SCIENTIFIC OASIS

Spectrum of Mechanical Engineering and Operational Research

Journal homepage: www.smeor-journal.org
eISSN: 3042-0288

A Bibliometric Analysis of Material Selection Using MCDM Methods: Trends and Insights

Sushil Kumar Sahoo[1,*], Bibhuti Bhusan Choudhury[1], Prasant Ranjan Dhal[1]

[1] Department of Mechanical Engineering, Indira Gandhi Institute of Technology (BPUT, Rourkela), Sarang, Dhenkanal, Odisha, India

ARTICLE INFO

Article history:
Received 7 April 2024
Received in revised form 19 July 2024
Accepted 5 August 2024
Available online 11 August 2024

Keywords:
Bibliometric Analysis, MCDM, Material selection, VOSviewer, Science Mapping.

ABSTRACT

The selection of appropriate materials is a critical decision-making process in engineering, impacting both performance and sustainability. Multi-Criteria Decision-Making (MCDM) methods have become increasingly popular for navigating the complex trade-offs involved in material selection. This study presents a comprehensive bibliometric analysis of research on material selection using MCDM methods, covering publications from 2010 to 2024. Using tools like VOSviewer 1.6.20, this analysis identifies key trends, influential authors, prominent institutions, and geographic distribution of research contributions. The findings reveal a significant growth in publications, particularly after 2010, reflecting the expanding recognition of MCDM's importance in material selection processes. Notable contributors, including key researchers and leading institutions, have shaped the field through high-impact studies. The geographic analysis highlights a strong concentration of research in regions such as Asia and Europe, underscoring their leadership in advancing MCDM methodologies. This paper provides valuable insights into the evolution of material selection research using MCDM, offering a foundation for future studies and applications in engineering and beyond.

1. Introduction

Material selection in engineering applications is a multifaceted process that plays a crucial role in determining the performance, cost-effectiveness, and durability of a product. Engineers must carefully consider a wide array of factors to choose the optimal material for a given application. This process begins with defining the requirements based on the application's functional needs, which may include mechanical properties such as strength, stiffness, toughness, fatigue resistance, and hardness; physical properties like density, thermal and electrical conductivity, and thermal expansion; chemical properties, including corrosion resistance, chemical stability, and reactivity; and environmental factors such as exposure to extreme temperatures, humidity, UV radiation, and corrosive environments [1].

* *Corresponding author.*
E-mail address: sushilkumar00026@gmail.com

https://doi.org/10.31181/smeor11202417

In addition to these performance-related criteria, economic considerations such as material cost, availability, ease of processing, and lifecycle costs, including maintenance and recyclability, play a vital role. Engineers often utilize material selection charts, like Ashby charts, which visually compare materials based on key properties, to identify candidate materials that meet the initial criteria [2]. The next step involves screening these materials by eliminating those that do not meet essential requirements and ranking the remaining options based on how well they satisfy the desired properties. This step may involve trade-offs, as a material with superior strength might be heavier or more expensive, requiring engineers to balance competing priorities [3]. Detailed analysis through simulations, prototyping, and testing further refines the selection, ensuring that the chosen material will perform as expected under specific conditions.

For instance, in aerospace applications, materials like titanium alloys, aluminum alloys, and carbon fiber-reinforced polymers (CFRP) are often preferred due to their high strength-to-weight ratios and excellent fatigue resistance, although the final choice might depend on factors such as manufacturability and cost [4]. In contrast, electronic components may prioritize materials like copper or silicon due to their excellent electrical conductivity and thermal stability. Additionally, the selection process must consider the manufacturing methods compatible with the material, as certain materials may be more amenable to processes like casting, machining, or additive manufacturing. Furthermore, sustainability has become an increasingly important factor, with engineers looking for materials that not only meet technical requirements but also have a lower environmental impact, including the potential for recycling or reuse. This comprehensive approach ensures that the final material choice aligns with the overall goals of the project, including performance, safety, cost, and environmental responsibility.

1.1 Importance of applying MCDM methods in material selection

The application of Multi-Criteria Decision-Making (MCDM) methods in material selection is crucial due to the complex nature of material choice in engineering and manufacturing. Here's why MCDM methods are important in this context:

i. Complex Decision Environment**:** Material selection involves various criteria such as mechanical properties, cost, availability, environmental impact, and durability. MCDM methods help in evaluating and balancing these diverse factors systematically.
ii. Objective Evaluation**:** MCDM methods provide a structured framework for evaluating multiple criteria objectively. This helps in minimizing biases and ensures that the material selection process is based on quantitative analysis rather than intuition alone.
iii. Trade-off Analysis**:** MCDM methods enable decision-makers to understand the trade-offs between different criteria. For example, a material might be more cost-effective but less durable. MCDM helps in assessing these trade-offs to make informed decisions.
iv. Enhanced Decision Quality**:** By incorporating various criteria and stakeholder preferences, MCDM methods enhance the quality of decision-making. They allow for a more comprehensive assessment, leading to better and more reliable material choices.
v. Support for Complex Projects**:** In projects with stringent requirements and multiple constraints, MCDM methods help in identifying the most suitable material by considering all relevant factors simultaneously.
vi. Adaptability: MCDM methods can be adapted to various industries and applications, making them versatile tools for material selection across different fields.

vii. Improved Communication**:** The structured approach of MCDM methods facilitates better communication among team members and stakeholders by providing clear rationale and justification for material choices.

Overall, MCDM methods streamline the material selection process, making it more systematic, transparent, and aligned with the overall project goals and constraints.

1.2 Past Literature on Bibliometric analysis on MCDM methods

The significance of research in Multi-Criteria Decision-Making (MCDM) has grown considerably. Academics have conducted numerous bibliometric analyses to systematically explore the patterns, trends, and impact of MCDM research. Bibliometric analysis provides valuable insights into the evolution of MCDM literature by identifying key themes, influential authors, seminal publications, and emerging research areas. This summary reviews previous bibliometric studies on MCDM, highlighting major findings and suggesting future research directions, as illustrated in Table 1.

Table 1
Past works on bibliometric analysis

Sl.No.	Authors	Research Title	Data base and Tools	Findings
1	Kökçam et al., [5]	Bibliometric analysis of artificial intelligence techniques for predicting soil liquefaction: insights and MCDM evaluation.	Web of Science, Vosviewer	AI techniques for soil liquefaction show growth
2	Srivastava et al., [6]	Multi-criteria decision making (MCDM) in diverse domains of education: a comprehensive bibliometric analysis for research directions	Vosviewer, R package "bibliometrics" and Tableau	China leads MCDM research in education, with fuzzy techniques and notable collaborations.
3	Demir et al., [7]	Sensitivity analysis in multi-criteria decision making: A state-of-the-art research perspective using bibliometric analysis	RStudio, CiteSpace, and VOSviewer	Sensitivity analysis in MCDM is underexplored; China leads, India excels in collaboration.
4	Rocha et al., [8]	Review and Bibliographic Analysis of Metaheuristic Methods in Multicriteria Decision-Making: A 45-Year Perspective Across International, Latin American, and Colombian Contexts	Scopus, and Vosviewer	MCDA research spans 45 years; India, China, Iran lead publications; TOPSIS popular.
5	Nirmal et al., [9]	Application of fuzzy methods in green and sustainable supply chains: critical insights from a systematic review and bibliometric analysis	Web of Science, Scopus, and Vosviewer	Social sustainability research is limited; Industry 4.0 integration with GSC shows promise.
6	Khulud et al., [10]	Sustainable Supplier Selection through Multi-Criteria Decision Making (MCDM) Approach: A Bibliometric Analysis	Scopus, and Vosviewer	Sustainable supplier selection via MCDM grew significantly in 2019; articles dominate.
7	Vatankhah et al., [11]	MCDM in travel and tourism research since 1997: A bibliometric approach	Scopus, and Vosviewer	MCDM techniques are underexplored in travel and tourism.

