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# JOURNAL OF CIVIL ENGINEERING AND MANAGEMENT: CONTRIBUTION TO DEVELOPMENT AND APPLICATION OF MCDM METHODS IN CONSTRUCTION MANAGEMENT

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**Abstract.** Multi-criteria decision-making (MCDM) methods have improved considerably since the 1970s and are applied in many fields, demonstrating that the field of decision research remains important and valuable. Multi-criteria methods contribute to the research in civil engineering and construction management by identifying the optimal alternatives considering conflicting objectives. Researchers are applying MCDM methods in specific areas of civil engineering to resolve conflicts between economic, environmental and technological criteria. On the occasion of the 80th birthday of Prof. E. K. Zavadskas and 30 years of the *Journal of Civil Engineering and Management* (JCEM), this article aims to summarize the performance indicators of JCEM and its contribution to the development and application of MCDM methods in construction management. The journal's performance indicators are outlined using bibliometric analysis.

**Keywords:** Journal of Civil Engineering and Management, bibliometric review, MCDM methods, construction management.

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## 1. Introduction

Organizations in the construction sector are operating in a constantly changing environment over their entire life cycle. Various construction stakeholders (industry representatives, institutions, society, and local authorities) influence construction system performance, mainly through regulation, information exchange, research and education. Constantly advancing and emerging technologies have a major impact on the efficiency of the construction sector. Obviously, the application of new techniques and methods that could increase the efficiency of processes will play an important role in the future development of the construction industry.

The decision-making process in engineering is multifaceted, influenced by multiple criteria and has a subjective nature of evaluation. In this context, decision-makers need a sound methodology to make impartial decisions, address ethical issues and ensure a thorough and transparent decision-making process. The nature of engineering problems implies the necessity of implementing a methodology that can integrate the various disciplines, complex variables, the subjective nature of the criteria weights, and decision analysis in a coherent manner. The aforementioned categories constitute an integral part of the multi-criteria decision-making (MCDM) methodology. MCDM offers a structured approach to evaluating alternatives based on multiple criteria, which is particularly relevant in the context of today's complex decision-making processes.

Multi-criteria decision-making (MCDM) methods have improved considerably since the 1970s and have been applied in a wide range of fields. New MCDM methods have been developed and existing methods have been modified, demonstrating that the field of decision-making research is still very important and valuable. One of the first and most distinguished authors, who has been working continuously on the development and improvement of the MCDM methods since 1976, is Professor Edmundas Kazimieras Zavadskas. The research school, headed by Professor E. K. Zavadskas, aims to develop and apply multi-criteria methods in the fields of sustainable development and civil engineering to help solve a variety of problems in these areas, balancing economic, environmental and technological efficiency objectives. Research is concentrated in three broad areas: Operational Research, Civil Engineering and Sustainable Development. Professor E. K. Zavadskas

as founder of the JCEM journal since the early stages of the journal existence, has made great efforts to promote the use of the MCDM methods in civil engineering and construction management. The JCEM journal reached an important milestone in 2025, its 30th anniversary, counting from 1995, when the decision was taken to combine several journals into a single periodical research journal. Seven volumes of the new journal were published in 1995 under the title *Statyba* (*Civil Engineering*). In 2002, the journal was renamed to *Journal of Civil Engineering and Management*. The aim of this paper is to summarize the performance indicators of the JCEM journal and the contribution to the development and application of MCDM methods in construction management on the occasion of Professor E. K. Zavadskas' 80th birthday and the 30th anniversary of the JCEM journal.

## 2. Background: the origins of the JCEM journal

The *Journal of Civil Engineering and Management* is a peer-reviewed journal that publishes the latest original research, developments and advances at an international level. The aim of the JCEM journal is to provide relevant information and new ideas to help improve the competence, efficiency and productivity of civil engineering within the global markets. Topics like building materials and structures, Building Information Modelling, digital twin, smart built environment, IoT, operational research, construction technology, intelligent decision support systems, structural mechanics and physics, geotechnical engineering, fire protection, urban engineering, economy and management, robotics, information technologies in construction, are essential but not complete list of topics published by the journal.

The JCEM journal has its origins from the merger of several journals published by Vilnius Gediminas Technical University. Initially, a journal titled *Statyba* (*Civil Engineering*) was established in 1995 by Prof. E. K. Zavadskas. Between 1995 and 2001, 7 volumes of articles were published in different languages (ISSN 1392-1525 for the printed version and ISSN 1822-3605 for the online version). Each volume contained 4–6 issues.

In line with the global trend, the journal was renamed to *Journal of Civil Engineering and Management* in 2002. In the period from 2002 to 2004, 8 to 10 volumes of 4 issues each were published in English (ISSN 1392-3730 for the printed version and, and ISSN 1822-3605 for the online version).

Since 2002, JCEM has been indexed in the Scopus database. Since 2008, JCEM has been included in the Web of Science Thomson Reuters Science Citation Index Expanded. In 2010 an impact factor (IF) was assigned to the journal by the Thomson Reuters Institute for Scientific Information (ISI). JCEM is also endorsed by CIB (the International Council for Research and Innovation in Construction) since 2010. This reflects the high scientific standard of the journal. The journal is currently indexed in the following databases: Clarivate Analytics databases (Web of Science Core Collection, Journal Citation Reports (SSCI edition)); Dimensions Directory of Open Access Journals (DOAJ); EBSCOhost (Academic Search Complete, Central & Eastern European Academic Source, GreenFILE, Current Abstracts, TOC Premier); Elsevier Bibliographic Databases (SCOPUS, El Compendex (Engineering Village), INSPEC); Gale® (Academic OneFile, InfoTrac Custom); Google Scholar; The International CONstruction DAtabase (ICONDA); Microsoft Academic; MyScienceWork; OpenAIRE2020; ProQuest (ProQuest Central, Summon™, Ulrichsweb™). The most recent rankings of the JCEM journal by Clarivate Analytics and Scopus are as follows: Clarivate Analytics Impact factor (2023), IF = 4.3; JCR Category – Engineering, Civil; Category Rank – 26/181; Category Quartile – Q1. Scopus SCImago Journal Ranking (2022), SJR = 0.653; Scopus Source Normalized Impact per Paper (2022), SNIP = 1.399.

## 3. Methodology

### 3.1. Study outline

Various metrics have been developed to measure the impact of scientific journals, studies, and researchers. Bibliometric analysis combines a variety of systems, tools, and methods to study and analyze the citation of scientific publications (Farooq, 2024). Bibliometric analysis is useful for mapping accumulated scientific knowledge and evolutionary nuances, rigorously assessing large amounts of unstructured data (Donthu et al., 2021a). Bibliometric analysis can help researchers discover new article trends, journal performance, most productive authors, and collaboration patterns. Bibliometric methods and techniques allow for a detailed analysis of the entire production of a given journal, revealing its internal structure and trends of development, identifying topics within the analyzed field and visualizing the results.

A bibliometric analysis method was used in prior studies to perform a comprehensive analysis of the journal's indicators. For example, Laengle et al. (2017) performed a bibliometric analysis of forty years of the *European Journal of Operational Research*. Yu et al. (2019) analyzed the evolution of the journal *Applied Intelligence* using bibliometric analysis. Zurita et al. (2020) conducted a bibliometric review of the *Journal of Network and Computer Applications* to perform an intrinsic analysis and to reveal the structural and hidden implications of this journal. To commemorate the 60th anniversary of the *Management International Review* (MIR), Mukherjee et al. (2021) published a bibliometric analysis to present a retrospective of the journal by analyzing its content from 2006 to 2020. Donthu et al. (2021b) used a variety of bibliometric techniques to analyze the scholarly contributions, influence, performance, and impact of the journal *International Marketing Review*. A 25-year review of the *Journal of International Management* was carried out by means of a bibliometric analysis by Kumar et al. (2023).

Adapting the PRISMA framework (Yepes-Nuñez et al., 2021) to the needs and scope of bibliometric analysis of the *Journal of Civil Engineering and Management*, the main steps of the analysis performed are shown in Figure 1.

### 3.2. Database selection

Gusenbauer and Haddaway (2020) compared 28 scientific databases based on research quality and the ability to download and analyze full results. The study showed that only 14 databases could be considered for the review because they met al. the necessary requirements. When evaluating the ability to download the full search results for review, Web of Science (WoS) and Scopus were found to contain the most organized bibliographic data and support the most complex search strings of the databases compared. High-quality, peer-reviewed articles are indexed in these two databases. These databases allowed the download of both the bibliographic data and the full record of the selected articles (i.e. WoS, up to 1000 articles at a time; Scopus, all search results at a time). The decision to use the databases was also based on the fact that the Scopus database has an integrated analytical tool, SciVal, which is based on Scopus data. It allows flexible evaluation of any research area, as well as research results for researchers, research groups and countries, and uses advanced techniques such as machine learning to extract meaningful insights from research information. After considering all the pros and cons discussed in the research papers, and taking into account time and performance constraints, WoS Core Collection and Scopus were selected for this review.

