier selection, underscoring their critical role in enhancing ecological, societal, and financial outcomes across diverse supply chains. Through an extensive bibliometric and content analysis of 79 recent studies sourced from the Scopus database, this study identifies key trends, research hotspots, and global collaboration patterns, offering valuable insights into the current landscape of MCDM applications. The bibliometric analysis highlights China, India, and Turkey as leading contributors in this field, reflecting a strong global commitment to sustainability in supplier selection. Notably, strategic research collaborations, particularly between China and countries such as Iran, India, and the USA, indicate an expanding global network that enhances the impact and scope of MCDM studies.

Findings from the content analysis reveal that the application of MCDM methods has significantly improved various dimensions of supply chain performance. Research consistently demonstrates that these techniques enhance the precision and depth of supplier evaluations by systematically integrating economic, environmental, and social criteria. Specifically, methods such as AHP, TOPSIS, and fuzzy logic facilitate the management of trade-offs among conflicting objectives, leading to more balanced and sustainable sourcing decisions. These approaches have proven effective in minimising biases and managing uncertainties in supplier selection, thereby contributing to enhanced risk mitigation and alignment with corporate sustainability goals. Furthermore, empirical applications highlight MCDM's adaptability to industry-specific requirements, supporting decision-makers in sectors such as manufacturing, healthcare, and electronics in optimising cost efficiencies, ensuring compliance with environmental regulations, and fostering greater stakeholder trust.

Despite the significant contributions of MCDM, this review identifies several gaps that present opportunities for future research. One critical limitation is the minimal integration of real-time data, which is essential for adjusting to rapidly evolving sustainability standards. Additionally, empirical studies examining MCDM applications across diverse operational and geographic contexts remain scarce. Another key gap is the underutilisation of AI and machine learning in MCDM processes, despite their potential to enhance the flexibility and accuracy of supplier evaluations. Future research should prioritise the development of AI-driven MCDM models capable of adapting dynamically to market fluctuations and evolving sustainability criteria. Incorporating real-time data analytics could significantly improve the precision of supplier assessments, while integrating local socio-economic factors would enable more context-sensitive and regionally tailored supply chain strategies.

From both practical and policy perspectives, the strategic adoption of MCDM techniques enables companies to align supplier selection with broader corporate sustainability goals. For industry practitioners, these methods enhance decision-making accuracy and adaptability by integrating environmental and social considerations alongside conventional cost and quality metrics. This comprehensive approach not only facilitates the development of sustainable supply chains but also strengthens corporate reputation in increasingly competitive markets. Moreover, establishing standardised industry frameworks that integrate MCDM methodologies with sustainability performance indicators could promote greater transparency and accountability in supplier selection processes.

Acknowledgment
The authors acknowledge the support of the American University of Sharjah under the Open Access Program. This paper represents the opinions of the authors and does not mean to represent the position or opinions of the American University of Sharjah.