Sl.No.	Authors	Research Title	Data base and Tools	Findings
8	Sahin, [12]	A Systematic Overview of Decision-Making on Public Transport Systems Using Bibliometric Analysis on Vosviewer	Vosviewer	Significant annual increase in publications on public transport showing, countries, institutions, journals, and authors
9	Delcea et al., [13]	Quantifying Neutrosophic Research: Bibliometric Study	Web of Science, Vosviewer	Neutrosophic theory shows significant growth and diverse applications, with key contributors and global research expansion
10	Raza et al., [14]	Research themes in machine learning applications in supply chain management using bibliometric analysis tools	R-package "bibliometrix"	The analysis identifies key authors, topics, collaborations, and clusters using bibliometrics and multivariate techniques.
11	Pereira et al., [15]	Charting the managerial and theoretical evolutionary path of AHP using thematic and systematic review: a decadal (2012–2021) study	Scopus, and Vosviewer	AHP's growth in decision science is analyzed, revealing key trends, collaborations, and future research directions.
12	Calleo et al., [16]	Delphi-based future scenarios: a bibliometric analysis of climate change case studies	Web of Science, Scopus	Delphi-based scenarios effectively address climate change uncertainty, offering insights for future research methodologies.
13	Ayan and Abacıoğlu, [17]	Bibliometric analysis of the MCDM methods in the last decade: WASPAS, MABAC, EDAS, CODAS, COCOSO, and MARCOS	Scopus, Biblioshiny	MCDM methods show increasing research, with key authors, topics, and countries like China leading citations.
14	Girardi et al., [18]	Bibliometric study on multi-criteria decision-making methods applied to life cycle management of defense systems	Web of Science, Scopus	MCDM methods, especially AHP, are widely applied in military Life Cycle Management across all stages.
15	Costa et al., [19]	Bibliometric studies on multi-criteria decision analysis (MCDA) methods applied in military problems	Web of Science, Scopus	MCDA methods, especially AHP, are crucial in military decision-making across tactical, operational, and strategic levels.
16	Dai et al., [20]	Knowledge mapping of multicriteria decision analysis in healthcare: a bibliometric analysis	Web of Science, VOSviewer, R-bibliometrix, and CiteSpace	MCDA is crucial in healthcare, with potential for further methodological and application advancements.
17	Castelló-Sirvent et al., [21]	Three decades of fuzzy AHP: A bibliometric analysis	Web of Science	Fuzzy AHP research shows thematic evolution, collaboration networks, and publication opportunities, guiding future academic agendas.

Sl.No.	Authors	Research Title	Data base and Tools	Findings
18	Barcellos-Paula et al., [22]	Bibliometric review of research on decision models in uncertainty, 1990–2020	Web of Science, VOSviewer, R, and Python	Decision models under uncertainty show growth, with AHP as the most used; China leads in collaborations.

1.3 Novelty and Research Gap of the present study

a) Novelty

This study provides a comprehensive bibliometric analysis of material selection using Multi-Criteria Decision-Making (MCDM) methods, offering fresh insights into research trends and methodologies. The novelty lies in its systematic approach to evaluating the evolution of MCDM techniques specifically applied to material selection, highlighting emerging trends, influential studies, and key research gaps. The study utilizes advanced bibliometric tools to analyze a large dataset of publications, uncovering significant patterns and shifts in research focus over time.

b)Research Gap

Despite the growing body of literature on MCDM methods for material selection, several research gaps remain. First, there is a need for a deeper exploration of how newer MCDM methods, such as hybrid approaches and advanced algorithms, are being integrated into material selection processes. Additionally, there is limited research on the practical implementation of these methods in real-world scenarios and their effectiveness compared to traditional techniques.

1.4 Objective of the present study

The objective of this study is to conduct a comprehensive bibliometric analysis of research on material selection using Multi-Criteria Decision-Making (MCDM) methods. Specifically, the study aims to:

i. Analyze Trends: Identify and analyze trends in the application of MCDM methods for material selection over time, including the evolution of methodologies and their adoption across various industries.
ii. Evaluate Research Impact: Assess the impact of key publications, influential authors, and leading journals in the field, highlighting significant contributions and high-citation works.
iii. Map Research Networks: Examine collaboration networks among researchers, institutions, and countries to understand the global distribution and cooperative dynamics within the field.

2. Bibliometric Analysis Methods

In order to accomplish its goals, this review uses bibliometric analysis and VOSviewer, a specialist tool for bibliometric and bibliographic mapping [23]. With its thorough visualizations of the literature, VOSviewer makes it easier to examine research patterns pertaining to material selection in depth. The study intends to shed light on current research and identify important areas of interest within the discipline by extracting and summarizing data from a carefully chosen collection of papers.

Using VOSviewer enables a thorough investigation of the evolution of decision-making processes in the material selection, revealing important trends and linkages in the literature [24]. The program facilitates the mapping of significant studies, authors, and collaborative efforts, providing a more comprehensive picture of the research environment [25]. This method not only illustrates the evolution of research ideas but also the relationships between different contributors and institutions [26]. Through providing an in-depth summary of the field's current situation, the review hopes to give scholars important insights into ongoing trends in material selection aspect. As shown in Figure

1, a methodical procedure consisting of five discrete steps was used to accomplish the goals of this evaluation. Using the Dimensions.ai database's basic search capability, pertinent materials were gathered in the first phase. The search was conducted using the terms "MCDM method" and "Material Selection" and it was limited to the years 2010 through 2024. On August 11, 2024, this data collection took place. A total of 3502 documents were obtained. Phase 2 involved a shift in focus to a more in-depth assessment of the publication output by nation, which was accomplished by hand analysis using the WOS database's first associated author's address. This assessment assisted in determining the geographic distribution of the field's research contributions.

Ultimately, a thorough examination and discussion of the tables and bibliographic maps produced by the VOSviewer analysis revealed patterns, significant studies, and areas that demand more investigation in the context of public transportation decision-making [27]. This exhaustive analysis not only emphasized the current status of research but also provided insightful avenues for future research and collaborations.