### 3.3. Research questions

Considering the aim of this paper to summarize the performance indicators of the JCEM journal and the achievements in the development of MCDM methods, the main research question was formulated as follows: "*What are the dynamics of the JCEM performance and what is the contribution of JCEM publications to the development of MCDM methods*?". To address this issue, the study attempts to examine more fully the JCEM journal's indicators and contribution to the development of MCDM methods. The following sub-questions are defined according to the main research question:

- **RQ1:** *Which periods produced the most articles and how did citation rates change?*
- **RQ2:** *What are the most productive influential countries publishing the research in the JCEM journal?*
- **RQ3:** *Who are the main authors contributing to the research published in the JCEM journal?*
- **RQ4:** *What topics are predominant in JCEM publications?*
- **RQ5:** *How do JCEM articles address the MCDM topic?*

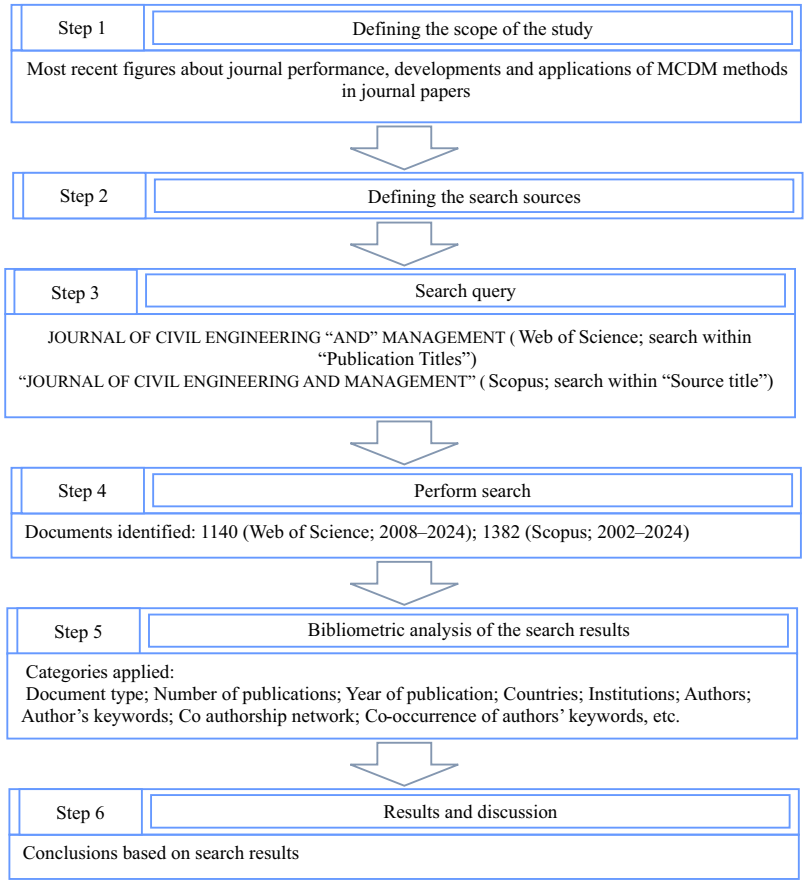


**Figure 1.** The research steps of bibliometric analysis

Based on the results of the bibliometric analysis of the WoS and Scopus datasets, the answers to the research questions are presented in Section 4 of this paper.

### 3.4. Records extraction and data refinement

The information analyzed in this study includes 1,140 JCEM publications (only articles and reviews), from the Clarivate Analytics Web of Science (WoS) database covering the years 2008 and 2024, and 1,382 from the Scopus database dating between 2002–2024 retrieved on August 21st, 2024. Editorial Material and Correction papers were removed from the data sets to allow a more accurate assessment of the results. For the analysis of articles on MCDM, the datasets were further manually reviewed to ensure that all relevant articles were included in the analysis.

The data set extracted and used for the authors' keyword co-occurrence analysis was prepared by keyword refinement using a Thesaurus. Since authors usually use similar terms to describe the same phenomena, there is a risk of double counting the same terms/keywords. The usefulness of a map is usually increased by excluding similarities and cleaning up irrelevant keywords. The Thesaurus was made to refine the keywords, obtain a more relevant set of keywords and to minimize the risk of double counting according to the following rules:

- exclude general keywords, such as "literature review", "review", "bibliometric analysis", etc.;
- exclude keywords that do not contain important information, such as city names, regions or indication of affiliation with a city or region, like "Hong Kong", "China", "Australia", etc.;
- merge the abbreviated keywords with the full keywords, like "analytic hierarchy process" and "ahp"; "building information modeling", "building information modeling (bim)" and "bim", etc.;
- merge different word spellings, like "multi-criteria analysis", "multi-criteria decision making", "multi-criteria decision-making", "multiple criteria decision making" and "mcdm"; "artificial neural network (ann)" and "artificial neural network" and "artificial neural networks", etc.;
- merge synonyms, like "fuzzy", "fuzzy set" and "fuzzy set theory" and "fuzzy logic"; "construction sector" and "construction industry"; "performance measurement" and "performance evaluation", etc.

The Thesaurus consists of 259 keywords, some of them merged and excluded. It can be found at https://github.com/Vilutta/JCEM (accessed on October 11, 2024).

To determine the contribution of the JCEM journal to the development and promotion of MCDM methods in construction management, the search in the WOS database was performed using the search string: (*"MCDM*"*) *AND* (*"construction management"*. The publication type was limited to Article and Review. Source type limited to "journal", excluding "book chapter", "proceeding papers", and "early access". The final data set included only articles written in English. Web of Science categories included in the search limitations are: Engineering civil; Construction building technology; Engineering industrial; Management; Materials science multidisciplinary; Engineering mechanical; Architecture; Computer science interdisciplinary applications; Engineering environmental; Regional urban planning; Urban studies. With these limitations the final set of 129 documents was identified and used to identify the journals that have contributed most to the development of research in MCDM, and to find the position of the JCEM journal.

To determine the contribution of the authors to the development of MCDM methodologies, the additional search in the WOS database was performed using the search string: (*"MCDM*"*) *AND* (*"Multi-criteria*"*) *AND* (*"Multiple criteria*"*). Not related subject areas were excluded, and other limitations applied (like language, type of publication, source type). The publication type was limited to Article and Review. Source type limited to "journal", excluding "book series" and "trade journal". The analysis includes only articles written in English. Engineering; Engineering Civil; Construction Building Technology; Engineering Multidisciplinary; Computer Science; Mathematics; Business, Management and Accounting; Environmental Science; Decision Sciences; Energy; Multidisciplinary are among the subject areas included in the search limitations. With these limitations the final set of 9,854 documents found and used for the analysis. This data set was used to analyze the authors that have contributed most to the development of research in MCDM, to analyze the clusters of most active authors with publications on MCDM, and to determine the top 10 authors by number of publications on MCDM.

### 3.5. Methods and tools used for the analysis of data sets

Bibliometric analysis allows you to summarize large amounts of bibliometric data and present the state-of-the-art and emerging trends in a particular research topic or field. As recommended by Donthu et al. (2021a, 2021b), bibliometric analysis is used when the scope of the review is broad and the dataset is too large for manual review. Bibliometric analysis techniques allow quantitative analysis of datasets and involve evaluating and interpreting the data obtained.

The main techniques of bibliometric analysis used in this study include:

1. The journal performance analysis, which presents publication-related metrics, such as total publications, the number of citations of the articles published in the JCEM, the most productive influential authors, the most productive influential countries, number and share of JCEM publications on the MCDM topic.
2. Mapping techniques including: co-occurrence of authors' keywords; the top 50 keyphrases; co-authorship network, keyword timeline analysis based on studying the year of keyword occurrence. The bibliometric data structure is summarized through the use of bibliometric analysis improvement tech-

niques, i.e. clustering and visualization. The cognitive relationships between the papers are revealed and grouped into related clusters using keyword clustering analysis. The clusters of co-authoring are analyzed and the largest collaboration clusters for the MCDM topic are identified.

The tool VOSviewer (https://www.vosviewer.com/ (accessed on August 21, 2024)) was used for the analysis of the dataset and the mapping. VOSviewer (van Eck et al., 2010) is a tool for visualizing networks of bibliographic data. One of the advantages of VOSviewer is the ability to graphically display bibliometric data. VOSviewer allows the display of large bibliometric maps in an easily interpretable way. The use of this tool ensures an unbiased evaluation of the information.

The Elsevier SciVal tool was used to create a map of keyphrases appearing in the JCEM articles based on the Scopus dataset. Based on the information provided by the SciVal tool, key phrases are obtained by annotating the content with a unified thesaurus (OmniScience) covering all major disciplines and creating a list of standardized terms. The SciVal tool was also used to analyze the largest topic clusters of articles published in the JCEM using the Scopus dataset.

## 4. Results of bibliometric analysis

### 4.1. The latest facts and figures about the JCEM journal

In order to answer the research question RQ1 (*Which periods produced the most articles and how citation rates changed?*), in this part of the study we analyze the dynamics of the number of publications in the JCEM during different periods. The graph in Figure 2a shows the publication dynamics from 2008 to 2024, as the WoS database provides information on JCEM publications only from 2008 onwards. As can be seen from Figures 2a and 2b, the highest number of publications in the JCEM were published in 2016 (106 – WoS; 106 – Scopus) and 2017 (108 – WoS; 108 – Scopus). During the reporting period, an average of 60–66 articles were published annually in the journal. The polynomial trend line (dashed curve) shows that the number of articles in the JCEM increased until 2017, but has been fluctuating recently. Clarivate Analytics data provided in Figure 3 show that despite a limited number of publications, the journal's citation rate has grown strongly over the last decade.

### 4.2. The most productive countries

The insights provided in this part of the study help to answer research question RQ2 (*What are the most productive influential countries publishing the research in the JCEM journal?*). As shown in Figure 4, based on WoS data set in, the period between 2008 and 2024, the Chinese authors have the largest number of publications (238) in the journal, followed by Lithuanian authors (231), Poland (99), USA (96), Taiwan (86), Iran (69) and South Korea (63). Table 1 presents the ten most productive influential countries by publications in the JCEM over the last decade and compares data from both databases. In order to ensure comparability of data from the two databases, the period from 2014 to 2024 (the last decade) has been selected. This is due to the fact that Scopus data is available from 2002, while WoS data is available from 2008. China ranks first, having the highest number of publications, H-index, and cited papers, followed by Lithuania, the USA, Taiwan and Poland.

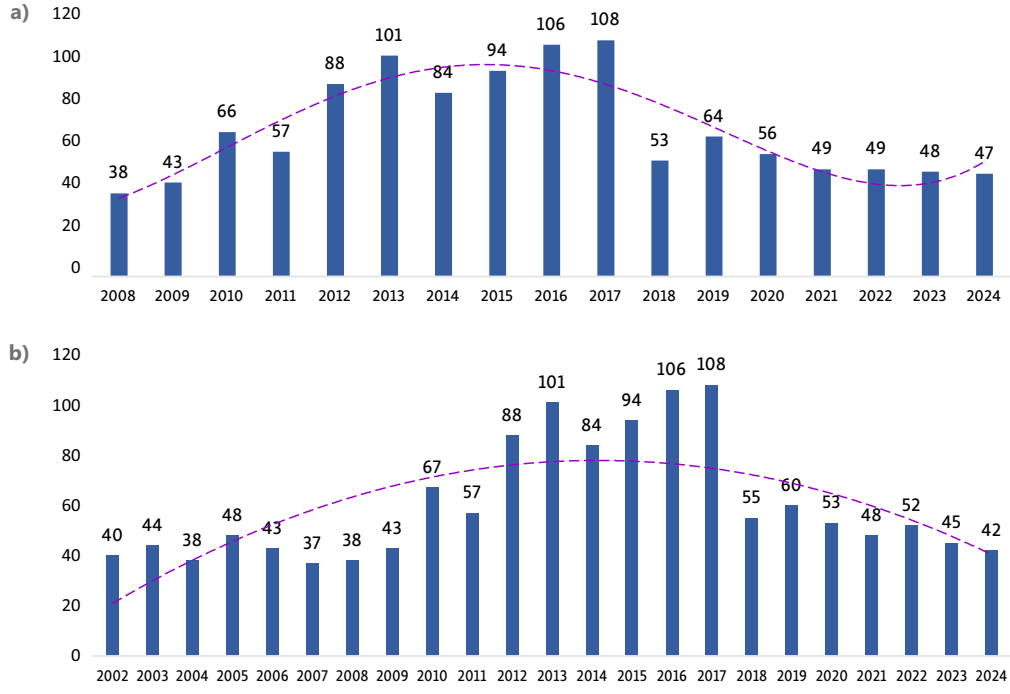


**Figure 2.** Number of articles published in the JCEM: a – in the period from 2008 to 2024 Q3 (using data set from WoS); b – in the period from 2002 to 2024 Q3 (using data set from Scopus)

