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# TRENDS AND RESEARCH LANDSCAPE OF THE FUZZY DELPHI METHOD: A BIBLIOMETRIC ANALYSIS (2015-2024)

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**Abstract:**

The Fuzzy Delphi Method (FDM) has gained significant attention over the past decade as a structured expert consensus technique widely applied in multidisciplinary decision-making contexts. Despite its growing popularity, a comprehensive overview of its research landscape remains limited. This study aims to analyze the trends, patterns, and research dynamics of FDM-related publications from 2015 to 2024 through a bibliometric approach. The main problem addressed is the lack of systematic insight into the evolution of FDM applications, key contributors, thematic developments, and international collaborations. Data were retrieved from the Scopus database using the keywords "fuzzy delphi" in the title, abstract, or keywords, restricted to journal articles published between 2015 and 2024. The final dataset comprised 1,096 documents. For data processing and analysis, Scopus's built-in analytics tool was used to obtain basic bibliometric indicators, while OpenRefine was employed for data cleaning and standardization. VOSviewer software was utilized to visualize co-authorship, country collaboration, and keyword co-occurrence networks. The numerical results reveal a significant increase in publication output, especially between 2020 and 2024, with Iran, Taiwan, and Malaysia emerging as the top contributing countries. The subject areas most

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associated with FDM include social sciences, engineering, business, and environmental science, indicating its wide applicability. Keyword analysis highlights dominant themes such as sustainability, multi-criteria decision-making, and integration with tools like AHP, DEMATEL, and Industry 4.0. The co-authorship network demonstrates strong regional and international collaboration, with notable contributions from countries in Asia and Europe. The results also indicate the presence of a core group of countries and institutions actively publishing and collaborating in this field. In conclusion, this bibliometric analysis provides valuable insights into the development of FDM research over the past decade, identifying leading contributors, emerging themes, and potential.

**Keywords:**

Fuzzy Delphi, Bibliometric Analysis, Scopus, Research Trends, VOSviewer, Methodology

## Introduction

The Fuzzy Delphi Method (FDM) is an advanced variant of the traditional Delphi technique, integrating fuzzy set theory to enhance decision-making processes by addressing uncertainties and ambiguities inherent in expert consensus. Since its inception, FDM has been widely adopted across various fields, including education, human-computer interaction, and sustainable development, to name a few. This bibliometric analysis aims to explore the trends and research landscape of the Fuzzy Delphi Method from 2015 to 2024, providing insights into its evolution, application domains, and methodological advancements.

The Fuzzy Delphi Method has seen significant growth and diversification in its applications over the past decade. Initially developed to improve the traditional Delphi method by incorporating fuzzy logic, FDM has been extensively utilized in fields such as education, where it helps in designing instructional interventions and selecting competencies needed by industries (Ciptono et al. 2019). The method's ability to handle linguistic variables and mitigate human judgment ambiguities has made it particularly valuable in complex decision-making scenarios (Ibrahim et al. 2025). Moreover, the integration of Z-numbers and other fuzzy set enhancements has further refined FDM's precision in uncertain contexts, as seen in applications like reverse logistics and sustainable remanufacturing strategies (Nasir, Hamzah, and Zakaria 2024) (Anjaria 2023).

The research landscape of FDM is characterized by its broad applicability and continuous methodological improvements. Studies have highlighted the method's utility in diverse domains such as human-computer interaction, where it aids in developing user experience frameworks and evaluating mobile applications (Yusof, Hashim, and Hussain 2022). Additionally, FDM has been instrumental in identifying key factors affecting various sectors, from IT-based platform services to island tourism competitiveness (Kousari, Razban, and Sanaei 2024) (Fu and Chen 2019). Methodological advancements include the development of hybrid models combining FDM with other decision-making techniques like the fuzzy analytic hierarchy process (FAHP) and the fuzzy Decision-Making Trial and Evaluation Laboratory (DEMATEL), enhancing the robustness and reliability of expert consensus (Wu et al. 2014) (Rajput 2024).

International Journal of Modern Education
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The future of FDM research appears promising, with potential for further interdisciplinary applications and methodological refinements. The method's adaptability to different contexts, such as sustainable urban development and ecotourism, underscores its versatility and relevance in addressing contemporary challenges (Chang and Wu 2014) (Wang and Peng 2020). Future research could focus on standardizing FDM procedures and fostering transdisciplinary collaborations to develop comprehensive guidelines and best practices. Additionally, exploring the integration of emerging technologies like artificial intelligence and big data analytics with FDM could open new avenues for enhancing decision-making processes in various fields (Rajput 2024) (Khodyakov et al. 2023).

In conclusion, the Fuzzy Delphi Method has evolved into a critical tool for expert consensus and decision-making across multiple domains. Its continuous methodological advancements and expanding application landscape highlight its significance and potential for future research and practical implementations.