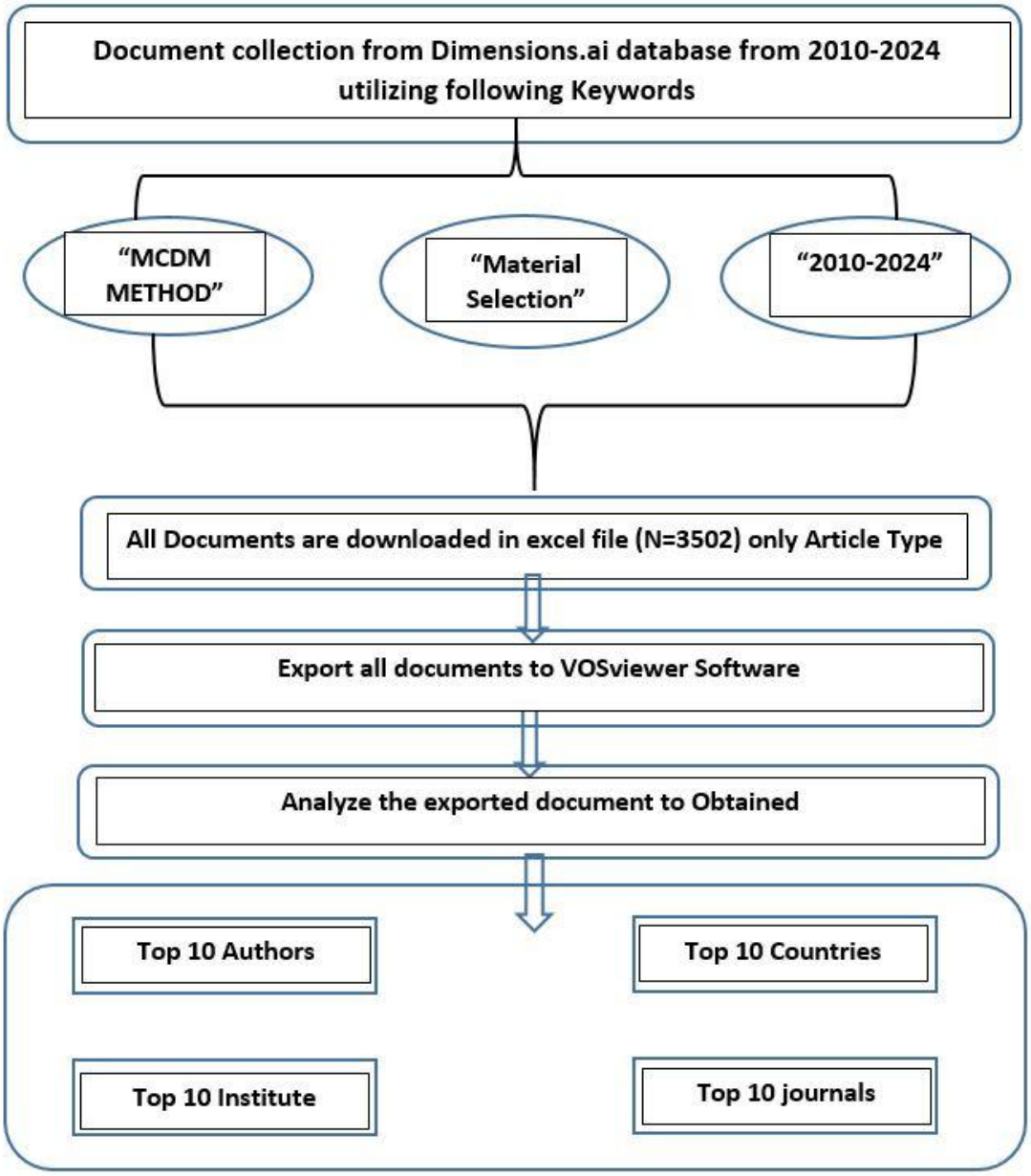

Fig. 1. Bibliometric analysis flowchart

3. Results and Discussion

3.1 Trend Analysis

The annual publication count of research papers on material selection using Multi-Criteria Decision-Making (MCDM) methods from 2010 to 2024 reveals a series of distinct phases that highlight the evolving interest and application of these methods as shown in Figure 2. In the early growth phase, from 2010 to 2014, there was a steady increase in publications, rising from 13 in 2010 to 76 in 2014. This period marks the initial recognition and adoption of MCDM methods within the material selection field, as the engineering and design communities increasingly saw the value of systematic decision-making processes to address the complexities of material selection.

From 2015 to 2020, the field experienced a period of rapid expansion, with publication numbers increasing significantly each year—from 122 in 2015 to 382 in 2020. This surge can likely be attributed to advancements in computational tools that facilitated the implementation of MCDM methods, a growing awareness of the need for sustainable material choices, and the broader adoption of these techniques across various industries. This period reflects an era of heightened interest and application, where researchers and practitioners alike recognized the benefits of integrating MCDM methods into their workflows.

The years 2021 to 2024 represent a period of peak activity, followed by a slight decline. The number of publications peaked in 2022 with 546 papers, indicating that MCDM methods had become well-established and widely utilized within the material selection community. However, in 2023, there was a small decrease to 534 publications, and data from 2024 shows a further reduction to 379. This decline might be due to several factors, such as market saturation, shifts in research focus, or natural fluctuations in research funding and publication trends. It suggests that while MCDM methods remain crucial, the field may be transitioning into a more mature phase where research is becoming more specialized or integrated with other decision-making frameworks [28].

Overall, the publication trends from 2010 to 2024 demonstrate sustained interest and maturity in the application of MCDM methods for material selection. The consistent growth over the years underscores the methods' relevance and utility in addressing material selection challenges. The peak observed in 2022 may indicate a saturation point, suggesting that most foundational and exploratory research has already been conducted. The slight decline in subsequent years hints at potential shifts in focus, where researchers might be exploring new methodologies or refining existing knowledge within the domain. This evolving trend suggests that the field is moving towards more specialized applications and integrated approaches, paving the way for future advancements in MCDM techniques and their implementation in material selection processes [29].

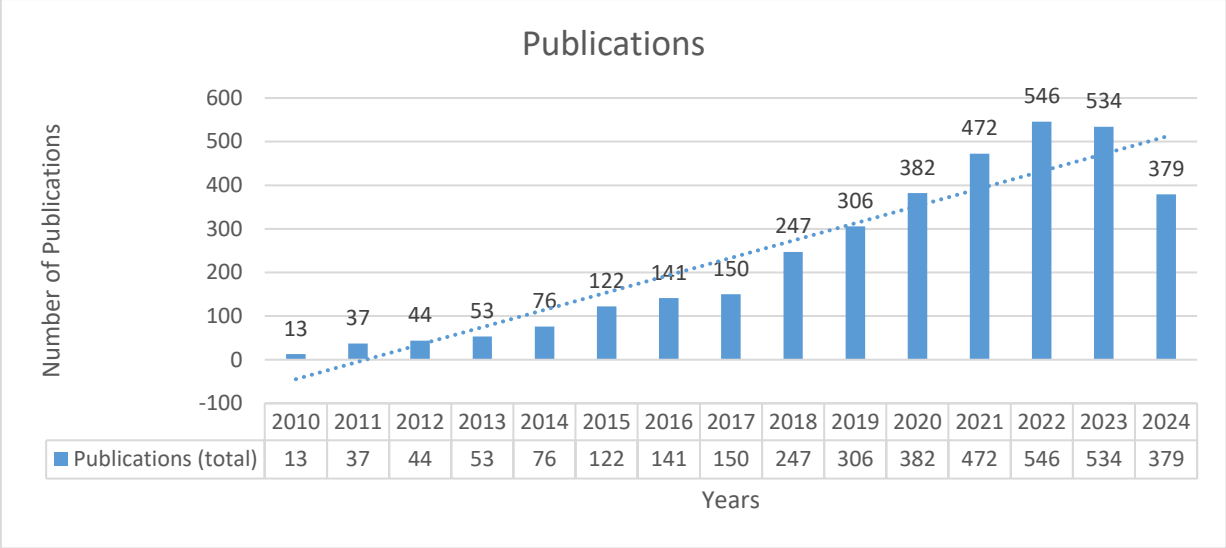

Fig. 2. Publications from 2010 to 2024 based on Dimension.ai Database

Between 2010 and 2014, the total number of citations grew from a modest 12 in 2010 to 976 in 2014. This period marks the early phase of the field's development, where MCDM methods were gradually gaining traction in material selection as shown in Figure 3. The relatively low citation counts during these years suggest that the research was still emerging, and it took time for these studies to be widely acknowledged by the academic community. The growth in citations during this phase indicates that foundational work was beginning to be recognized as valuable, laying the groundwork for future research.