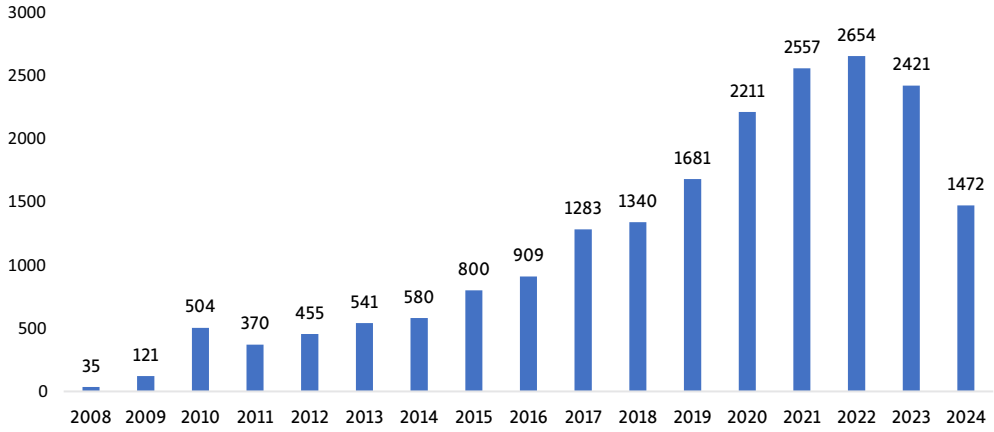


**Figure 3.** The number of citations of the articles published in the JCEM (2008–2024) (WoS)

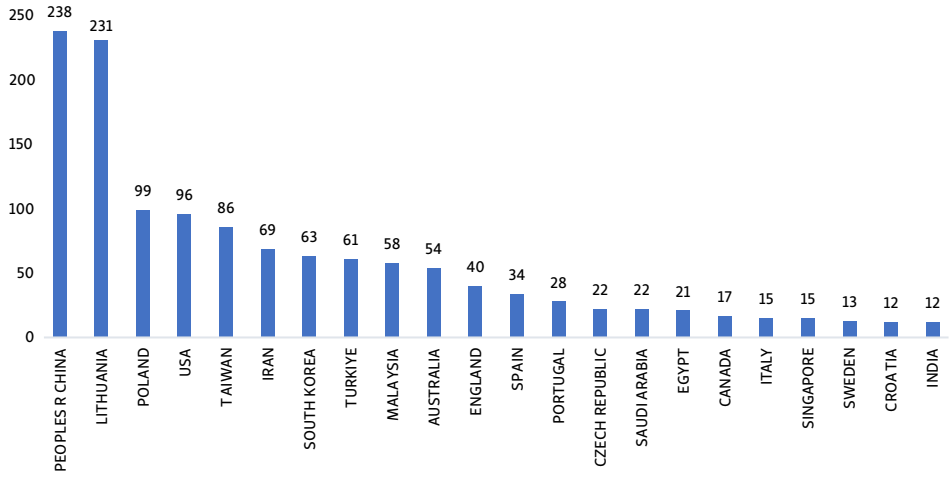


**Figure 4.** Number of articles by country published in the JCEM by country (WoS, Core Collection, 2008–2024)

**Table 1.** Ten most productive influential countries by publications in the JCEM in the period of 2014–2024 (21 August 2024)

| WoS Core Collection | | | | | Scopus | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Rank | Country/ Territory | Total publications | H-index | Total citations* | Rank | Country/ Territory | Total publications | H-index | Total citations* |
| 1 | China | 211 | 27 | 2925 | 1 | China | 192 | 27 | 2890 |
| 2 | Lithuania | 115 | 23 | 1963 | 2 | Lithuania | 113 | 26 | 2221 |
| 3 | USA | 65 | 21 | 1319 | 3 | USA | 65 | 23 | 1502 |
| 4 | Taiwan | 58 | 20 | 879 | 4 | Taiwan | 57 | 22 | 1039 |
| 5 | Poland | 54 | 18 | 819 | 5 | Poland | 53 | 17 | 920 |
| 6 | South Korea | 52 | 10 | 456 | 6 | South Korea | 52 | 12 | 534 |
| 7 | Australia | 49 | 14 | 804 | 7 | Australia | 49 | 15 | 939 |
| 8 | Iran | 48 | 19 | 992 | 8 | Iran | 48 | 20 | 1128 |
| 9 | Malaysia | 35 | 13 | 604 | 9 | Turkey | 35 | 19 | 882 |
| 10 | Turkey | 33 | 17 | 763 | 10 | Malaysia | 34 | 14 | 676 |

*Note*: * Times cited (total).

To analyze the geographical collaboration of authors over the last decade, the Scopus SciVal analytical tool is used. According to the results of this analysis, the majority of research published in the JCEM is based on international collaboration (35.5%), with only national and institutional collaboration accounting for similar percentages (26.5% and 31.5%, respectively). In addition, a small percentage is reported for single-author publications (5.5%).

The largest clusters of collaborating countries were identified using WoS data and the VOSviewer tool (Figure 5). The map was created by setting a threshold of at least 5 documents. Out of 77 countries, only 47 met this

criterion, and finally only 46 countries were mapped since one country, although meeting the criterion, did not have any joint publications with institutions in other clusters. In the first largest cluster of collaborating countries that publish research in the JCEM are Malaysia, Saudi Arabia, Egypt, Sweden, India, Japan and Iraq with 140 joint publications. Czech Republic, Croatia, Denmark, Latvia, Austria, Germany and Slovenia are the second cluster of cooperating countries with 75 joint publications. The third cluster group includes England, Spain, Portugal, Italy, Scotland and Chile with 132 joint publications. Poland, Taiwan, South Korea, Vietnam, Pakistan and Indonesia are in the fourth cluster with 267 joint publications. The fifth cluster consists of researchers from Canada, Brazil, Algeria, Jordan and France with 46 joint publications. Researchers from the USA, Turkey, Serbia, Qatar and the Netherlands form a sixth cluster with 172 joint publications. The seventh cluster include researchers from Lithuania, Estonia, Slovakia and Ukraine with 254 joint publications. Finally, China, along with Australia, Singapore and Israel, represents the eighth most isolated cluster. Although this cluster does not cover a larger number of countries, it has a higher share of publications than the other clusters, with a total of 312 papers.

## 4.3. The most productive authors

Table 2 presents the 10 most productive authors in the JCEM journal, thus answering research question RQ3 (*Who are the main authors contributing to the research published in the JCEM journal?*). According to the data obtained from the WoS data base M. J. K. Skibniewski from the University of Maryland, USA, leads the rank in publications number.

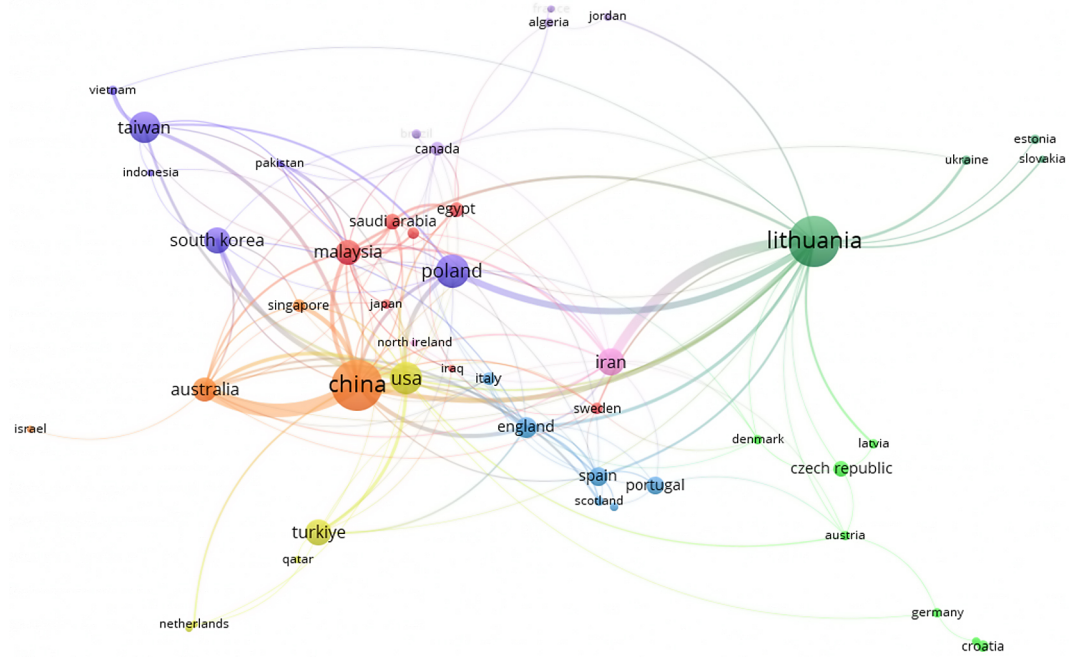


**Figure 5.** Co-authorship network of the countries (based on the WoS Core Collection dataset)

**Table 2.** Ten most productive and influential authors according to publications in the JCEM

| WoS Core Collection (2008–2024) | | | | | | Scopus (2002–2024) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rank | Authors | Publications in JCEM | Total publications | H-index | Times cited* | Rank | Authors | Publications in JCEM | Total publications | H-index | Times cited* |
| 1 | Skibniewski M. J. | 20 | 370 | 57 | 9 459 | 1 | Zavadskas E. K. | 23 | 659 | 106 | 40 578 |
| 2 | Zavadskas E. K. | 16 | 623 | 97 | 34 660 | 2 | Skibniewski M. J. | 22 | 322 | 52 | 9 353 |
| 3 | Turskis Z. | 15 | 178 | 65 | 13 406 | 3 | Turskis Z. | 18 | 191 | 68 | 16 325 |
| 4 | Sivilevičius H. | 13 | 77 | 20 | 1 171 | 4 | Sivilevičius H. | 16 | 83 | 22 | 1 345 |
| 5 | Ustinovichius L. | 13 | 80 | 19 | 1 274 | 5 | Mačiulaitis R. | 14 | 54 | 11 | 403 |
| 6 | Cheng M. Y. | 12 | 182 | 36 | 5 281 | 6 | Ustinovichius L. | 13 | 94 | 24 | 1 934 |
| 7 | Mačiulaitis R. | 12 | 56 | 9 | 249 | 7 | Cheng M. Y. | 13 | 221 | 40 | 6 773 |
| 8 | Skitmore M. | 10 | 415 | 59 | 11 966 | 8 | Kala Z. | 12 | 145 | 30 | 2 477 |
| 9 | Kala Z. | 10 | 182 | 32 | 3 409 | 9 | Marzouk M. | 11 | 253 | 35 | 4 598 |
| 10 | Adeli H. | 9 | 429 | 113 | 31 886 | 10 | Kliukas R. | 11 | 61 | 13 | 461 |

*Note*: * Total citations.