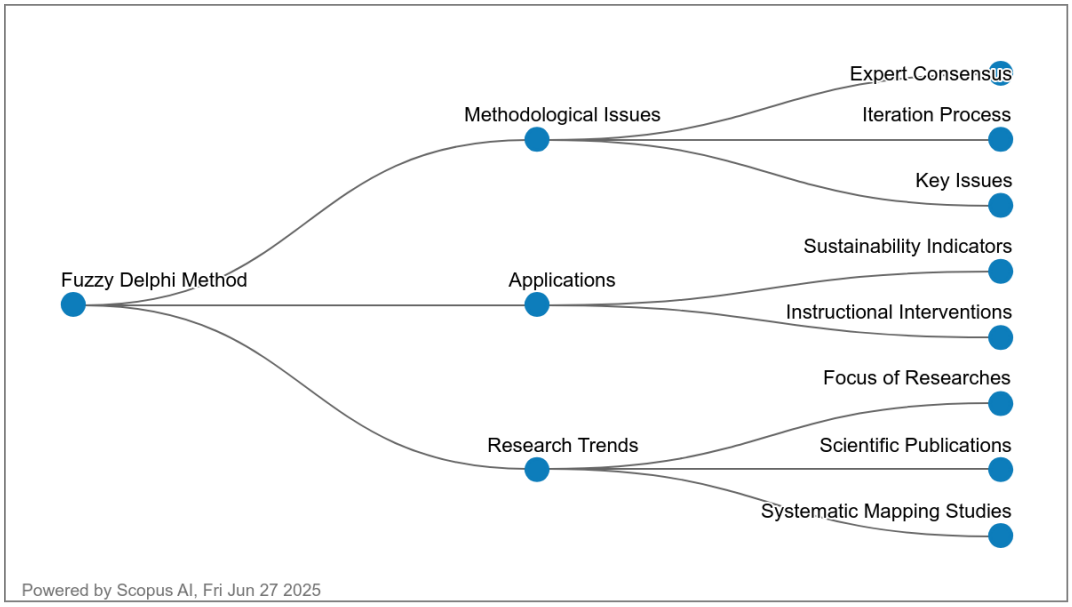


**Figure 1: Overview of Literature**

Source: Adapted from Scopus Database, accessed on 27th June 2025 (https://www.scopus.com)

**Research Question**

1. What is the annual publication trend of scientific output on the Fuzzy Delphi Method from 2015 to 2024?
2. Which subject areas contribute most to Fuzzy Delphi Method research?
3. What are the top 10 most cited articles related to the Fuzzy Delphi Method?
4. Which countries have contributed the most publications on the Fuzzy Delphi Method?
5. What are the most frequently used keywords in Fuzzy Delphi Method publications from 2015 to 2024?
6. What does the co-authorship network reveal about international collaboration in Fuzzy Delphi Method research?

International Journal of Modern Education
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## Methodology

Bibliometric analysis entails the collection, organization, and evaluation of bibliographic information derived from scientific literature (Alves, Borges, and De Nadae 2021; Assyakur and Rosa 2022; Verbeek et al. 2002). In addition to basic metrics such as identifying relevant journals, publication years, and prominent authors (Wu and Wu 2017), bibliometric methods also encompass more advanced techniques like document co-citation analysis. A thorough literature review demands an iterative and structured process involving the selection of appropriate keywords, systematic searching, and detailed examination.

This method ensures the creation of a comprehensive bibliography and supports the production of reliable findings (Fahimnia, Sarkis, and Davarzani 2015). Accordingly, this study emphasized high-impact publications, as they offer valuable perspectives on the theoretical foundations that define the research domain. To guarantee data reliability, SCOPUS was utilized as the main data source (Al-Khoury et al. 2022; Khiste and Paithankar 2017; di Stefano, Peteraf, and Veronay 2010). For consistency and scholarly relevance, the analysis was limited to articles published in peer-reviewed academic journals, while other sources such as books and lecture notes were intentionally excluded (Gu et al. 2019). The dataset was compiled using Elsevier's Scopus, recognized for its extensive coverage, and included publications indexed between 2020 and December 2023.

## Data Search Strategy

The bibliometric data for this study was retrieved from the Scopus database on 27th June, 2025 using a defined search strategy. The search string used was: TITLE-ABS-KEY ("fuzzy delphi") AND PUBYEAR > 2014 AND PUBYEAR < 2025 AND (LIMIT-TO (DOCTYPE , "ar")). This query was designed to extract scientific articles that specifically mention the term "fuzzy delphi" in the title, abstract, or keywords, published between 2015 and 2024, and limited to journal articles only (document type: "ar"). The search yielded a total of 1,096 results, representing the core dataset for the bibliometric analysis of research trends and developments related to the Fuzzy Delphi Method over the past decade.