The period from 2015 to 2019 witnessed a substantial increase in citations, rising from 1,409 in 2015 to an impressive 8,478 in 2019. This significant growth corresponds with the broader adoption and application of MCDM methods across various disciplines. The sharp rise in citations during these years indicates that research in this area was not only becoming more prevalent but also highly impactful. The growing number of studies citing foundational work in MCDM for material selection reflects the maturation of the field. Researchers were increasingly building upon previous work, leading to more extensive applications and refinements of these methods.

From 2020 onwards, the field saw the most dramatic increase in citations, with the count skyrocketing to 11,364 in 2020 and continuing to grow, reaching 23,189 by 2023. The data for 2024, though incomplete, shows a citation count of 15,985. This period represents the peak of the field's influence, indicating that MCDM methods have become integral to material selection research. The exponential rise in citations during these years suggests that the research is widely recognized, with numerous studies relying on these methods for their decision-making processes. The slight decrease observed in 2024 could be due to incomplete data or a natural plateau as the field reaches saturation in terms of citation potential.

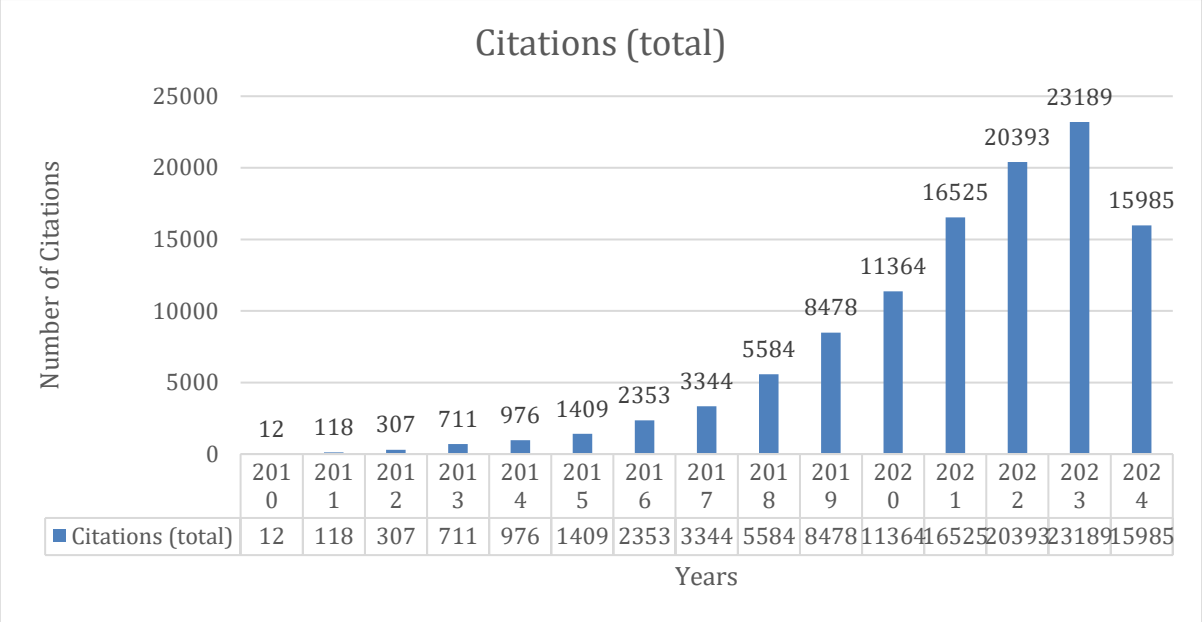

Fig. 3. Citations from 2010 to 2024 based on Dimension.ai Database

3.2 Co-authorship Analysis

In bibliometrics, co-author analysis examines how academics work together by examining academic publications [30-32]. Software called VOSviewer aids in the creation of a network map. When authors collaborate on a publication, they become nodes with edges connecting them.

Here's how each of these units is utilized in co-authorship analysis within VOSviewer:

i. Authors: 3502 authors are detected in this study by excluding texts that have a maximum of 25 authors each. Just 232 authors—who have at least four documents and an author citation—meet the requirements. Figure 4 illustrates that of the 232 authors, 116 authors had the greatest number of related things.

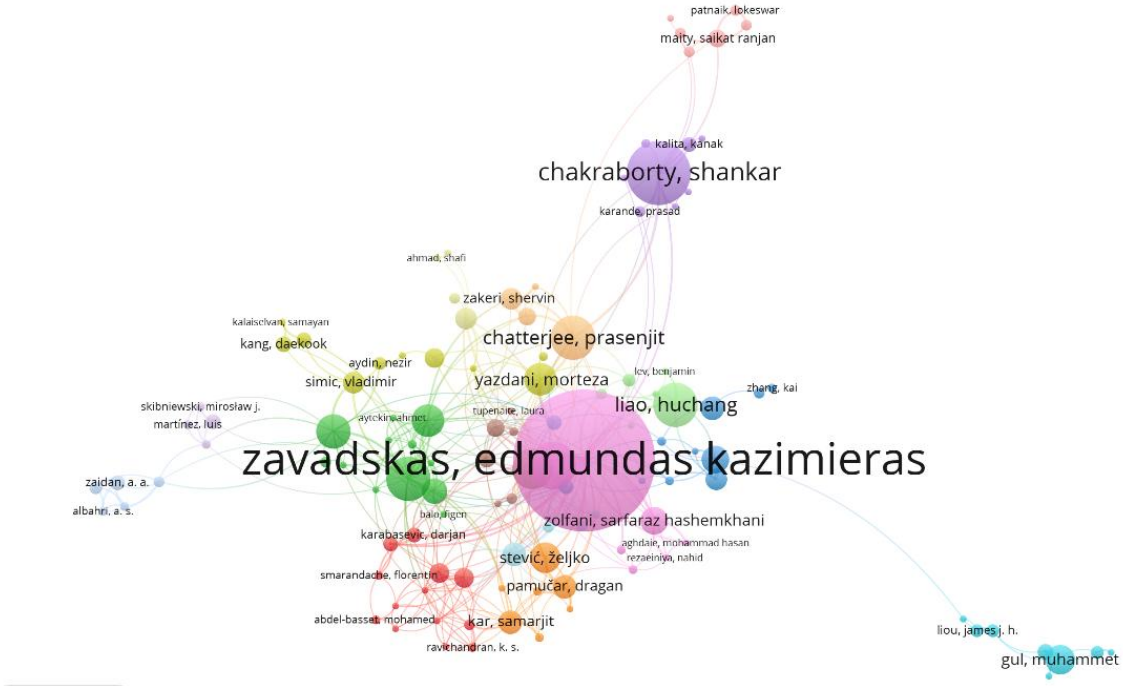

Fig. 4. Bibliometric map on co-authorship with Network visualization mode

The top authors in material selection using MCDM methods display a blend of foundational and specialized research. Notably, Abbas Mardani and Ahmad Jusoh, with fewer but highly cited publications, highlight the impact of innovative work in this field. The trend toward higher citation rates reflects evolving, sophisticated approaches, with some authors focusing on advanced methodologies. Overall, the research landscape shows a shift towards specialization and significant contributions, indicating continuous refinement and innovation in MCDM methods for material selection as shown in Table 2.