However, according to the data obtained from the Scopus data base the rank in publications number is led by E. K. Zavadskas from Vilnius Gediminas Technical University (VILNIUS TECH), Lithuania. Z. Turskis from VILNIUS TECH, Lithuania follows these two authors and appears in the same position in both datasets. It should be noted that different databases provide different information on the number of publications published by the authors, as JCEM's publications in the WoS database have only been available since 2008, while in Scopus since 2002. Different databases may contain different sets of publications; therefore, this can be the reason for possible differences in the number of publications and respectively the ranks of authors. Differences can also be caused by different search dates, so searches performed later than this timeframe may generate different results and the ranking of authors will change accordingly.

### 4.4. The main focus of studies published in the JCEM journal

The analysis of the main focus of studies published in the JCEM journal helps to answer research question RQ4 (*What topics are predominant in the JCEM publications?*). The journal's publications fall into three main Web of Science Categories, i.e., civil engineering (42.22%), construction building technology (26.89%), material science multidisciplinary (12.50%) (Figure 6). Articles focusing on topics of environmental sciences, green sustainable science technology, management and industrial engineering are also among the most frequently published.

Predominant sustainable development goals of studies published in the JCEM journal are (Figure 7): Industry Innovation and Infrastructure (406); Sustainable Cities and Communities (283); Responsible Consumption and Production (131); Climate Action (78). Other goals are not so well developed, with less than 10 publications, i.e. Affordable and Clean Energy (8); Good Health and Well Being (6); Life on Land (5); No Poverty (4); Zero Hunger (4); Quality Education (4); Decent Work and Economic Growth (2); Clean Water and Sanitation (1); Reduced Inequality (1).

To determine the contribution of the JCEM journal to the development of MCDM methodologies in construction management research (and thereby to answer research question RQ5), a bibliometric analysis was performed using the WoS Core Collection database records. This data set was used to analyze the journals that have contributed most to the development of research applying MCDM methods in construction management. There are 129 documents and 29 journals in total in this dataset. Figure 8 depicts only those journals that have published three or more articles on the application of MCDM in construction management. In total, there are ten such journals. The remaining 19 journals published a single article or two on this topic. As can be seen from Figure 8, the journals that have contributed most to the development of research focused on MCDM in the construction management

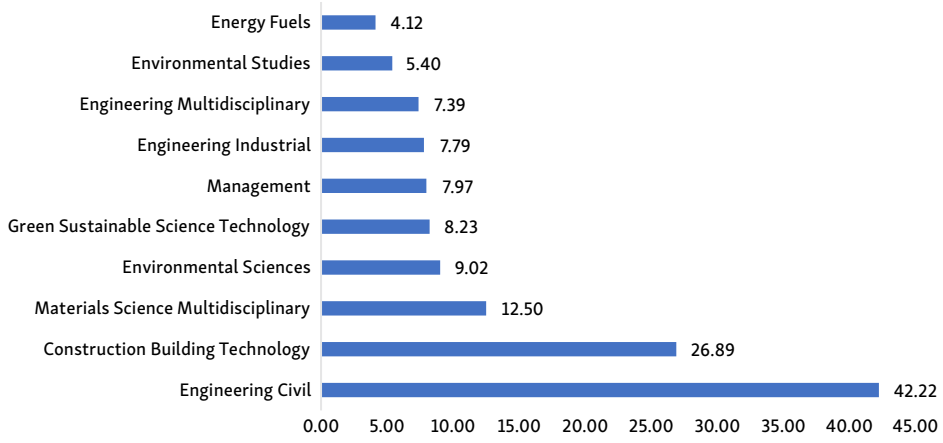


**Figure 6.** Web of Science Categories of the JCEM by Clarivate Analytics (2024, %)

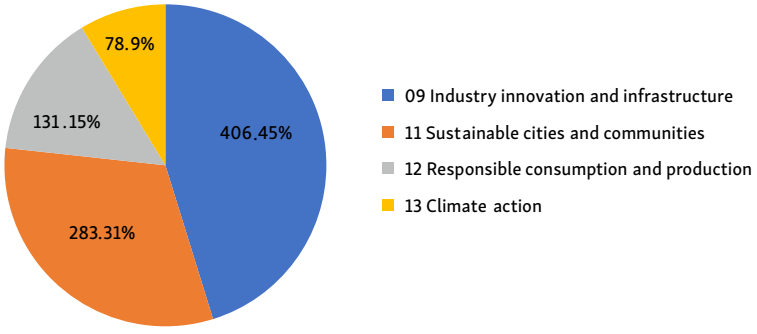


**Figure 7.** Sustainable development goals of studies published in the JCEM (WoS, Core Collection, 21 August 2024)

research domain are: *Journal of Civil Engineering and Management* with 33 publications; *Journal of Construction Engineering and Management* (14); *Buildings* (13); *International Journal of Construction Management* (12); *Engineering Construction and Architectural Management* (11); *Automation in Construction* (8); *Archives of Civil and Mechanical Engineering* (7); *Journal of Management in Engineering* (4); *Built Environment Project and Asset Management* (3); and *Journal of Building Engineering* (3).

The distribution of MCDM articles published in the JCEM was calculated using the WoS Core Collection dataset and is shown in Figure 9. In the period from 2008 to 2024, the proportion of JCEM publications on MCDM compared to all other topics in this journal was 9.74%. As can be seen from the figure, the number of publications on MCDM has varied considerably over the period under review, and the highest number of publications on MCDM was in 2013 and 2017. The share of publications from these two years compared to all MCDM publications in this journal was 25.69%.

## 4.5. Co-occurrence of keywords and topic clusters

In order to analyze in more detail, the topics on which the research published in the JCEM is focused, a co-occurrence of keywords and a clustering of topics were carried out. This type of analysis is observed in bibliometric studies, and is based on the results of the current situation and allows the identification of the area of interest. Analyzing the most frequently used keywords helps to answer the research question RQ4 (*What topics are predominant in JCEM publications?*).

This analysis allows the creation of a network of the most frequent keywords, based on the number of occurrences of the keyword in the articles. Co-occurrence analysis is useful for identifying the main content of articles and the range of areas covered, as well as providing a general picture of the field and trends in the research area. This analysis has been carried out on the basis of the data presented in in related clusters that were generated by the VOSviewer.

A map of the most common keywords (those that occur most frequently in research papers) was created to identify the predominant topics in the JCEM. In the creation of this map, we have limited the minimum number of occurrences of the keywords to 5. Using the VOSviewer, we were able to identify 41 keywords out of 4070 that were within this threshold. The ten most relevant keywords (RQ-4) were the following (Figure 10): "construction industry" (81), "bim" (57), "mcdm" (38), "risk analysis" (32), "reinforced concrete" (29), "construction projects" (28), "finite element method" (26), "compressive strength" (25), "ahp" (21), "fuzzy logic" (20), and "artificial neural networks" (20).

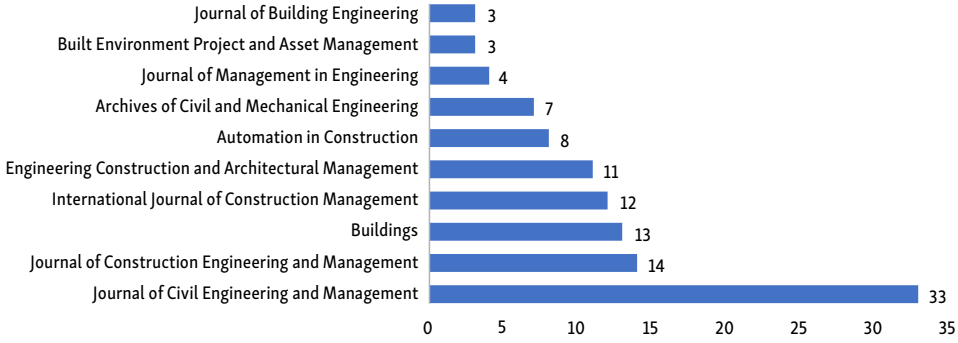


**Figure 8.** The journals that have contributed most to the development of research on MCDM in construction management (WoS, Core Collection, 19 August 2024)

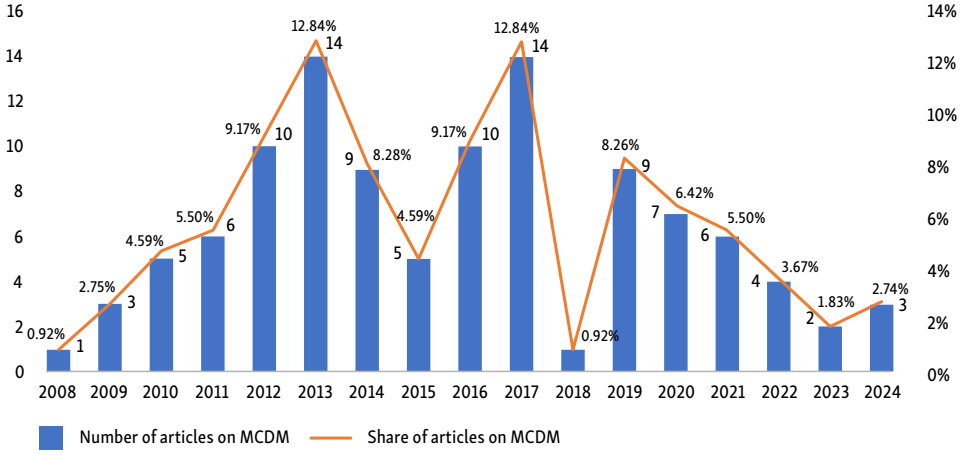


**Figure 9.** The number of MCDM-related articles in JCEM in the period from 2008 to 2024 (based on WoS Core Collection dataset)