The year 2025 was excluded from the search to ensure the completeness and reliability of the data. As the year is still ongoing, publication records for 2025 may be incomplete, inconsistently indexed, or subject to future updates. Including data from an incomplete publication year could skew the analysis and misrepresent annual trends, especially in terms of publication output and citation counts. Therefore, only data from **fully completed years (2015-2024)** were considered for this study

**Table 1: The Search String**

| | |
|---|---|
| **Scopus** | **TITLE-ABS-KEY ( "fuzzy delphi" ) AND PUBYEAR > 2014 AND PUBYEAR < 2025 AND ( LIMIT-TO ( DOCTYPE , "ar" ) )** |

**Table 2: The Selection Criterion in Searching**

| Criterion | Inclusion | Exclusion |
|---|---|---|
| Time line | 2015 - 2024 | < 2015, >2024 |
| Literature type | Journal | Non- Journal |

International Journal of Modern Education
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**Data Analysis**

VOSviewer is a bibliometric software tool designed by Nees Jan van Eck and Ludo Waltman from Leiden University in the Netherlands (van Eck and Waltman 2010, 2017). Recognized for its user-friendly design, the software is widely applied in the visualization and analysis of scientific literature. It is particularly effective in generating network visualizations, identifying clusters of related items, and creating density maps. The software supports the analysis of co-authorship, co-citation, and keyword co-occurrence networks, enabling researchers to gain a comprehensive view of research structures and developments. Its interactive interface and ongoing software updates contribute to the efficient handling of large bibliographic datasets. Furthermore, VOSviewer offers capabilities for metric calculation, visualization customization, and compatibility with various data formats, making it a valuable tool for exploring complex academic domains.

Among its notable functions, VOSviewer allows for the transformation of large bibliometric datasets into visual network maps that are easy to interpret. Emphasizing network visualization, the tool effectively identifies keyword co-occurrence patterns and research clusters. Its intuitive interface accommodates both beginner and advanced users, facilitating a clear understanding of research trends and relationships. Continuous improvements to the software ensure its ongoing relevance in bibliometric studies, particularly through its flexible data handling and strong analytical capabilities. VOSviewer is suitable for diverse types of bibliometric data, such as citation links and collaborative authorship, which underscores its importance in generating meaningful insights across multiple research areas.

For this study, datasets containing metadata such as publication years, article titles, author names, source journals, citation counts, and keywords were downloaded in PlainText format from the Scopus database, covering the period from 2004 to December 2024. These datasets were analyzed using VOSviewer version 1.6.19. The software's clustering and mapping features enabled the generation of bibliometric visualizations. Unlike traditional Multidimensional Scaling (MDS), VOSviewer employs a technique that positions items in a low-dimensional space where distances reflect their relatedness (van Eck and Waltman 2010). Although it shares conceptual similarities with MDS (Appio, Cesaroni, and Di Minin 2014), VOSviewer uses a more suitable normalization approach for co-occurrence frequencies, such as association strength ($AS_{ij}$), which is calculated based on the ratio between observed and expected co-occurrence frequencies under statistical independence assumptions (Van Eck and Waltman 2007).

$$AS_{ij} = \frac{C_{ij}}{w_i w_j}$$

which is "proportional to the ratio between on the one hand the observed number of cooccurrences of i and j and on the other hand the expected number of co-occurrences of i and j under the assumption that co-occurrences of i and j are statistically independent" (Van Eck and Waltman 2007).