References

[1] Naqvi, M. A., & Amin, S. H. (2021). Supplier selection and order allocation: a literature review. *Journal of data, information and management*, *3*(2), 125-139. https://doi.org/10.1007/s42488-021-00049-z
[2] Taherdoost, H., & Brard, A. (2019). Analyzing the process of supplier selection criteria and methods. *Procedia Manufacturing*, *32*, 1024-1034. https://doi.org/10.1016/j.promfg.2019.02.317
[3] Kannan, D., Khodaverdi, R., Olfat, L., Jafarian, A., & Diabat, A. (2013). Integrated fuzzy multi criteria decision making method and multi-objective programming approach for supplier selection and order allocation in a green supply chain. *Journal of Cleaner production*, *47*, 355-367. https://doi.org/10.1016/j.jclepro.2013.02.010
[4] Dou, Y., Zhu, Q., & Sarkis, J. (2018). Green multi-tier supply chain management: An enabler investigation. *Journal of Purchasing and Supply Management*, *24*(2), 95-107. https://doi.org/10.1016/j.pursup.2017.07.001
[5] Zimmer, K., Fröhling, M., & Schultmann, F. (2016). Sustainable supplier management–a review of models supporting sustainable supplier selection, monitoring and development. *International journal of production research*, *54*(5), 1412-1442. https://doi.org/10.1080/00207543.2015.1079340
[6] Schramm, V. B., Cabral, L. P. B., & Schramm, F. (2020). Approaches for supporting sustainable supplier selection-A literature review. *Journal of Cleaner production*, *273*, 123089. https://doi.org/10.1016/j.jclepro.2020.123089
[7] Gladwin, T. N., Kennelly, J. J., & Krause, T.-S. (1995). Shifting paradigms for sustainable development: Implications for management theory and research. *Academy of management Review*, *20*(4), 874-907. https://doi.org/10.5465/amr.1995.9512280024
[8] Rogers, E. (2003). Diffusion of innovations. https://worldveg.tind.io/record/19450/
[9] Wang, C.-N., Tsai, H.-T., Ho, T.-P., Nguyen, V.-T., & Huang, Y.-F. (2020). Multi-criteria decision making (MCDM) model for supplier evaluation and selection for oil production projects in Vietnam. *Processes*, *8*(2), 134. https://doi.org/10.3390/pr8020134
[10] Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Bmj*, *339*. https://doi.org/10.1136/bmj.b2535
[11] Siddaway, A. P., Wood, A. M., & Hedges, L. V. (2019). How to do a systematic review: a best practice guide for conducting and reporting narrative reviews, meta-analyses, and meta-syntheses. *Annual review of psychology*, *70*(1), 747-770. https://doi.org/10.1146/annurev-psych-010418-102803
[12] Van Eck, N., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *scientometrics*, *84*(2), 523-538. https://doi.org/10.1007/s11192-009-0146-3

[13] Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of business research*, *133*, 285-296. https://doi.org/10.1016/j.jbusres.2021.04.070

[14] Krippendorff, K. (2018). *Content analysis: An introduction to its methodology*. Sage publications. https://pascal-francis.inist.fr/vibad/index.php?action=getRecordDetail&idt=12476993

[15] Bengtsson, M. (2016). How to plan and perform a qualitative study using content analysis. *NursingPlus open*, *2*, 8-14. https://doi.org/10.1016/j.npls.2016.01.001

[16] Hamdan, S., Cheaitou, A., Shikhli, A., & Alsyouf, I. (2023). Comprehensive quantity discount model for dynamic green supplier selection and order allocation. *Computers & Operations Research*, *160*, 106372. https://doi.org/10.1016/j.cor.2023.106372

[17] Zhang, N., Zhou, Q., & Wei, G. (2022). Research on green supplier selection based on hesitant fuzzy set and extended linmap method. *International Journal of Fuzzy Systems*, *24*(7), 3057-3066. https://doi.org/10.1007/s40815-022-01250-x

[18] Rao, A. D., Chaitanya, A., Seshaiah, T., Bridjesh, P., & Sivakrishna. (2021). An Integrated Approach by Using Various Approaches for a Green Supplier Selection Problem. In *Recent Advances in Manufacturing, Automation, Design and Energy Technologies: Proceedings from ICoFT 2020* (pp. 909-919). Springer. https://doi.org/10.1007/978-981-16-4222-7_99

[19] Eghbali-Zarch, M., Zabihi, S. Z., & Masoud, S. (2023). A novel fuzzy SECA model based on fuzzy standard deviation and correlation coefficients for resilient-sustainable supplier selection. *Expert systems with applications*, *231*, 120653. https://doi.org/10.1016/j.eswa.2023.120653

[20] Hezam, I. M., Rani, P., Mishra, A. R., & Alshamrani, A. (2023). An intuitionistic fuzzy entropy-based gained and lost dominance score decision-making method to select and assess sustainable supplier selection. *Applied Mathematics for Modern Challenges*, *8*(5). http://doi.org/10.3934/math.2023606

[21] Liaqait, R. A., Warsi, S. S., Agha, M. H., Zahid, T., & Becker, T. (2022). A multi-criteria decision framework for sustainable supplier selection and order allocation using multi-objective optimization and fuzzy approach. *Engineering Optimization*, *54*(6), 928-948. https://doi.org/10.1080/0305215X.2021.1901898

[22] Zhong, S., Zhang, J., He, X., & Liu, S. (2022). Sustainable supply chain partner selection and order allocation: A hybrid fuzzy PL-TODIM based MCGDM approach. *Plos one*, *17*(9), e0271194. https://doi.org/10.1371/journal.pone.0271194