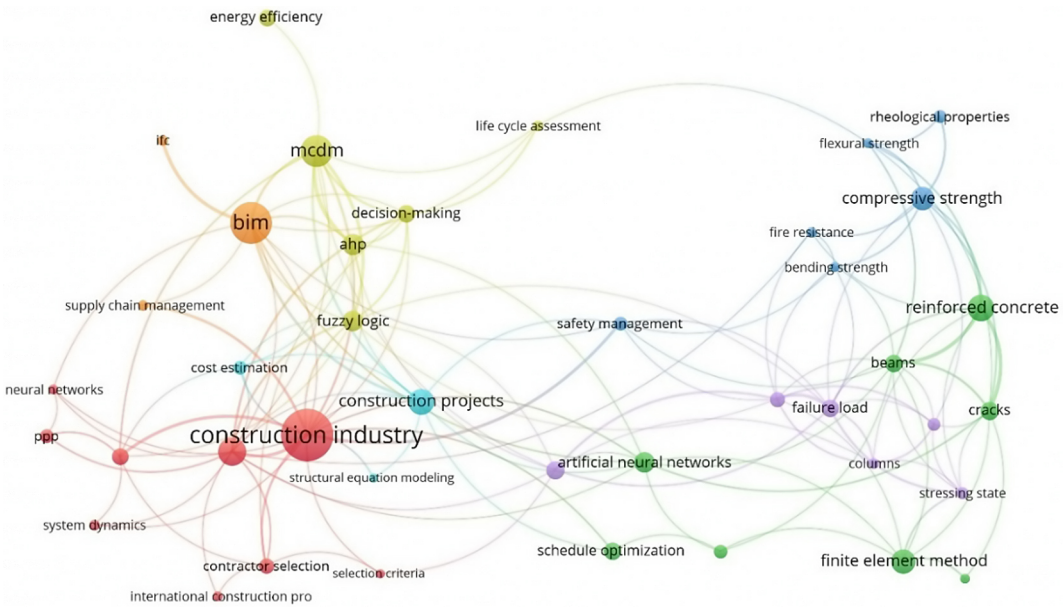


**Figure 10.** Co-occurrence of authors' keywords in JCEM articles (WOS, Core Collection, 21 August 2024)

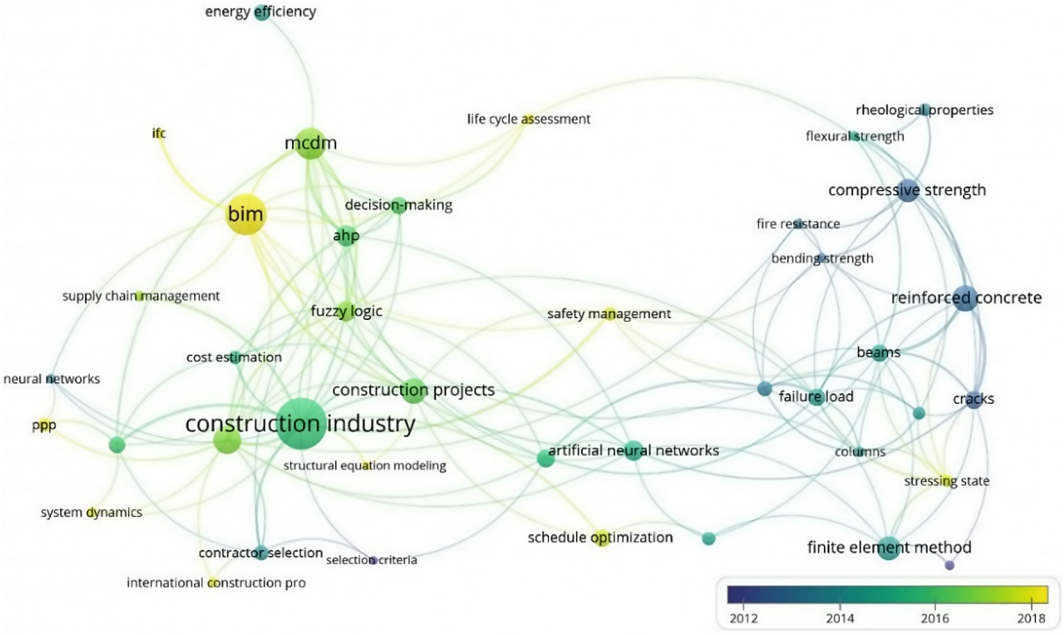


**Figure 11.** The most common keywords in JCEM articles presented in the timeline (WOS, Core Collection, 21 August 2024)

In Figure 11, all of the most frequently used keywords are colored according to the average publication year (APY) of the articles in which they appear. As can be seen in the figure, the APY of the most frequently used keywords varied in the interval 2012–2018. The newest keywords in this interval were the following: "bim", "ifc", "ppp", system dynamic", "safety management", "life cycle assessment", "mcdm", "fuzzy logic", "risk analysis", "construction industry", "construction projects", decision-making". It should be noted that the most recent keywords (ranging from 2020 to 2024) are not included in this set because their frequency of use is low, i.e. they are mentioned less than 3 times in the analyzed data set. However, a subset of these recent keywords can be constructed using VosViewer. The most recent keywords from this subset are: "technological innovation", "internet of things (iot)", "blockchain", "random forest", "sustainability assessment", "openbim", "integrated project delivery", "technology adoption", "dfma". Preliminarily, we can conclude that technological innovations like a design for manufacture and assembly (DFMA), internet of things (IoT), blockchain based technologies and integrated project delivery with BIM are relatively new topics discussed in JCEM papers.

Using this dataset, an additional cluster analysis was carried out to identify the most frequent applications of methods and technologies. On the basis of the results provided by VosViewer, it has been found that the key words are distributed in a total of 7 clusters (Table 3).

**Table 3.** Largest clusters of keywords in JCEM publications (keywords listed by number of occurrences)

| Cluster 1 | Cluster 2 | Cluster 3 | Cluster 4 | Cluster 5 | Cluster 6 | Cluster 7 |
|---|---|---|---|---|---|---|
| construction industry, contractor selection, international construction projects, neural networks, performance evaluation, ppp, risk analysis, selection criteria, system dynamics | artificial neural networks, beams, cracks, finite element method, genetic algorithms, non-linear analysis, reinforced concrete, schedule optimization | bending strength, compressive strength, fire resistance, flexural strength, rheological properties, safety management | ahp, decision-making, energy efficiency, fuzzy logic, life cycle assessment, mcdm | columns, failure load, sensitivity analysis, steel structures, strengthening, stressing state | construction projects, cost estimation, structural equation modeling | bim, ifc, supply chain management |

The keywords of the *first cluster* include: "construction industry", "constructor selection", "international construction projects", "neural networks", "performance evaluation", "ppp", "risk analysis", "selection criteria", "system dynamics". Based on this, it can be concluded that the studies in this cluster address the problems of performance evaluation of contractors in construction projects, risk assessment and appraisal of the public-private partnership (PPPs) infrastructure projects; risk assessment methodology for construction projects. For the evaluation of contractors, researchers used data envelopment analysis (DEA). For the risk assessment and appraisal of PPPs infrastructure projects applied fault tree, artificial neural networks, and analytical network process. To predict the frequency of claims in construction projects the neural network model was applied.

The keywords in the *second cluster* suggest that research in this cluster focuses on applications of Artificial neural networks (ANN) in various domains of civil engineering. For instance, multi-layer perceptron (MLP) and radial basis neural networks (RBNN) are utilized for damage diagnosis in beam-like structures. ANN applied for compressive strength prediction of lightweight short columns at elevated temperature. Research in this cluster also analyses and compares the accuracy of risk predictions made using the Random Forest (RF) method, support vector machines and artificial neural networks.

The research in the *third cluster* focuses on the safety management and fire resistance of construction materials, i.e. concrete elements, timber, fire protective paint coatings, materials based on polyester resin. Research in this cluster also analyses the rheological properties of self-compacting and other types of concrete mixes, bending strength and other physical and mechanical properties of fiber-reinforced composite materials, of timber, of concrete with crumb rubber waste additives.

The research in the *fourth cluster* focuses on the application of MCDM methods for decision-making in various domains of civil engineering. For instance, the combination of analytical hierarchy process (AHP) and Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) methods under a fuzzy environment is used in order to select a proper shaft sinking method. A multi-criteria decision-making system based on the MIVES method is utilized for assessing the global sustainability index scores of existing wind-turbine support systems. A method based on fuzzy analytic network process (F-ANP) and interpretive structural modeling (ISM) was proposed for the risk assessment of PPP projects. Analytic Hierarchy Process (AHP) and Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (Fuzzy TOPSIS) were applied to select the most suitable surveying technique for producing a Digital Terrain Model (DTM). An integrated MCDM approach under uncertainty is proposed for construction project selection. This approach integrates Fuzzy Preference Programming (FPP) as a modification of the Fuzzy Analytical Hierarchy Process (FAHP), with Fuzzy Inference System (FIS) as a fuzzy rule based expert system.

The research in the *fifth cluster* examining the load-bearing capacity of structural elements. For example, studies analyzed the working behavior characteristics of a large-curvature continuous prestressed concrete box-girder (CPCBG) bridge model based on structural stressing state theory. Other studies investigated the structural performance of reinforced concrete (RC) box-girders.

The research in the *sixth cluster* focused mainly on the construction cost estimation and prediction in the early stage of project development. For example, studies presented models to calculate construction costs during the conceptual phase of a project; utilized gene expression programming (GEP) technique to develop prediction models to automate construction cost estimation.

The research in the *seventh cluster* focused on the integrated use of BIM with other tools for decision-making in construction and the mitigation of asymmetric information problems in construction projects. As an example, studies proposed approaches for BIM management in supply chains using mixed-modes of information delivery, including object-based information transferred in IFC (Industry Foundation Classes) format. Others integrated the use of energy simulation software, a cost database, and BIM software to create and assess different scenarios.