Table 2
Top 10 Authors publications, citations, and average citation per article

Rank	Author	Publications	Citations	Average Citation per article
1	Edmundas Kazimieras Zavadskas	77	7506	97.48
2	Hu-Chen Liu	39	4241	108.74
3	Abbas Mardani	13	3137	241.31
4	Morteza Yazdani	18	3097	172.06
5	Zenonas Turskis	26	2850	109.62
6	Ahmad Jusoh	6	2446	407.67
7	Dragan Pamučar	13	2421	186.23
8	Prasenjit Chatterjee	24	2107	87.79
9	Shankar Chakraborty	35	2030	58.00
10	Jian-Xin You	14	1595	113.93

ii. Organizations (Affiliations): VOSviewer allows the study of organizations or affiliations that writers are a part of in addition to the analysis of authors [33-35]. Using a maximum of 30 organizations per document, 2101 organizations are detected in this analysis by ignoring documents. Only 313 organizations—having at least four papers and an organization citation—meet the requirements. Figure 5 illustrates that 288 organizations—out of 313 organizations—have the greatest collection of related things.

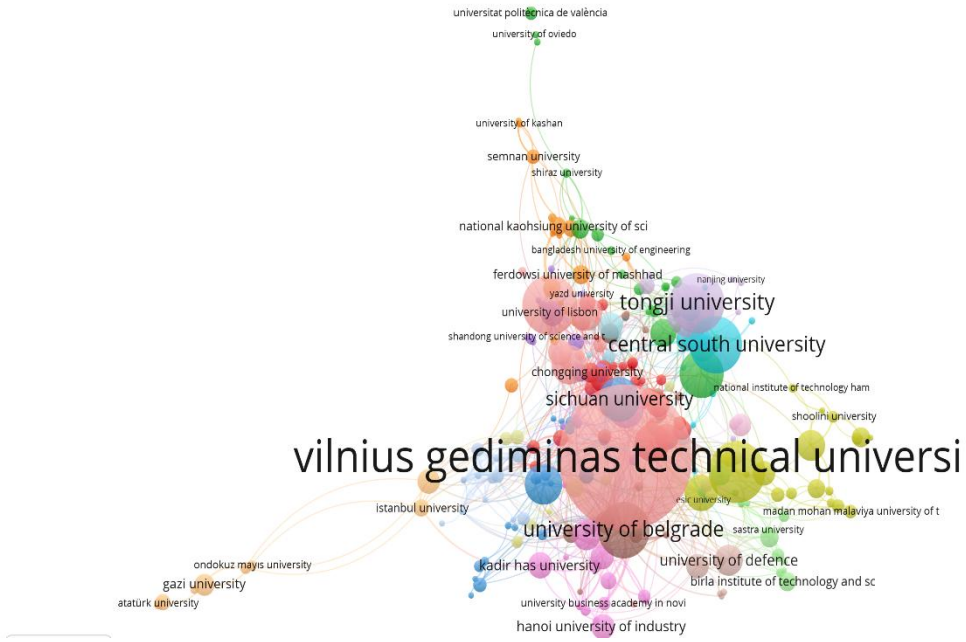

Fig. 5. Bibliometric map on Organization with Network visualization mode

The top universities that use MCDM techniques for material selection showcase a variety of research accomplishments. With the most publications and a strong citation average, Vilnius Gediminas Technical University does exceptionally well and has a significant and widespread presence with respect to material selection. With fewer but noteworthy publications, Tongji University and Shanghai University, with high average citation counts, show a great effect. The subject is witnessing a move towards specialized research, as evidenced by the contributions of universities such as Yıldız Technical University and Jadavpur University, which have lower citation rates yet contribute a combination of fundamental and developing work as shown in Table 3.

Table 3
Top 10 Organization publications, citations, and average citation per article

Rank	Organization	Publications	Citations	Average Citation per article
1	Vilnius Gediminas Technical University	123	8315	67.60
2	Jadavpur University	48	2016	42.00
3	Tongji University	46	4501	97.85
4	University Of Tehran	46	2059	44.76
5	Central South University	44	2590	58.86
6	University Of Belgrade	43	1844	42.88
7	Shanghai University	40	3901	97.53
8	Anna University, Chennai	36	1142	31.72
9	Sichuan University	33	1858	56.30
10	Yıldız Technical University	30	1119	37.30

iii. Countries: Additionally, VOSviewer makes it easier to analyze the nations in co-authorship networks. 92 nations are detected in this study by excluding papers that contain a maximum of 25 countries each. As illustrated in Figure 6, only 64 organizations satisfy the requirements with a minimum of 4 papers and country citations.

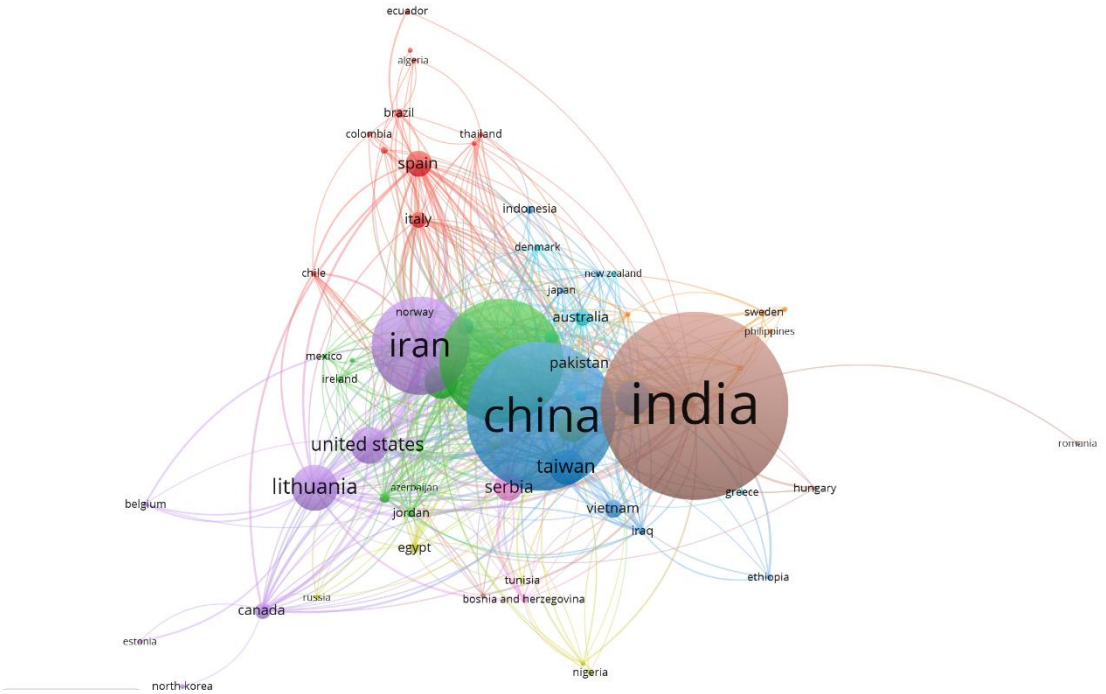

Fig. 6. Bibliometric map on Country with Network visualization mode

India is at the forefront of research on material selection using MCDM approaches; yet, the average number of citations per article is lower, indicating a greater distribution of research but a lesser influence as shown in Table 4. Despite having fewer publications, China has more citations, which indicates that its work is more influential. Despite producing fewer publications, Malaysia and Lithuania have the greatest average citation counts, indicating a considerable effect. With nations like Iran and the UK displaying high citation rates, indicating significant and specialized research contributions, trends point to a shift away from quantity and towards quality.