[23] Deniz, N. (2020). Cognitive biases in MCDM methods: An embedded filter proposal through sustainable supplier selection problem. *Journal of Enterprise Information Management*, *33*(5), 947-963. https://doi.org/10.1108/JEIM-09-2019-0285

[24] Aslani, B., Rabiee, M., & Tavana, M. (2021). An integrated information fusion and grey multi-criteria decision-making framework for sustainable supplier selection. *International Journal of Systems Science: Operations & Logistics*, *8*(4), 348-370. https://doi.org/10.1080/23302674.2020.1776414

[25] Cao, G. (2020). A multi-criteria picture fuzzy decision-making model for green supplier selection based on fractional programming. *International Journal of Computers Communications & Control*, *15*(1). http://dx.doi.org/10.15837/ijccc.2020.1.3762

[26] Ma, W., Lei, W., & Sun, B. (2020). Three-way group decisions under hesitant fuzzy linguistic environment for green supplier selection. *Kybernetes*, *49*(12), 2919-2945. https://doi.org/10.1108/K-09-2019-0602

[27] Kumar, A., Shrivastav, S., Adlakha, A., & Vishwakarma, N. K. (2022). Appropriation of sustainability priorities to gain strategic advantage in a supply chain. *International Journal of*

Productivity and Performance Management, *71*(1), 125-155. https://doi.org/10.1108/IJPPM-06-2020-0298
[28] Peng, J.-j., Tian, C., Zhang, W.-y., Zhang, S., & Wang, J.-q. (2020). An integrated multi-criteria decision-making framework for sustainable supplier selection under picture fuzzy environment. *Technological and Economic Development of Economy*, *26*(3), 573-598. https://doi.org/10.3846/tede.2020.12110
[29] Erdogan, H., & Tosun, N. (2021). Evaluation of sustainable supplier problem: A hybrid decision making model based on SWARA-WASPAS. *LogForum*, *17*(4). http://doi.org/10.17270/J.LOG.2021.613
[30] Rouyendegh, B. D., Yildizbasi, A., & Üstünyer, P. (2020). Intuitionistic fuzzy TOPSIS method for green supplier selection problem. *Soft computing*, *24*, 2215-2228. https://doi.org/10.1007/s00500-019-04054-8
[31] Alkan, N., & Kahraman, C. (2023). A novel continuous intuitionistic fuzzy CODAS method and its application to IOT service provider selection for sustainable supply chain. International Conference on Intelligent and Fuzzy Systems, 371-381. https://doi.org/10.1007/978-3-031-39777-6_45
[32] Chakraborty, S., & Saha, A. K. (2023). Novel Fermatean Fuzzy Bonferroni Mean aggregation operators for selecting optimal health care waste treatment technology. *Engineering Applications of Artificial Intelligence*, *119*, 105752. https://doi.org/10.1016/j.engappai.2022.105752
[33] Stević, Ž., Pamučar, D., Puška, A., & Chatterjee, P. (2020). Sustainable supplier selection in healthcare industries using a new MCDM method: Measurement of alternatives and ranking according to COmpromise solution (MARCOS). *Computers & industrial engineering*, *140*, 106231. https://doi.org/10.1016/j.cie.2019.106231
[34] Nayeri, S., Khoei, M. A., Rouhani-Tazangi, M. R., GhanavatiNejad, M., Rahmani, M., & Tirkolaee, E. B. (2023). A data-driven model for sustainable and resilient supplier selection and order allocation problem in a responsive supply chain: A case study of healthcare system. *Engineering Applications of Artificial Intelligence*, *124*, 106511. https://doi.org/10.1016/j.engappai.2023.106511
[35] Remadi, F. D., & Frikha, H. M. (2020). The intuitionistic fuzzy set FlowSort methodology for green supplier evaluation. 2020 International Conference on Decision Aid Sciences and Application (DASA), 1728196779. https://doi.org/10.1109/DASA51403.2020.9317061
[36] Kusi-Sarpong, S., Gupta, H., Khan, S. A., Chiappetta Jabbour, C. J., Rehman, S. T., & Kusi-Sarpong, H. (2023). Sustainable supplier selection based on industry 4.0 initiatives within the context of circular economy implementation in supply chain operations. *Production Planning & Control*, *34*(10), 999-1019. https://doi.org/10.1080/09537287.2021.1980906
[37] Chaouni Benabdellah, G., Bennis, K., Chaouni Benabdellah, A., & Zekhnini, K. (2021). Resilient sustainable supplier selection criteria assessment for economics enhancement in industry 4.0 context. IFIP international conference on product lifecycle management, 194-208. https://doi.org/10.1007/978-3-030-94335-6_14
[38] Ambilkar, P., Verma, P., & Das, D. (2024). Sustailient supplier selection using neutrosophic best–worst approach: a case study of additively manufactured trinkets. *Benchmarking: An International Journal*, *31*(5), 1515-1547. https://doi.org/10.1108/BIJ-02-2023-0122
[39] Tavakkoli-Moghaddam, R., Alipour-Vaezi, M., & Mohammad-Nazari, Z. (2020). A new application of coordination contracts for supplier selection in a cloud environment. Advances in Production Management Systems. Towards Smart and Digital Manufacturing: IFIP WG 5.7 International Conference, APMS 2020, Novi Sad, Serbia, August 30–September 3, 2020,