To validate the findings of this analysis, we performed an additional analysis of the JCEM journal publications using the Scopus dataset and the SciVal tool. The SciVal tool allows the user to select different year intervals for this kind of analysis, including 2021–2023, 2021–2024, 2021–2025, 2019–2023, 2019–2024, 2019–2025, and 2014–2023. It should be noted that only the specified year intervals are available for consideration. In light of the above, the authors have chosen to focus on the most recent decade. This analysis revealed that the top ten most frequently mentioned and most relevant keywords in the publications for the period 2014–2023 are as follows (Figure 12): Building Information Modeling (43); Architectural Design (43); Construction Industry (40); Construction Management (29); Information Modeling (28); Multi-Criteria Decision-Making (18); Genetic Algorithm (24); Office Buildings (15); Precast Concrete (12); Prefabricated Construction (10).

Most articles published in JCEM fall into the topic cluster "Public-Private Partnership; Construction Industry; Project Scheduling (TC.547)" (Figure 13) which explores public-private partnerships (PPPs) in the construction and infrastructure sector. It delves into risk analysis, project governance, information technology, project scheduling, and resource management. Key aspects of the research include: defining project governance for large capital projects; addressing challenges in implementing management best practices in construction firms; predicting financial losses, and identifying cost estimation models; evaluating the viability and impact of PPPs in the construction and infrastructure sector; applying heuristic algorithms for optimizing construction project time-cost-quality; proposing novel hyper-heuristic based filtering genetic programming for multi-project scheduling; developing models and methods for using information technologies to enhance sentiment analysis, and recommendation systems.


**Figure 12.** Top 50 key phrases in JCEM articles by relevance (Scopus, SciVal, 2014–2023)

The second largest cluster by number of publications is "Information Theory; Construction Industry; Interoperability (TC.1331)". It is about the integration of Building Information Modeling (BIM) in the construction industry, focusing on information management, structural design, risk analysis, project planning, and technological advancements. Key aspects of the research include: exploring the impact of BIM adoption, integrated project delivery, and BIM use cases; improving information management and data integration in construction using BIM-AM system and RFID technology; optimizing project planning, scheduling, and transportation in prefabricated construction using dynamic methods and mathematical models; advancing structural design and seismic behavior analysis through innovative modular construction and joint connections.

Topic cluster "Multiple-Criteria Decision Analysis; Analytical Hierarchy Process; Artificial Intelligence (TC.375)" is the third largest cluster by number of publications and includes topics on modeling uncertainty, decision-making, and system development using various methods and evidence theories. It encompasses the studies of probability, risk analysis, and multi-criteria decision-making techniques. Key aspects of the research include: utilizing fuzzy logic, and MCDM methods for decision-making; proposing novel methods; forecasting energy consumption and system development using grey models and multi-criteria decision-making methods; modeling uncertainty and risks. The top 5 key phrases in this cluster (for all publications on the MCDM topic) are: "Analytical Hierarchy Process", "Multiple-Criteria Decision-Making", "AHP Approach", "Multiple-Criteria Decision Analysis", "Technique for Order of Preference by Similarity to Ideal Solution".

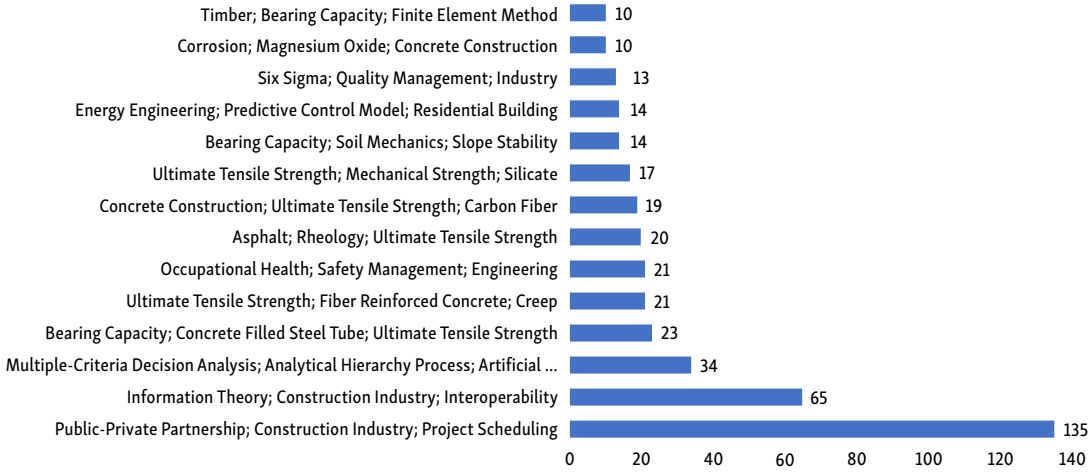


**Figure 13.** Largest topic clusters of articles published in the JCEM (Scopus, SciVal, 2014–2023)

### 4.6. Co-authorship clusters on the development of the MCDM methods

In order to determine the contribution of the most active JCEM authors to the development of MCDM methods (RQ3; RQ5), performance analysis of authors, co-authorship analysis and clustering were performed using the WoS dataset. As can be seen from Figure 14, the top ten most active authors are: E. K. Zavadskas (217 publications), D. Pamucar (121), Z. Turskis (81), J. Antucheviciene (79), J. Q. Wang (73), G. H. Tzeng (72), S. Hashemkhani Zolfani (63), Z. Hu (63), H. Liao (62), Ž. Stevič (60). A co-authorship analysis performed using VosViewer revealed that 54 authors work in six non-isolated clusters, forming a highly collaborative network of researchers (Figure 15). It is noteworthy that the number of authors publishing articles on MCDM is considerably higher. However, in order to identify the most active authors, the analysis was set to limit the minimum number of papers per author to 30. The biggest co-authorship cluster by number of researchers (1st cluster) contains twenty researchers mainly from China (in Figure 15 marked in red color). The 2nd cluster is the biggest co-authorship cluster by a number of publications led by E. K. Zavadskas (in Figure 15 marked in green color) with more than 600 publications on the MCDM topic. The cluster includes twelve scientists from Lithuania, Iran, Serbia, India, Turkey, and Spain. The 3rd cluster is the next biggest co-authorship cluster by number of publications with more than 450 publications on the MCDM topic. It includes ten scientists from India, England, India, South Korea, Serbia, Pakistan, and Bosnia & Herzegovina (in Figure 15 marked in blue color). The 4th cluster includes five scientists from Jordan. Malaysia, Iraq, Australia, United Arab Emirates, and Taiwan (in Figure 15 marked in dark gold color). The 5th cluster includes four scientists from the USA, India, India, and Lithuania (in Figure 15 marked in

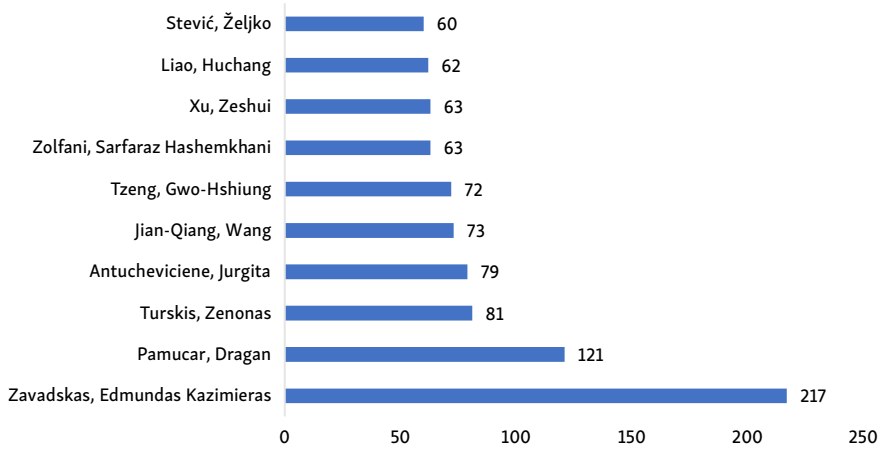


**Figure 14.** Top 10 authors by number of publications on MCDM in various sources (WOS, Core Collection, 19 August 2024)

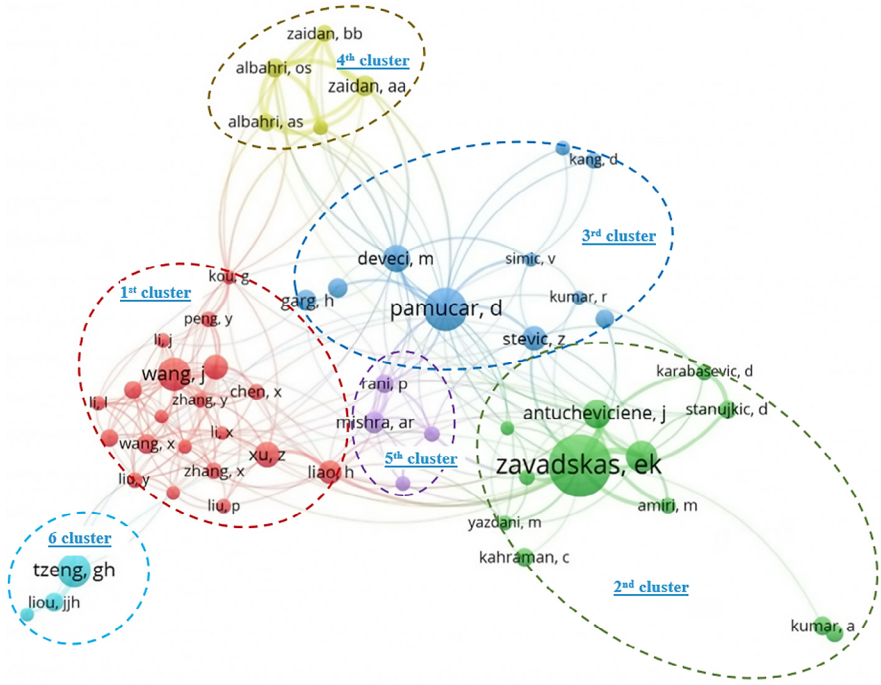


**Figure 15.** Clusters of authors with publications on MCDM (WOS, Core Collection, 19 August 2024)

purple color). Each of these clusters published 159 papers. The sixth cluster consists of three researchers from Taiwan with 146 publications (in Figure 15 marked in light blue color). A more intense degree of collaboration is observed among clusters one, two and three. The most collaborative countries include China, Lithuania, Iran, Serbia, India, Turkey, Spain, and Bosnia & Herzegovina.