Table 4
Top 10 Country publications, citations, and average citation per article

Rank	Country	Publications	Citations	Average Citation per article
1	India	534	14460	27.08
2	China	424	19137	45.13
3	Turkey	354	9951	28.11
4	Iran	280	14050	50.18
5	Lithuania	132	8817	66.80
6	United States	107	4145	38.74
7	Malaysia	100	8866	88.66
8	Taiwan	100	3136	31.36
9	United Kingdom	95	4851	51.06
10	Saudi Arabia	88	2080	23.64

3.3 Citation Analysis

VOSviewer, a popular tool for bibliometric analysis, indeed allows researchers to analyze citation relationships across various units, including documents and sources [36-37]. Let's break down how each of these units contributes to citation analysis in VOSviewer:

i. Documents: The main subject of citation analysis is individual academic works, such as journal articles, conference papers, books, or patents [38]. With the aid of VOSviewer, scholars can analyze the relationships between citations in documents, identifying key works, following the progression of ideas, and comprehending the intellectual framework of an area of study. There are 2,500 documents found in this analysis. Merely 1801 documents satisfy the criterion with a minimum of four citations each. Figure 7 illustrates that, of the 1801 documents, 1000 papers had the greatest number of related things.
ii. Sources: Journals and conference proceedings are examples of publications that are considered sources [39,40]. Through the use of VOSviewer, scholars can examine the patterns of citations across sources to determine which articles are commonly mentioned in tandem and how they add to the body of knowledge in a certain topic or study. There are 806 sources in this analysis. Merely 137 sources satisfy the required minimum of 4 documents and source citations. Figure 8 illustrates that of the 137 sources, 130 have the greatest collection of related items.

Elsevier dominates the top journals for MCDM research in material selection; Expert Systems with Applications leads in both publications and citations, indicating high impact and relevance; Applied Soft Computing and Materials & Design also make significant contributions with strong citation metrics; Renewable and Sustainable Energy Reviews gets special attention with the highest impact factor and Cite score, indicating its influence; and trends indicate a preference for high-impact, Q1 journals, highlighting the significance of quality and influence in disseminating MCDM research in material selection as shown in Table 5.

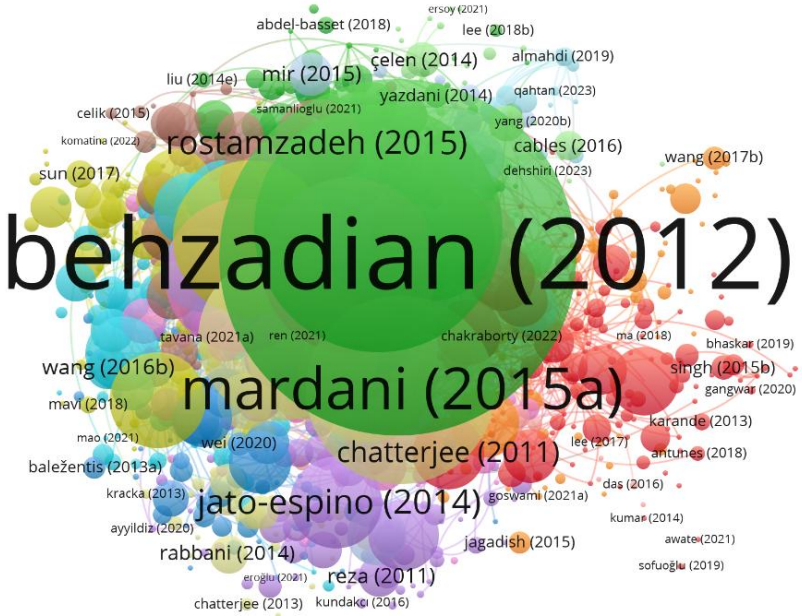

Fig. 7. Bibliometric map on co-citation with Network visualization mode

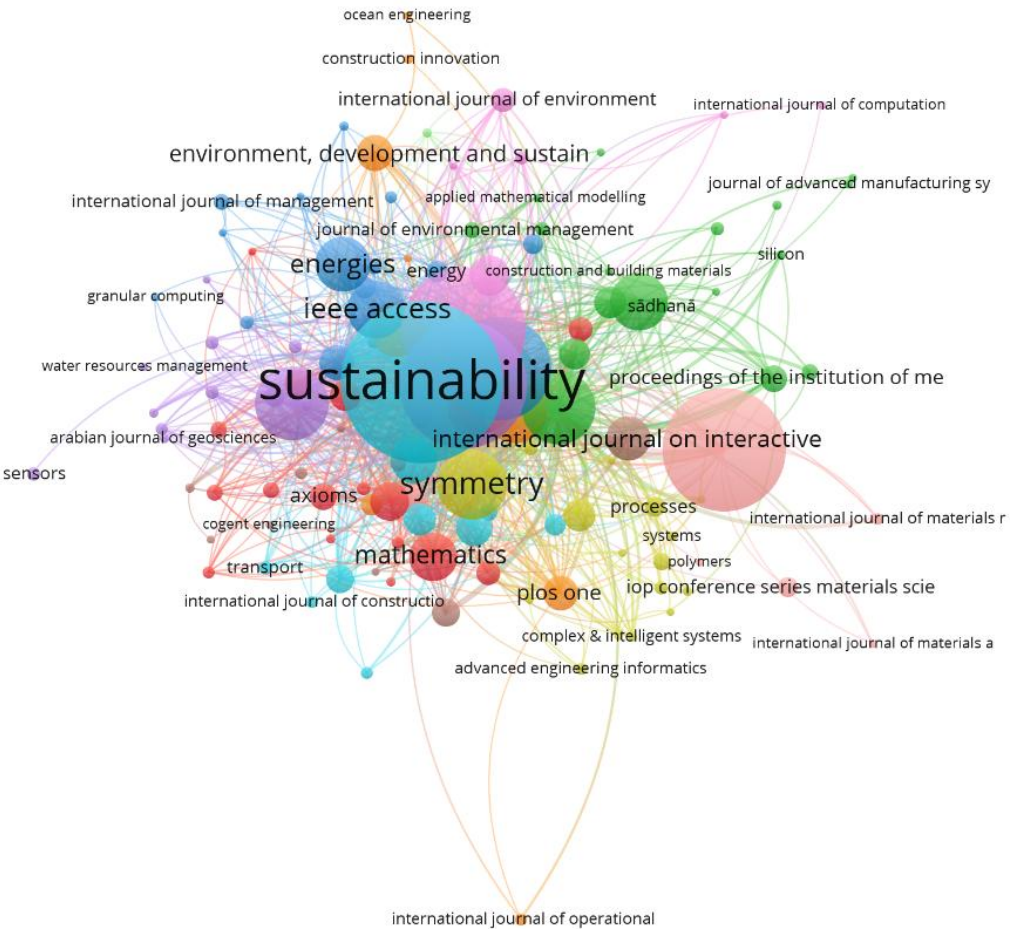

Fig. 8. Bibliometric map on co-citation with Network visualization mode based on sources

Table 5
The topmost productive sources with the most cited articles

Rank	Sources	Publication	Citation	Citescore 2023	Quartile	Impact Factor	Publisher	SNIP	SJR	h-Index
1	Expert Systems with Applications	62	7501	13.8	Q1	7.5	Elsevier	2.433	1.875	271
2	Applied Soft Computing	61	4363	15.8	Q1	7.2	Elsevier	2.13	1.843	190
3	Materials & Design	36	3817	14.3	Q1	7.6	Elsevier	1.918	1.684	233
4	Journal Of Cleaner Production	50	3317	20.4	Q1	9.7	Elsevier	2.236	2.058	309
5	Renewable And Sustainable Energy Reviews	17	2959	31.2	Q1	16.3	Elsevier	3.592	3.596	421
6	Computers & Industrial Engineering	31	2582	12.7	Q1	6.7	Elsevier	2.014	1.701	161
7	Technological And Economic Development of Economy	23	1924	10	Q1	4.8	Vilnius Gediminas Technical University	1.131	0.858	64
8	Sustainability	79	1905	6.8	Q1	3.3	MDPI	1.086	0.672	169
9	Symmetry	34	1881	5.4	Q2	2.2	MDPI	0.943	0.485	90
10	Omega	10	1680	13.8	Q1	6.7	Elsevier	2.333	2.647	167

Researchers can uncover important players and collaboration networks, learn important information about the dynamics of scholarly communication, and make informed decisions about research policy by examining the citation links between these units. To aid in this examination of citation data, VOSviewer provides strong visualization and analytic features.