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## Findings and Discussion

***What Is the Annual Publication Trend of Scientific Output on The Fuzzy Delphi Method from 2015 To 2024?***

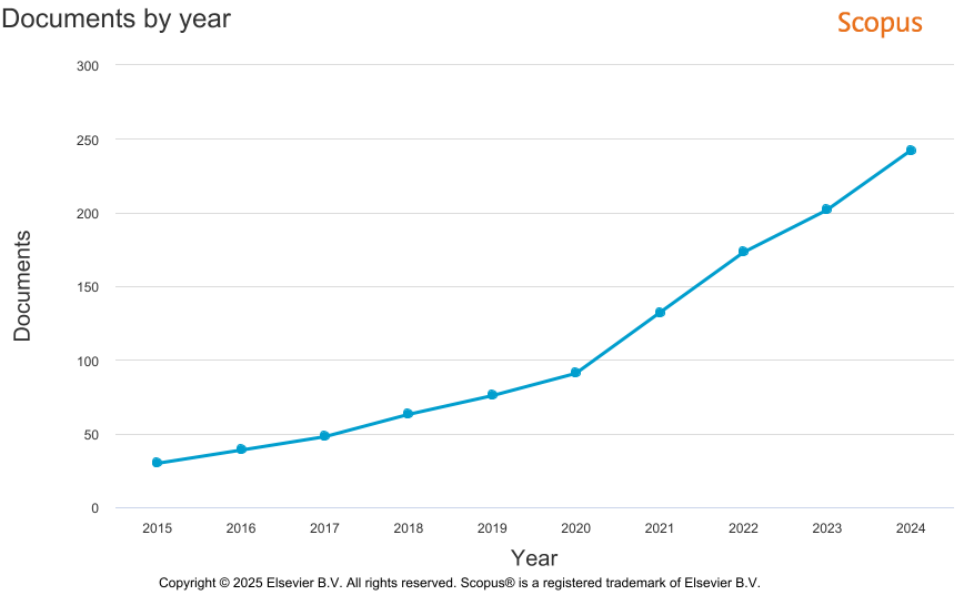


**Figure 2: Annual Scientific Publications On The Fuzzy Delphi Method (2015-2024)**
Source: Adapted from Scopus Database, accessed on 27th June 2025 (https://www.scopus.com)

**Table 3: Number Of Publications Per Year On The Fuzzy Delphi Method (2015-2024)**

| Year | No. of Article | Percentage |
|---|---|---|
| 2024 | 242 | 22.1% |
| 2023 | 202 | 18.4% |
| 2022 | 173 | 15.8% |
| 2021 | 132 | 12.0% |
| 2020 | 91 | 8.3% |
| 2019 | 76 | 6.9% |
| 2018 | 63 | 5.7% |
| 2017 | 48 | 4.4% |
| 2016 | 39 | 3.6% |
| 2015 | 30 | 2.7% |

Source: Data retrieved from Scopus Database (https://www.scopus.com), accessed on 27th June 2025

The annual publication trend from 2015 to 2024 shows a consistent and significant increase in research output related to the Fuzzy Delphi Method. Starting with only 30 articles in 2015, the number of publications has grown more than eightfold by 2024, which recorded the highest output at 242 articles, accounting for 22.1% of the total dataset. This upward trajectory highlights growing interest and acceptance of the Fuzzy Delphi Method in academic and applied research fields over the past decade. Notably, there is a sharp increase between 2020 and 2024, suggesting a post-pandemic boost in scholarly activity and a possible shift towards structured expert consensus methods in response to complex decision-making environments.

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The data also reveals that over 66% of the publications were produced in the last four years (2021-2024), indicating an accelerating trend and a maturing research landscape. Earlier years such as 2015 to 2017 contributed relatively few publications, with each year accounting for less than 5% of the total. This pattern suggests that the Fuzzy Delphi Method has transitioned from a niche methodology to a more mainstream research tool, increasingly utilized across various disciplines. The continued rise in publication numbers may also reflect advancements in computational tools and the integration of FDM with other hybrid decision-making methods, contributing to its growing popularity and application.