An impressive contribution to the development of MCDM methods has been made by Prof. E. K. Zavadskas, the founder of the JCEM journal, and researchers from his cluster. This scientific cluster has developed various methods of multi-criteria analysis, including a method of Multi-Objective Optimisation on the Basis of Ratio Analysis (MOORA); MULTIMOORA (MOORA plus full multiplicative form); COmplex PRoportional ASsessment (COPRAS), COPRAS with Grey Relations (COPRAS-G), COPRAS method for Group Decision Making in an Interval-Values Intuitionistic Fuzzy Environment, COPRAS applying Fuzzy Sets (COPRAS-F); extension of LINAMP model with Grey Numbers; Step-Wise Weight Assessment Ratio Analysis (SWARA); TOPSIS modification applying Mahalanobis Distance Measure (TOPSIS-M); Weighted Aggregated Sum Product Assessment (WASPAS). In the Thomson Reuters database, around 20 papers presenting these methods have been nominated as Hot Papers. To improve the efficiency of decision-making, researchers are constantly developing new MCDM methods and modifying existing ones. Table 4 shows the multi-criteria methods developed and modified by this research cluster. A complete list of articles on the developed MCDM methods that have been published by researchers in this cluster is available on the EWG ORSDCE website: https://www.euro-online.org/websites/orsdce/articles-published/.

All the above methods have had wide practical applications in various domains, i.e., sustainable development in civil engineering, building life cycle analysis, decision-making in construction projects, risk management in construction, quality control in construction projects, etc. For example, Stefano et al. (2015) analyzed applications of the COPRAS method and concluded that the COPRAS approach has been successfully applied in a wide range of fields and industrial sectors, with different time frames and topics, requiring a stronger focus on interdisciplinary and societal decision-making issues. Passos Neto et al. (2023), in a systematic review, showed that COPRAS along with AHP, SAW, ANP, PROMETHEE, BWM and DEMATEL are the most commonly applied methods for assessing social sustainability in the built environment. Gul et al. (2016) presented a literature review on the applications of VIKOR and its fuzzy extensions. The study suggests that the integration of interval type 2 fuzzy sets, hesitant fuzzy sets, and intuitionistic fuzzy sets with VIKOR can be addressed as future research in the problems of material selection, robot selection, and new product development. Mardani et al. (2017) reviewed 55 studies on various applications of SWARA and WASPAS methods, and noted the significant role of integrating fuzzy set theory and grey numbers with the WASPAS method. For example, the WASPAS method integrated with interval type-2 fuzzy sets, combined the WASPAS method based on interval-valued intuitionistic fuzzy numbers, the WASPAS method combined with a single-valued neutrosophic set and the WASPAS method with grey numbers. The study suggested that future papers can focus on integrating the WASPAS and SWARA methods with other types of fuzzy theory sets, fuzzy integrals and aggregation operators, and combining these two techniques with qualitative information and quantitative data based on hesitant fuzzy linguistic term sets. Hafezalkotob et al. (2019) analyzed developments, applications, and challenges related to the MULTIMOORA method. The study revealed that this method is most commonly used in the construction industry, but it is also widely used in other sectors, including economics, civil services & environmental policy-making, and medical/healthcare management. Pandey et al. (2023) noted the perspective towards the development of hybrid MCDM methods, in which the TOPSIS method can be hybridized with some MCDM methods developed by Zavadskas cluster, like MOORA, MULTIMOORA, and WASPAS, and their extended versions under different types of uncertainty theories such as fuzzy set theory and rough set theory. Fan et al. (2024) derived the EDAS technique for the methods based on bipolar complex fuzzy linguistic (BCFL) information and applied it to the development of rural energy infrastructure. Batwara et al. (2025) applied fuzzy EDAS to assess and rank smart, sustainable manufacturing (SSM) solutions and suggested that the current analysis will help business leaders strategically plan to overcome barriers to making decisions.

The aforementioned studies represent merely a sampling of the most recent applications of the MCDM methods developed by the scientific cluster of Prof. E. K. Zavadskas. It seems reasonable to posit that a significant number of studies of this nature have been conducted, but it is unlikely that an accurate estimation can be made without additional search on methods. Nevertheless, such comprehensive analysis is beyond the scope of the present study and may be recommended for future research. It is suggested that researchers could further explore the application of the methods proposed by this cluster in a variety of fields. In light of the objective of this paper, which is to provide a summary of the performance indicators of the JCEM journal and its contribution to the development and application of MCDM methods in construction management on the occasion of Professor E. K. Zavadskas' 80th birthday and the 30th anniversary of the JCEM journal, it seems pertinent to present a brief overview of the key facts pertaining to the founder of this journal. Professor Edmundas Kazimieras Zavadskas is celebrating his 80th birthday this year. He was born on May 12, 1944 in Vilnius, Lithuania. In 1962–1967, E. K. Zavadskas studied at the Faculty of Civil Engineering, at the Vilnius branch of Kaunas Polytechnic Institute (VISI) (now – Vilnius Gediminas Technical University). His impressive academic career began in 1973, when he defended his PhD thesis on building structures. Then, in 1987, he obtained a Doctor of Science degree in building technology and management. A selection of decision-making solutions dominated this research. In 1993 he obtained a Doctor Habil. degree.

**Table 4.** Original and modified MCDM methods developed by the cluster of E. K. Zavadskas

| Original MCDM methods | Extensions (modifications) of the MCDM methods |
|---|---|
| COPRAS (1995) | COPRAS-F (2007); COPRAS-G (2008); COPRAS-IVIF (2013); COPRAS-SVNS (2015); COPRAS-WIRN (2019) |
| MOORA (2006) | MULTIMOORA (2010) |
| LOGARITHMIC NORMALIZATION (2008) | |
| | VIKOR-F (2008); VIKOR-IVNS (2015) |
| | TOPSIS-M (Mahalanobis) (2010); TOPSIS-G (2010); TOPSIS-FADR (2018) |
| MULTIMOORA (2010) | MULTIMOORA-IVIF (2015); HFL-MULTIMOORA (2019); BIPOLAR FUZZY MULTIMOORA (2019); TARGET-BASED MULTIMOORA (2020); M-GENERALIZED Q-NEUTROSOPHIC MULTIMOORA (2020); IVNS-MULTIMOORA (2021) |
| SWARA (2011) | SWARA-E (2019); R-SWARA (2018); FMEA-SWARA (2020) |
| | SAW-G (2012) |
| | LINMAP-G (2012) |
| WASPAS (2012) | WASPAS-IVIF (2014); WASPAS-SVNS (2015); WASPAS-F (2015); WASPAS-2FS (2016); WASPAS-G (2016); IRN-WASPAS (2018); WASPAS-Fermatean (2020); LPFS-WASPAS (2020) |
| KEMIRA (2014) | ENTROPY-KEMIRA (2017) |
| EDAS (2015) | EDAS-F (2016); EDAS-IGN (2017); EDAS-IFS (2017); EDAS-2FS (2017); EDAS-I2FS (2017); Stochastic EDAS (2017); Dynamic EDAS (2018); EDAS-M (Minkowski space) (2019) |
| MWSM (2015) | |
| AFRAF (2016) | |
| CODAS (2016) | CODAS-F (2017) |
| EAMRIT (2016) | |
| CILOS (2016) | F-CILOS (2020) |
| IDOCRIW (2016) | FIDOCRIW (2020) |
| PMADM (2016) | |
| | OCRA-IGN (2017) |
| ARCAS (2017) | |
| WEBIRA (2017) | |
| MAMVA (2017) | SVN-MAMVA (2017) |
| R-ROV (2018) | |
| SECA (2018) | SECA-2FT (2019) |
| PIPRECIA (2019) | PIPRECIA-IVTFM (2020) |
| | BWM-PAARWISE COMPARISON (2019) |
| | PROMETHEE-NS (2019) |
| CoCoSo (2019) | HFL-CoCoSo (2019); PFS-CoCoSo (2020); TARGET-BASED CoCoSo (2020); CoCoSo WITH MAXIMUM VARIANCE OPTIMIZATION (2020); INTERVAL ROUGH BOUNDARIES (2020); PYTHAGOREAN FUZZY CoCoSo (2020); CoCoSo-F (2021); HFS-CoCoSo (2021) |
| FME+HFS (2020) | |
| | INTERVAL VALUED INTUITIONISTIC TODIM (2020); TODIM-IVIF (2020) |
| MACONT (2020) | |
| | SVNS HAMMING DISTANCE TOPSIS (2020) |
| | INVAR SVN (2021) |
| | IFS WISP (2022) |

In 1990, E. K. Zavadskas was elected to the position of Rector of the Vilnius Engineering Construction Institute (VISI). E. K. Zavadskas successfully reorganized the institute into Vilnius Technical University during his rectorship. The name of the university was subsequently changed to Vilnius Gediminas Technical University (VGTU), and E. K. Zavadskas was elected to the position of rector for a new period (1996–2002). From 2002 to 2011 he held the position of Vice Rector of VGTU. During this period, he focused on making the university one of the largest universities in Lithuania and a leader in engineering education and research.

E. K. Zavadskas is the author or co-author of more than 50 books, including five textbooks and 16 monographs, 10 popular science books, over 700 research articles and several hundred articles on different social and cultural issues. In 1996 he received the Lithuanian Research Award for the series of works "Multiple criteria assessment of construction projects and technological solutions" (1980–1996) and in 2004 for the series of work "Modelling in construction

(methods, simulation, decision support and information systems, web-based technologies, practical application)" (1996–2003). In 1996 he also was awarded the 4th class medal of the Lithuanian Grand Duke Gediminas.

E. K. Zavadskas was an Expert Member (1991–1993), a Corresponding Member (1993–2011) and from 2011 a Full Member of the Lithuanian Academy of Sciences. E. K. Zavadskas, in the years 2001–2012, was the President of the Operational Researchers Society in Lithuania and Baltic States. Furthermore, he has been granted the title of Honorary Doctor of Poznań University of Technology and the Honorary International Professor of the National Taipei University of Technology.

E. K. Zavadskas was one of the main initiators of the international German–Lithuanian–Polish colloquia devoted to Operational Research (OR) in the field of Civil Engineering. Since 1986, the colloquia have been organized every two years. Nineteen Colloquia have been organized since the first one. On the basis of this successful collaboration, during the 23rd European Conference on Operational Research "OR creating competitive advantage" held in Bonn in 2009, the new EURO Working Group "OR in Sustainable Development and Civil Engineering" (EWG-ORSDCE) was established. E. K. Zavadskas chairs this working group, which brings together researchers from his leading cluster.