Proceedings, Part II, 197-205. https://doi.org/10.1007/978-3-030-57997-5_23
[40] Chakraborty, S., Chattopadhyay, R., & Chakraborty, S. (2020). An integrated D-MARCOS method for supplier selection in an iron and steel industry. *Decision Making: Applications in Management and Engineering*, *3*(2), 49-69. https://doi.org/10.31181/dmame2003049c
[41] Zandkarimkhani, S., Amiri, M., & Mousavi, S. M. H. (2022). A hybrid multi-criteria decision making method for sustainable supplier selection: a case study. *International Journal of Management and Decision Making*, *21*(2), 113-128. https://doi.org/10.1504/IJMDM.2022.121917
[42] Sulistyoningarum, R., Rosyidi, C. N., & Rochman, T. (2020). Supplier Selection and Order Allocation of Recycled Plastic Materials: A Case Study in a Plastic Manufacturing Company. *International Journal of Information and management Sciences*, *31*(4), 315-330. http://doi.org/10.6186/IJIMS.202012
[43] Jain, N., Singh, A., & Upadhyay, R. (2020). Sustainable supplier selection under attractive criteria through FIS and integrated fuzzy MCDM techniques. *International Journal of Sustainable Engineering*, *13*(6), 441-462. https://doi.org/10.1080/19397038.2020.1737751
[44] Gahona-Flores, O. F., & Juárez-Rubio, F. (2022). Metodologías para seleccionar proveedores en la cadena de suministro de la minería del cobre en Chile. *Información tecnológica*, *33*(3), 107-116. http://dx.doi.org/10.4067/S0718-07642022000300107
[45] Jermsittiparsert, K., Zahar, M., Sumarni, S., Voronkova, O. Y., Bakhvalov, S. Y., & Akhmadeev, R. (2021). Selection of sustainable suppliers in the oil and gas industry using fuzzy multi-criteria decision-making methods. *International Journal of Industrial Engineering and Management*, *12*(4), 253-261. https://doi.org/10.24867/IJIEM-2021-4-292
[46] Ortiz-Barrios, M., Cabarcas-Reyes, J., Ishizaka, A., Barbati, M., Jaramillo-Rueda, N., & de Jesús Carrascal-Zambrano, G. (2021). A hybrid fuzzy multi-criteria decision making model for selecting a sustainable supplier of forklift filters: A case study from the mining industry. *Annals of operations research*, *307*, 443-481. https://doi.org/10.1007/s10479-020-03737-y
[47] Wu, C., Lin, Y., & Barnes, D. (2021). An integrated decision-making approach for sustainable supplier selection in the chemical industry. *Expert systems with applications*, *184*, 115553. https://doi.org/10.1016/j.eswa.2021.115553
[48] Oey, E., Veronica, T., & Muliawan, A. (2020). Multi criteria decision making in supplier selection process–A case study in a Palm Oil Processor. 2020 International Conference on Information Management and Technology (ICIMTech), 260-265. https://doi.org/10.1109/ICIMTech50083.2020.9211294
[49] Chai, N., Zhou, W., Lodewijks, G., & Chen, Z. (2024). Comparative analysis of fuzzy multi-criteria decision making methods for selecting sustainable battery suppliers of battery swapping station. *International Journal of Green Energy*, *21*(7), 1500-1522. https://doi.org/10.1080/15435075.2023.2259977
[50] Gupta, A. K. (2022). Framework for the selection of sustainable suppliers using integrated compensatory fuzzy AHP-TOPSIS multi-criteria approach. 2022 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), 0772-0775. https://doi.org/10.1109/IEEM55944.2022.9989663
[51] Izadikhah, M., & Farzipoor Saen, R. (2020). Ranking sustainable suppliers by context-dependent data envelopment analysis. *Annals of operations research*, *293*(2), 607-637. https://doi.org/10.1007/s10479-019-03370-4
[52] Wang, R., Li, X., & Li, C. (2021). Optimal selection of sustainable battery supplier for battery swapping station based on Triangular fuzzy entropy-MULTIMOORA method. *Journal of Energy Storage*, *34*, 102013. https://doi.org/10.1016/j.est.2020.102013