***Which Subject Areas Contribute Most to Fuzzy Delphi Method Research?***

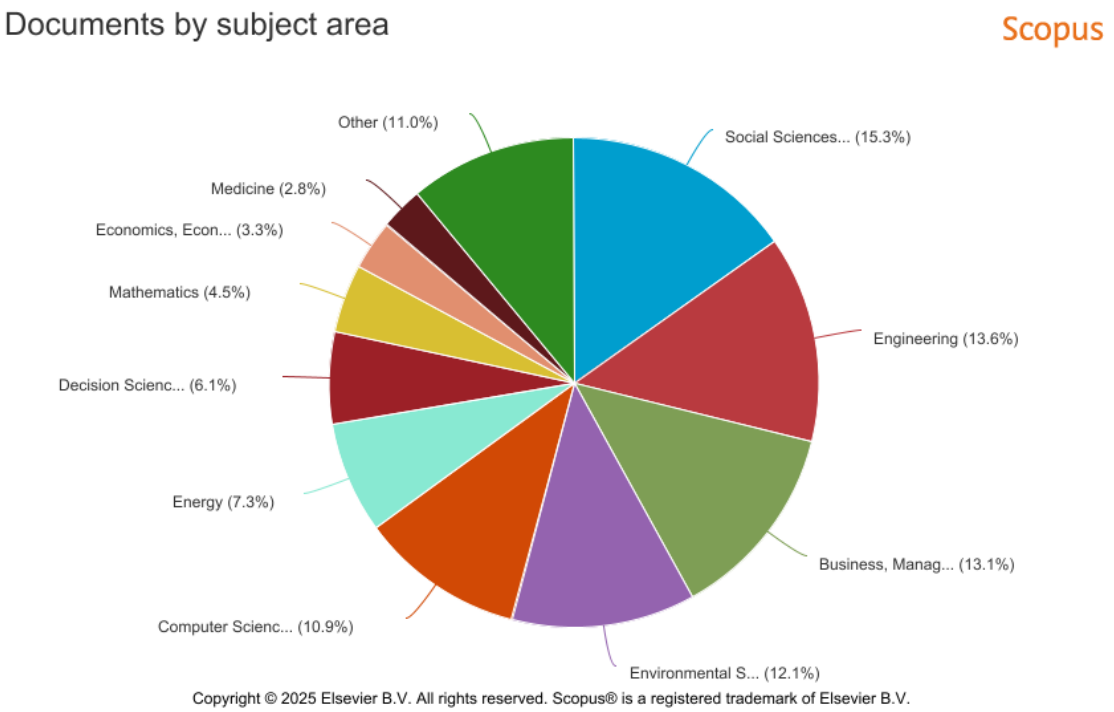


**Figure 3: Distribution of Fuzzy Delphi Method publications by subject area (2015-2024)**
Source: Adapted from Scopus Database, accessed on 27th June 2025 (https://www.scopus.com)

**Table 4: Top Subject Areas For Fuzzy Delphi Method Publications (2015-2024)**

| Subject Area | Number of Article | Percentage |
|---|---|---|
| Social Sciences | 371 | 15.3% |
| Engineering | 331 | 13.6% |
| Business, Management and Accounting | 317 | 13.1% |
| Environmental Science | 295 | 12.1% |
| Computer Science | 264 | 10.9% |
| Energy | 178 | 7.3% |
| Decision Sciences | 147 | 6.1% |
| Mathematics | 110 | 4.5% |
| Economics, Econometrics and Finance | 79 | 3.3% |
| Medicine | 69 | 2.8% |

Source: Data retrieved from Scopus Database (https://www.scopus.com), accessed on 27th June 2025

International Journal of Modern Education
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The analysis of subject areas reveals that the Fuzzy Delphi Method (FDM) has been widely applied across a diverse range of disciplines, with a particularly strong presence in the social sciences, which lead with 371 articles (15.3%). This indicates the method's significant role in areas involving expert consensus, policy development, and qualitative decision-making. Following closely are engineering (13.6%) and business, management and accounting (13.1%), highlighting FDM's growing utility in technical assessments, strategic planning, and organizational research. These three domains alone account for over 40% of the total publications, showing the method's versatility in both theoretical and applied contexts.

The distribution also reflects the interdisciplinary nature of FDM. Fields such as environmental science (12.1%), computer science (10.9%), and energy (7.3%) demonstrate that FDM is increasingly integrated into sustainability-related research, technological development, and complex systems evaluation. Meanwhile, areas like decision sciences, mathematics, and economics collectively contribute to a foundational understanding of decision-making models and quantitative reasoning. Although medicine has a smaller share (2.8%), its presence suggests emerging interest in using FDM for expert-driven clinical evaluations or health policy formulation. Overall, the data underscores FDM's broad applicability across both social and technical disciplines, with increasing adoption in fields requiring structured expert judgment.

***What Are the Top 10 Most Cited Articles Related to the Fuzzy Delphi Method?***

**Table 5: The Top 10 Most Cited Articles in Arabic Language Research**

| Authors | Title | Year | Source title | Cited by |
|---|---|---|---|---|
| Bouzon M. et al. (Bouzon et al. 2016) | Identification and analysis of reverse logistics barriers using fuzzy Delphi method and AHP | 2016 | Resources, Conservation and Recycling | 332 |
| Kannan D. (Kannan 2018) | Role of multiple stakeholders and the critical success factor theory for the sustainable supplier selection process | 2018 | International Journal of Production Economics | 302 |
| Tseng M.-L. et al. (Tseng et al. 2021) | Sustainable industrial and operation engineering trends and challenges Toward Industry 4.0: a data driven analysis | 2021 | Journal of Industrial and Production Engineering | 283 |
| Bui T.D. et al. (Bui et al. 2020) | Identifying sustainable solid waste management barriers in practice using the fuzzy Delphi method | 2020 | Resources, Conservation and Recycling | 232 |
| Tseng M. et al. (Tseng, Lim, and Wong 2015) | Sustainable supply chain management: A closed-loop network hierarchical approach | 2015 | Industrial Management and Data Systems | 200 |
| Lee T.H. et al. (Lee and Hsieh 2016) | Indicators of sustainable tourism: A case study from a Taiwan's wetland | 2016 | Ecological Indicators | 193 |
| Sindhwani R. et al. | Can industry 5.0 revolutionize the wave of resilience and social value | 2022 | Technology in Society | 188 |