E. K. Zavadskas chairs and participates in the editorial boards of a number of scientific journals. He is the founder of three international scientific journals: *Journal of Civil Engineering and Management* (Editor-in-chief from 1995 to 2019), *Technological and Economic Development of Economy* (Editor-in-chief since 1994 till 2019), and *International Journal of Strategic Property Management* (Editor-in-chief from 1997 to 2011). All three journals have been included in the Thomson Reuters Web of Science database from 2008 and have impact factors (IF) since 2010. Since 2010, these journals have been published by the VGTU publishing house Technika in cooperation with the publishing house Taylor & Francis.

E. K. Zavadskas has published the most articles in the following Clarivate Analytics Web of Science categories: Economics (155), Engineering Civil (86), Computer Science Artificial Intelligence (72), Environmental Sciences (70), Computer Science Information Systems (66), Construction Building Technology (63), Business (62), Green Sustainable Science Technology (54), Automation Control Systems (52), Operations Research Management Science (51). The most significant contributions are in Operations Research (30%), Computer Science Artificial Intelligence (29%).

One of the highest acknowledgements of his many years of work was received in 2014, when E. K. Zavadskas was included in the list of the most cited scientists in the world in the "Clarivate Analytics Highly Cited Researchers: Engineering category". In 2018 and 2019, E. K. Zavadskas was among the world's most cited researchers in the Cross-Field Category, as much of his research and publications are interdisciplinary, primarily combining work in civil engineering, management, economics, and computer engineering. E. K. Zavadskas in 2020 was in the top 1% of the world's most cited scientists in two fields, "Engineering" and "Economics and Business", and in 2021 in "Economics and Business". Stanford University recognized E. K. Zavadskas as one of the top 2% of the most cited researchers in "Civil Engineering" for the period 2020–2024. At the same time, he was ranked in the Stanford/Elsevier 2024 list of the top 100 researchers in "Engineering".

On the occasion of his jubilee, we congratulate Professor Edmundas Kazimieras Zavadskas as an outstanding scientist. We wish him good health and creativity in his further contribution to the development of MCDM methods.

## 5. Conclusions

The JCEM journal is of significant importance in the context of the aggregation and transmission of knowledge in the domain of construction management. The analysis revealed that the JCEM has contributed the most to the development of MCDM methodologies in construction management research compared to other journals. Since its inception, the editors of the Journal of Civil Engineering and Management can be proud of promoting interesting research issues from an international perspective. In this review, a bibliometric analysis was employed to evaluate the performance of the JCEM journal and to present indicators related to publications. The analysis revealed that China was the most productive country, with a publication rate in JCEM that was more than twice that of second-placed Lithuania. The authors from China and Lithuania were followed by those from Poland, the USA, Taiwan, Iran, South Korea, Australia, Malaysia, and Turkey. The journal's rank has increased since entering international databases and obtaining the impact factor. The results are visible in the number of authors from all continents and a significant number of article citations. Over the past decade, the journal's citations have increased fourfold. Moreover, the prestige of the journal lies in the Q1 quartiles, both in the Scopus database and in the Web of Science database. Thus, the evolution and milestones in the development of the *Journal of Civil Engineering and Management* are undeniable, and it turns out that the contribution of the JCEM in the promotion of MCDM methods in construction management is significant.

According to the results of bibliometric analysis, the topics on which the journal's research was focused over the last decade include: Building Information Modeling (BIM), architectural design, construction industry, construction management, information modeling, MCDM, and optimization algorithms. The analysis indicated a significant interest in the application of digitization technologies in the construction sector. Technological advancements like the Internet of Things (IoT), and blockchain-based technologies are relatively new topics discussed in JCEM papers. Most recent JCEM papers propose that utilizing such technologies facilitates the development of sophisticated cyber-physical systems (CPSs), thereby enabling a more dynamic project control process, assessing on-site and overall project performance, tracking the progressive creation of as-built digital data, and streamlining the flow of data between the construction phase and the opera-

tional phase. It is evident that further research is required to enhance our comprehension of the role of disruptive technologies in driving progress within the construction industry.

The review shows the obvious dynamic development of the MCDM methods, as well as their usefulness. With their help, many engineering, economic and organizational problems have been solved, especially with incomplete data. The impact of standardization on the development of subsequent methods, including hybrid ones, is also visible. The review takes into account extensions and adaptations of existing methods, as well as the exposure of own methods (models) created by the academic community cooperating with the Journal of Civil Engineering and Management. The analysis revealed that authors are increasingly applying MCDM methods to a wide range of problems in construction management. Therefore, it is likely that new MCDM methods and modifications of existing methods may be developed in the future as this field develops. The integrated application of MCDM with advanced technologies, like Blockchain Technology (BT) and the Internet of Things (IoT) is expected to have benefits including, but not limited to: increasing transparency and reliability of data for the decision-making and decision-making process itself. It is therefore recommended that the authors further develop these topics in future research.

The prestige and rank of the journal have increased thanks to the contributions of Professor Edmundas Kazimieras Zavadskas, his collaborators across the globe, and the promotion of MCDM methods from the theoretical and practical side. First of all, Edmundas Kazimieras Zavadskas made a huge contribution to the development of journal and created a scientific school in which MCDM methods are predominant. Therefore, part of the article is devoted to his achievements. His numerous articles and, above all, authorship or co-authorship of books contribute to the theory and practice of MCDM and encourage continuous innovation in this field.

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## Author contributions

OK conceived the study and was responsible for the design and conceptualization. TV was responsible for the methodology of bibliometric analysis and data collection. OK and TV were responsible for data interpretation and analysis. TV wrote the first draft of the article. OK reviewed and edited the article. TV finalized the article. OK supervised the preparation of final version of the article. All authors have read and agreed to the published version of the manuscript.

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## References

Batwara, A., Sharma, V., & Makkar, M. (2025). Prioritization of the approaches for overcoming smart sustainable manufacturing barriers using stochastic fuzzy EDAS method. *International Journal on Interactive Design and Manufacturing* (*IJIDeM*). *19*, 1927–1949. https://doi.org/10.1007/s12008-024-01891-2

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021a). 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

Donthu, N., Kumar, S., Pattnaik, D., & Pandey, N. (2021b). A bibliometric review of International Marketing Review (IMR): past, present, and future. *International Marketing Review*, *38*(5), 840–878. https://doi.org/10.1108/IMR-11-2020-0244

Fan, Y., Ali, Z., & Yin, S. (2024). A systematic review and meta-analysis of EDAS method and power aggregation operators: Theory and applications with recent bipolar complex fuzzy linguistic developments. *IEEE Access*, *12*, 39110–39128. https://doi.org/10.1109/ACCESS.2024.3369917

Farooq, R. (2024). A review of knowledge management research in the past three decades: A bibliometric analysis. *VINE Journal of Information and Knowledge Management Systems*, *54*(2), 339–378. https://doi.org/10.1108/VJIKMS-08-2021-0169

Gul, M., Celik, E., Aydin, N., Gumus, A. T., & Guneri, A. F. (2016). A state of the art literature review of VIKOR and its fuzzy extensions on applications. *Applied Soft Computing*, *46*, 60–89. https://doi.org/10.1016/j.asoc.2016.04.040

Gusenbauer, M., & Haddaway, N. R. (2020). Which academic search systems are suitable for systematic reviews or meta-analyses? Evaluating retrieval qualities of Google Scholar, PubMed, and 26 other resources. *Research Synthesis Methods*, *11*, 181–217. https://doi.org/10.1002/jrsm.1378

Hafezalkotob, A., Hafezalkotob, A., Liao, H., & Herrera, F. (2019). An overview of MULTIMOORA for multi-criteria decision-making: Theory, developments, applications, and challenges. *Information Fusion*, *51*, 145–177. https://doi.org/10.1016/j.inffus.2018.12.002

Kumar, S., Chavan, M., & Pandey, N. (2023). Journal of International Management: A 25-year review using bibliometric analysis. *Journal of International Management*, *29*(1), Article 100988. https://doi.org/10.1016/j.intman.2022.100988

Laengle, S., Merigó, J. M., Miranda, J., Słowiński, R., Bomze, I., Borgonovo, E., Dysone, R. G., Oliveira, J. F. & Teunter, R. (2017). Forty years of the European Journal of Operational Research: A bibliometric overview. *European Journal of Operational Research*, *262*(3), 803–816. https://doi.org/10.1016/j.ejor.2017.04.027

Mardani, A., Nilashi, M., Zakuan, N., Loganathan, N., Soheilirad, S., Saman, M. Z. M., & Ibrahim, O. (2017). A systematic review and meta-analysis of SWARA and WASPAS methods: Theory and applications with recent fuzzy developments. *Applied Soft Computing*, *57*, 265–292. https://doi.org/10.1016/j.asoc.2017.03.045

Mukherjee, D., Kumar, S., Donthu, N., Pandey, N. (2021). Research published in management international review from 2006 to 2020: A bibliometric analysis and future directions. *Management International Review*, *61*, 599–642. https://doi.org/10.1007/s11575-021-00454-x

Pandey, V., Komal, & Dincer, H. (2023). A review on TOPSIS method and its extensions for different applications with recent development. *Soft Computing*, *27*(23), 18011–18039. https://doi.org/10.1007/s00500-023-09011-0

Passos Neto, G. D. M., Alencar, L. H., & Valdes-Vasquez, R. (2023). Multiple-criteria methods for assessing social sustainability in the built environment: A systematic review. *Sustainability*, *15*(23), Article 16231. https://doi.org/10.3390/su152316231

Stefano, N. M., Casarotto Filho, N., Vergara, L. G. L., & da Rocha, R. U. G. (2015). COPRAS (Complex Proportional Assessment): State of the art research and its applications. *IEEE Latin America Transactions*, *13*(12), 3899–3906. https://doi.org/10.1109/TLA.2015.7404925

van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, *84*, 523–538. https://doi.org/10.1007/s11192-009-0146-3

Yepes-Nuñez, J. J., Urrútia, G., Romero-García, M., & Alonso-Fernández, S. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Revista Española de Cardiología*, *74*(9), 790–799. https://doi.org/10.1016/j.recesp.2021.06.016

Yu, D. J., Xu, Z. S., & Fujita, H. (2019). Bibliometric analysis on the evolution of applied intelligence. *Applied Intelligence*, *49*(2), 449–462. https://doi.org/10.1007/s10489-018-1278-z

Zurita, G., Shukla, A. K., Pino, J. A., Merigó, J. M., Lobos-Ossandón, V., & Muhuri, P. K. (2020). A bibliometric overview of the journal of network and computer applications between 1997 and 2019. *Journal of Network and Computer Applications*, *165*, Article 102695. https://doi.org/10.1016/j.jnca.2020.102695