4. Discussion

The review provides a comprehensive overview of the state of the field research on the interface between the MCDM method and material selection. The study, which makes use of bibliometric techniques, offers important insights on the evolution, new trends, and gaps in the literature that have occurred during the last 14 years. The results demonstrate a noteworthy surge in the material selection interest in MCDM method, as indicated by a rise in both publication counts and citation frequencies.

Key contributors to this field of study are identified in the report, including eminent writers, top research groups, and well-known nations. This information reveals significant networks of collaboration and worldwide research patterns. The review's thorough methodology not only improves our comprehension of GSCM in the automotive industry but also offers insightful advice to academics, business professionals, and legislators who must navigate the challenges of material selection.

5. Conclusion

This bibliometric analysis of material selection using MCDM methods reveals significant trends and insights that highlight the growing importance of this research area. The study demonstrates a steady increase in publications and citations, indicating the rising influence of MCDM techniques in material selection processes across various industries. Key authors, institutions, and countries have

been identified, showcasing the global collaborative efforts driving this field forward. The analysis also uncovers pivotal journals and seminal works that have shaped the discourse, pointing to emerging trends and potential research gaps. Overall, this study underscores the continued relevance and evolving nature of MCDM methods in material selection, offering valuable insights for future research and development in this critical area of study.

This bibliometric analysis of material selection using MCDM methods, while comprehensive, has certain limitations. The study relies on data from specific databases, which may not capture all relevant publications, potentially overlooking contributions from less indexed or emerging sources. Additionally, the focus on quantitative metrics like citations may not fully reflect the quality or impact of the research. Future work could address these limitations by incorporating a broader range of databases, including qualitative assessments of the research impact, and exploring newer MCDM applications in material selection. Further studies could also investigate interdisciplinary approaches, as well as the integration of advanced technologies such as AI and machine learning, to enhance the robustness and applicability of MCDM methods in evolving industrial contexts.

Acknowledgement
Conceptualization, S.K.S., B.B.C., P.R.D.; methodology, B.B.C., P.R.D.; software, B.B.C., P.R.D.; validation, S.K.S., B.B.C., P.R.D.; formal analysis, S.K.S., B.B.C., P.R.D.; investigation, S.K.S., B.B.C., P.R.D.; resources, S.K.S. and B.B.C.; data curation, S.K.S. and B.B.C.; writing—original draft preparation, S.K.S. and B.B.C.; writing—review and editing, B.B.C.; visualization, S.K.S.; supervision, B.B.C. All authors have read and agreed to the published version of the manuscript.

Funding
This research received no external funding.

Data Availability Statement
The data will be available on reasonable request to the corresponding author.

Conflicts of Interest
The authors declare that they have no conflict of interest.

References
[1] Emovon, I., & Oghenenyerovwho, O. S. (2020). Application of MCDM method in material selection for optimal design: A review. Results in Materials, 7, 100115. https://doi.org/10.1016/j.rinma.2020.100115
[2] Calderón, A., Torres-Rivas, A., Fernández, A. I., & Boer, D. (2024). Simulation tools to assist material choice. In Materials Selection for Sustainability in the Built Environment (pp. 267-297). Woodhead Publishing. https://doi.org/10.1016/B978-0-323-95122-7.00013-7
[3] Sahoo, S. K., & Choudhury, B. B. (2023). Evaluating Material Alternatives for low cost Robotic Wheelchair Chassis: A Combined CRITIC, EDAS, and COPRAS Framework. Jordan Journal of Mechanical & Industrial Engineering, 17(4). https://doi.org/10.59038/jjmie/170419
[4] Nagaraju, S. B., Priya, H. C., Girijappa, Y. G. T., & Puttegowda, M. (2023). Lightweight and sustainable materials for aerospace applications. In Lightweight and Sustainable Composite Materials (pp. 157-178). Woodhead Publishing. https://doi.org/10.1016/B978-0-323-95189-0.00007-X
[5] Kökçam, A. H., Erden, C., Demir, A. S., & Kurnaz, T. F. (2024). Bibliometric analysis of artificial intelligence techniques for predicting soil liquefaction: insights and MCDM evaluation. Natural Hazards, 1-29. https://doi.org/10.1007/s11069-024-06630-0
[6] Srivastava, S., Tripathi, A., & Arora, N. (2024). Multi-criteria decision making (MCDM) in diverse domains of education: a comprehensive bibliometric analysis for research directions. International Journal of System Assurance Engineering and Management, 1-18. https://doi.org/10.1007/s13198-024-02332-9

[7] Demir, G., Chatterjee, P., & Pamucar, D. (2024). Sensitivity analysis in multi-criteria decision making: A state-of-the-art research perspective using bibliometric analysis. Expert Systems with Applications, 237, 121660. https://doi.org/10.1016/j.eswa.2023.121660

[8] Rocha, C. M. M., Benitez, A. S., & Buelvas, D. A. (2024). Review and Bibliographic Analysis of Metaheuristic Methods in Multicriteria Decision-Making: A 45-Year Perspective Across International, Latin American, and Colombian Contexts. Journal of Applied Mathematics, 2024(1), 5577682. https://doi.org/10.1155/2024/5577682

[9] Nirmal, D. D., Nageswara Reddy, K., & Singh, S. K. (2024). Application of fuzzy methods in green and sustainable supply chains: critical insights from a systematic review and bibliometric analysis. Benchmarking: An International Journal, 31(5), 1700-1748. https://doi.org/10.1108/BIJ-09-2022-0563

[10] Khulud, K., Masudin, I., Zulfikarijah, F., Restuputri, D. P., & Haris, A. (2023). Sustainable Supplier Selection through Multi-Criteria Decision Making (MCDM) Approach: A Bibliometric Analysis. Logistics, 7(4), 96. https://doi.org/10.3390/logistics7040096

[11] Vatankhah, S., Darvishmotevali, M., Rahimi, R., Jamali, S. M., & Ale Ebrahim, N. (2023). MCDM in travel and tourism research since 1997: A bibliometric approach. International Journal of Contemporary Hospitality Management. http://dx.doi.org/10.2139/ssrn.4324990

[12] Sahin, S. N. A. (2023). A Systematic Overview of Decision-Making on Public Transport Systems Using Bibliometric Analysis on Vosviewer. Transport and Telecommunication Journal, 24(4), 459-470. DOI 10.2478/ttj-2023-0036

[13] Delcea, C., Domenteanu, A., Ioanăș, C., Vargas, V. M., & Ciucu-Durnoi, A. N. (2023). Quantifying Neutrosophic Research: A Bibliometric Study. Axioms, 12(12), 1083. https://doi.org/10.3390/axioms12121083

[14] Raza, S. A., Govindaluri, S. M., & Bhutta, M. K. (2023). Research themes in machine learning applications in supply chain management using bibliometric analysis tools. Benchmarking: An International Journal, 30(3), 834-867. https://doi.org/10.1108/BIJ-12-2021-0755