International Journal of Modern Education
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IJMOE
Volume 7 Issue 26 (September 2025) PP. 352-368
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| | | | | |
|---|---|---|---|---|
| (Sindhwani et al. 2022) | creation? A multi-criteria framework to analyze enablers | | | |
| Hsu C.-H. et al. (Hsu, Chang, and Luo 2017) | Identifying key performance factors for sustainability development of SMEs - integrating QFD and fuzzy MADM methods | 2017 | Journal of Cleaner Production | 178 |
| Ikram M. et al. (Ikram et al. 2021) | Assessing green technology indicators for cleaner production and sustainable investments in a developing country context | 2021 | Journal of Cleaner Production | 172 |
| Kamali M. et al. (Kamali et al. 2019) | Sustainability criteria for assessing nanotechnology applicability in industrial wastewater treatment: Current status and future outlook | 2019 | Environment International | 171 |

Source: Data retrieved from Scopus Database (https://www.scopus.com), accessed on 27th June 2025

The top 10 most cited articles in Fuzzy Delphi Method (FDM) research between 2015 and 2024 highlight the method's widespread application in sustainability-related fields. The most cited article, by Bouzon et al. (2016), received 332 citations for its use of FDM and AHP to analyse reverse logistics barriers, indicating strong relevance in environmental and operational research. Similarly, Kannan (2018) and Tseng et al. (2021) explored sustainable supply chain and industrial engineering challenges, with 302 and 283 citations respectively. These highly cited works suggest that the integration of FDM with other decision-making methods, such as AHP, MADM, and QFD has been a key trend in producing impactful research.

Moreover, most of the highly cited papers appeared in top-tier journals such as Resources, Conservation and Recycling, Journal of Cleaner Production, and International Journal of Production Economics, reflecting the high academic value and visibility of FDM-related studies in sustainability, production, and environmental fields. Authors like Tseng M.-L. and Ikram M. appear multiple times, indicating their influence in this research area. The consistent presence of themes such as green technology, waste management, sustainable tourism, and Industry 4.0 further emphasizes the method's practical contribution to real-world decision-making in complex, multi-stakeholder environments. This citation pattern demonstrates the Fuzzy Delphi Method's credibility and growing influence in multidisciplinary sustainability research.

International Journal of Modern Education
EISSN: 2637-0905
IJMOE
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***Which Countries Have Contributed the Most Publications on the Fuzzy Delphi Method?***

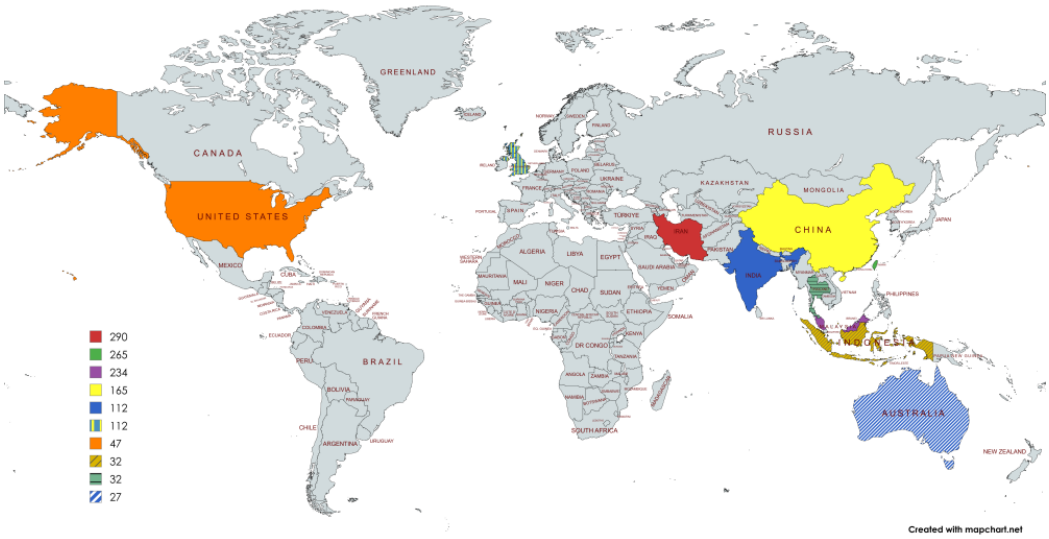


**Figure 4: Top 10 Countries By Number Of Publications On The Fuzzy Delphi Method (2015-2024)**

Source: Constructed by MapChart.Net based on Data from Scopus Database (https://www.scopus.com), Accessed on 27th June 2025

**Table 6: Country-Wise Publication Output On The Fuzzy Delphi Method (2015-2024)**

| Country/Territory | Number of Article | Percentage |
|---|---|---|
| Iran | 290 | 16.2% |
| Taiwan | 265 | 14.8% |
| Malaysia | 234 | 13.1% |
| China | 165 | 9.2% |
| India | 112 | 6.3% |
| United Kingdom | 112 | 6.3% |
| United States | 47 | 2.6% |
| Indonesia | 32 | 1.8% |
| Thailand | 32 | 1.8% |
| Australia | 27 | 1.5% |