[53] Bhayana, N., Gandhi, K., Jain, A., Darbari, J. D., & Jha, P. (2021). An integrated grey-based multi-criteria optimisation approach for sustainable supplier selection and procurement-distribution planning. *International Journal of Advanced Operations Management*, *13*(1), 39-91. https://doi.org/10.1504/IJAOM.2021.113665

[54] You, S.-Y., Zhang, L.-J., Xu, X.-G., & Liu, H.-C. (2020). A new integrated multi-criteria decision making and multi-objective programming model for sustainable supplier selection and order allocation. *Symmetry*, *12*(2), 302. https://doi.org/10.3390/sym12020302

[55] Ada, N. (2022). Sustainable supplier selection in agri-food supply chain management. *International Journal of Mathematical, Engineering and Management Sciences*, *7*(1), 115. https://doi.org/10.33889/IJMEMS.2022.7.1.008

[56] Yazdani, M., Pamucar, D., Chatterjee, P., & Torkayesh, A. E. (2022). A multi-tier sustainable food supplier selection model under uncertainty. *Operations Management Research*, *15*(1), 116-145. https://doi.org/10.1007/s12063-021-00186-z

[57] Khan, A. U., & Ali, Y. (2021). Sustainable supplier selection for the cold supply chain (CSC) in the context of a developing country. *Environment, development and sustainability*, 1-30. https://doi.org/10.1007/s10668-020-01203-0

[58] Puška, A., Nedeljković, M., Hashemkhani Zolfani, S., & Pamučar, D. (2021). Application of interval fuzzy logic in selecting a sustainable supplier on the example of agricultural production. *Symmetry*, *13*(5), 774. https://doi.org/10.3390/sym13050774

[59] Segura, M., Maroto, C., Segura, B., & Casas-Rosal, J. C. (2020). Improving food supply chain management by a sustainable approach to supplier evaluation. *Mathematics*, *8*(11), 1952. https://doi.org/10.3390/math8111952

[60] Polat, G., & Bayhan, H. G. (2022). Selection of HVAC-AHU system supplier with environmental considerations using Fuzzy EDAS method. *International Journal of Construction Management*, *22*(10), 1863-1871. https://doi.org/10.1080/15623599.2020.1742638

[61] Tu, Y., Zhou, R., Zhou, X., & Lev, B. (2023). Incorporating a new perspective of Z-number into ELECTRE II with group consensus involving reliance degree and prospect theory. *Applied Intelligence*, *53*(20), 23316-23335. https://doi.org/10.1007/s10489-023-04757-4

[62] Singh, A., Kumar, V., & Verma, P. (2025). Sustainable supplier selection in a construction company: a new MCDM method based on dominance-based rough set analysis. *Construction Innovation*, *25*(2), 328-362. https://doi.org/10.1108/CI-12-2022-0324

[63] Marzouk, M., & Sabbah, M. (2021). AHP-TOPSIS social sustainability approach for selecting supplier in construction supply chain. *Cleaner environmental systems*, *2*, 100034. https://doi.org/10.1016/j.cesys.2021.100034

[64] Li, P., & Chen, H. (2022). Evaluation of green building suppliers based on IVPLTS-CBR decision-making method. *International journal of intelligent computing and cybernetics*, *15*(1), 17-40. https://doi.org/10.1108/IJICC-06-2021-0118