[15] Pereira, V., & Bamel, U. (2023). Charting the managerial and theoretical evolutionary path of AHP using thematic and systematic review: a decadal (2012–2021) study. Annals of Operations Research, 326(2), 635-651. https://doi.org/10.1007/s10479-022-04540-7

[16] Calleo, Y., & Pilla, F. (2023). Delphi-based future scenarios: a bibliometric analysis of climate change case studies. Futures, 149, 103143. https://doi.org/10.1016/j.futures.2023.103143

[17] Ayan, B., & Abacıoğlu, S. (2022). Bibliometric analysis of the MCDM methods in the last decade: WASPAS, MABAC, EDAS, CODAS, COCOSO, and MARCOS. International Journal of Business and Economic Studies, 4(2), 65-85. https://doi.org/10.54821/uiecd.1183443

[18] Girardi, R., Galdino, J. F., Pellanda, P. C., Junior, J. A. F., & dos Santos, M. (2022). Bibliometric study on multi-criteria decision-making methods applied to life cycle management of defense systems. Procedia Computer Science, 214, 236-247. https://doi.org/10.1016/j.procs.2022.11.171

[19] Costa, I. P. D. A., Costa, A. P. D. A., Sanseverino, A. M., Gomes, C. F. S., & Santos, M. D. (2022). Bibliometric studies on multi-criteria decision analysis (MCDA) methods applied in military problems. Pesquisa Operacional, 42, e249414. https://doi.org/10.1590/0101-7438.2022.042.00249414

[20] Dai, Z., Xu, S., Wu, X., Hu, R., Li, H., He, H., & Liao, X. (2022). Knowledge mapping of multicriteria decision analysis in healthcare: a bibliometric analysis. Frontiers in Public Health, 10, 895552. https://doi.org/10.3389/fpubh.2022.895552

[21] Castelló-Sirvent, F., Meneses-Eraso, C., Alonso-Gómez, J., & Peris-Ortiz, M. (2022). Three decades of fuzzy AHP: A bibliometric analysis. Axioms, 11(10), 525. https://doi.org/10.3390/axioms11100525

[22] Barcellos-Paula, L., de La Vega, I., & Gil-Lafuente, A. M. (2022). Bibliometric review of research on decision models in uncertainty, 1990–2020. International Journal of Intelligent Systems, 37(10), 7300-7333. https://doi.org/10.1002/int.22882

[23] McAllister, J. T., Lennertz, L., & Atencio Mojica, Z. (2022). Mapping a discipline: a guide to using VOSviewer for bibliometric and visual analysis. Science & Technology Libraries, 41(3), 319-348. https://doi.org/10.1080/0194262X.2021.1991547

[24] Nikseresht, A., Hajipour, B., Pishva, N., & Mohammadi, H. A. (2022). Using artificial intelligence to make sustainable development decisions considering VUCA: a systematic literature review and bibliometric analysis. Environmental science and pollution research, 29(28), 42509-42538. https://doi.org/10.1007/s11356-022-19863-y

[25] Basílio, M. P., Pereira, V., Costa, H. G., Santos, M., & Ghosh, A. (2022). A systematic review of the applications of multi-criteria decision aid methods (1977–2022). Electronics, 11(11), 1720. https://doi.org/10.3390/electronics11111720

[26] Fagundes, M. V. C., Teles, E. O., de Melo, S. A. V., & Freires, F. G. M. (2020). Decision-making models and support systems for supply chain risk: literature mapping and future research agenda. European Research on Management and Business Economics, 26(2), 63-70. https://doi.org/10.1016/j.iedeen.2020.02.001

[27] Wang, X., Xu, Z., & Qin, Y. (2022). Structure, trend and prospect of operational research: a scientific analysis for publications from 1952 to 2020 included in Web of Science database. Fuzzy Optimization and Decision Making, 21(4), 649-672. https://doi.org/10.1007/s10700-021-09380-x

[28] Amirkhani, M., Martek, I., & Luther, M. B. (2021). Mapping research trends in residential construction retrofitting: A scientometric literature review. Energies, 14(19), 6106. https://doi.org/10.3390/en14196106

[29] Sahoo, S. K., Choudhury, B. B., & Dhal, P. R. (2024). Exploring the Role of Robotics in Maritime Technology: Innovations, Challenges, and Future Prospects. Spectrum of Mechanical Engineering and Operational Research, 1(1), 159-176. https://doi.org/10.31181/smeor11202414

[30] Qiu, J. P., Dong, K., & Yu, H. Q. (2014). Comparative study on structure and correlation among author co-occurrence networks in bibliometrics. Scientometrics, 101, 1345-1360. https://doi.org/10.1007/s11192-014-1315-6

[31] Smolinsky, L., & Lercher, A. J. (2020). Co-author weighting in bibliometric methodology and subfields of a scientific discipline. Journal of Data and Information Science, 5(3), 84-96. https://doi.org/10.2478/jdis-2020-0021

[31] Ülker, P., Ülker, M., & Karamustafa, K. (2023). Bibliometric analysis of bibliometric studies in the field of tourism and hospitality. Journal of Hospitality and Tourism Insights, 6(2), 797-818. https://doi.org/10.1108/JHTI-10-2021-0291

[32] Zupic, I., & Čater, T. (2015). Bibliometric methods in management and organization. Organizational research methods, 18(3), 429-472. https://doi.org/10.1177/1094428114562629

[33] Sahoo, S. K., Goswami, S. S., Sarkar, S., & Mitra, S. (2023). A review of digital transformation and industry 4.0 in supply chain management for small and medium-sized enterprises. Spectrum of Engineering and Management Sciences, 1(1), 58-72. https://doi.org/10.31181/sems1120237j

[34] Bindu, N., Sankar, C. P., & Kumar, K. S. (2019). Research collaboration and knowledge sharing in e-governance: Temporal analysis of co-author network. Transforming Government: People, Process and Policy, 13(1), 2-33. https://doi.org/10.1108/TG-03-2018-0022

[35] Derviş, H. (2019). Bibliometric analysis using bibliometrix an R package. Journal of scientometric research, 8(3), 156-160. DOI: 10.5530/jscires.8.3.32

[36] Al-Gerafi, M. A., Goswami, S. S., Sahoo, S. K., Kumar, R., Simic, V., Bacanin, N., & Lasisi, A. (2024). Promoting inclusivity in education amid the post-COVID-19 challenges: An interval-valued fuzzy model for pedagogy method selection. The International Journal of Management Education, 22(3), 101018. https://doi.org/10.1016/j.ijme.2024.101018

[37] Shah, S. H. H., Lei, S., Ali, M., Doronin, D., & Hussain, S. T. (2020). Prosumption: bibliometric analysis using HistCite and VOSviewer. Kybernetes, 49(3), 1020-1045. https://doi.org/10.1108/K-12-2018-0696

[38] Sahoo, S. K., & Goswami, S. S. (2024). Green supplier selection using MCDM: A comprehensive review of recent studies. Spectrum of Engineering and Management Sciences, 2(1), 1-16. https://doi.org/10.31181/sems1120241a

[39] Martins, J., Gonçalves, R., & Branco, F. (2022). A bibliometric analysis and visualization of e-learning adoption using VOSviewer. Universal Access in the Information Society, 1-15. https://doi.org/10.1007/s10209-022-00953-0

[40] Jia, C., & Mustafa, H. (2022). A bibliometric analysis and review of nudge research using VOSviewer. Behavioral Sciences, 13(1), 19. https://doi.org/10.3390/bs13010019