Source: Data retrieved from Scopus Database (https://www.scopus.com), accessed on 27th June 2025

The country-level analysis reveals that Iran leads in Fuzzy Delphi Method (FDM) research with 290 publications, representing 16.2% of the total output from 2015 to 2024. This is closely followed by Taiwan with 265 articles (14.8%) and Malaysia with 234 articles (13.1%). The strong presence of these three countries indicates a regional concentration of FDM-related research in Asia, particularly in countries where structured decision-making methods are increasingly applied in fields like sustainability, supply chain, and policy planning. Their dominance also reflects active academic communities and governmental support for research in these areas.

China, India, and the United Kingdom follow with moderate contributions ranging from 6.3% to 9.2%, showing a balanced global interest. Interestingly, Western countries such as the United States, Australia, and United Kingdom have relatively lower output compared to their Asian

International Journal of Modern Education
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counterparts, suggesting that FDM research may be more prevalent or prioritized in the Asia-Pacific region. The smaller yet notable contributions from Indonesia and Thailand show growing regional engagement. Overall, the data demonstrates that FDM is gaining significant traction in developing and emerging economies, where expert-based, structured decision frameworks are valuable for navigating complex development challenges.

***What Are the Most Frequently Used Keywords in Fuzzy Delphi Method Publications From 2015 To 2024?***

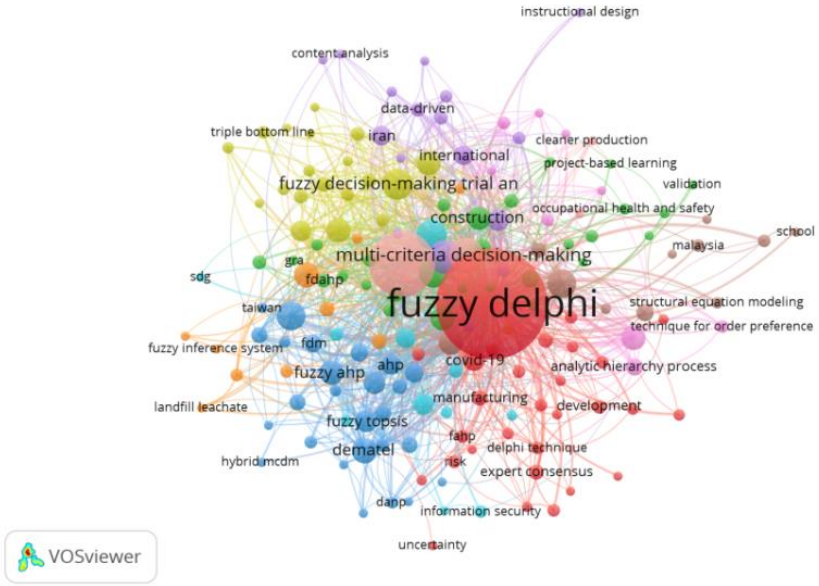


**Figure 5: Keyword Co-Occurrence Map In Fuzzy Delphi Method Publications (2015-2024)**

Source: Authors' Analysis using VOSviewer based on data retrieved from Scopus Database (https://www.scopus.com), accessed on 27th June 2025

**Table 7: Most Frequently Occurring Keywords In Fuzzy Delphi Method Publications (2015-2024)**

| Keyword | Occurrences | Total Link Strength |
|---|---|---|
| Fuzzy Delphi | 594 | 1107 |
| Sustainability | 210 | 490 |
| Multi-Criteria Decision-Making | 60 | 154 |
| Industry 4.0 | 54 | 121 |
| Fuzzy Decision-Making Trial And Evaluation Laboratory | 47 | 119 |
| Fuzzy Dematel | 45 | 124 |
| Fuzzy Analytic Hierarchy Process | 42 | 84 |
| Decision Making | 40 | 104 |
| Interpretive Structural Modeling | 40 | 97 |
| Environment | 33 | 78 |

Source: Data retrieved from Scopus Database (https://www.scopus.com), accessed on 27th June 2025

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The analysis of keywords from Fuzzy Delphi Method (FDM) publications between 2015 and 2024 indicates that "fuzzy delphi" is the most prominent term, with 594 occurrences and a total link strength of 1107, highlighting its central role in research within this period. This prominence signifies the continued relevance and widespread adoption of the FDM approach across various studies. Closely related keywords such as "sustainability" (210 occurrences, link strength 490) and "multi-criteria decision-making" (60 occurrences, link strength 154) suggest that FDM is frequently employed to tackle complex decision problems in environmental and sustainable development contexts. The high link strength associated with these keywords indicates their strong interconnectedness with other concepts, reflecting an integrated research landscape focused on applying fuzzy decision techniques to real-world issues.

Further, terms like "industry 4.0" (54 occurrences, 121 link strength), "fuzzy decision-making trial and evaluation laboratory" (47 occurrences, 119 link strength), and "fuzzy dematel" (45 occurrences, 124 link strength) reveal an expanding interest in leveraging advanced fuzzy methodologies within technological and industrial domains. The presence of "fuzzy analytic hierarchy process" (42 occurrences, 84 link strength) and "interpretive structural modeling" (40 occurrences, 97 link strength) underscores the methodological diversity and sophistication of research efforts aimed at improving decision-making frameworks. Overall, the keywords reflect a vibrant research landscape characterized by a focus on sustainability, technological applications, and methodological advancements in fuzzy decision-making over the past decade.

***What Does the Co-Authorship Network Reveal About International Collaboration In Fuzzy Delphi Method Research?***

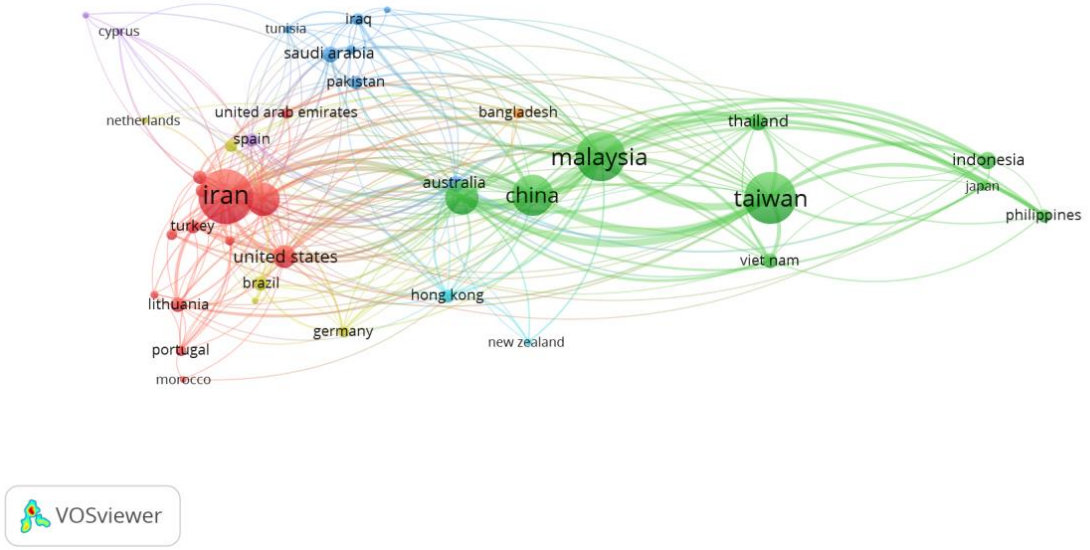


**Figure 6: International Co-Authorship Network On Fuzzy Delphi Method Research (2015-2024)**

Source: Authors' Analysis using VOSviewer based on data retrieved from Scopus Database (https://www.scopus.com), accessed on 27th June 2025

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**Table 8: Country Collaboration Matrix In Fuzzy Delphi Method Publications (2015-2024)**

| Country | Documents | Citations | Total Link Strength |
|---|---|---|---|
| Iran | 291 | 3211 | 146 |
| Taiwan | 265 | 6552 | 255 |
| Malaysia | 234 | 4372 | 254 |
| China | 165 | 4665 | 204 |
| India | 112 | 2993 | 90 |
| United Kingdom | 112 | 4164 | 260 |
| United States | 50 | 1345 | 68 |
| Indonesia | 32 | 274 | 46 |
| Thailand | 32 | 301 | 51 |
| Australia | 27 | 616 | 68 |

Source: Data retrieved from Scopus Database (https://www.scopus.com), accessed on 27th June 2025

The co-authorship network reveals a vibrant landscape of international collaboration in Fuzzy Delphi Method (FDM) research, with notable contributions from several countries. Taiwan leads both in the number of documents (265) and total link strength (255), suggesting it plays a central role in fostering collaborations and knowledge exchange within the research community. Malaysia and China also demonstrate significant engagement, with 234 and 165 documents respectively, and high link strengths (254 and 204), indicating strong collaborative ties, particularly within Asia. Iran, despite having the highest number of documents (291), has a relatively lower total link strength (146), which may suggest a more domestically focused research output or less extensive international collaborations compared to other top countries.

The network further highlights substantial collaboration among Western countries, with the United Kingdom and the United States showing high link strengths of 260 and 68, respectively, highlighting their involvement in global research efforts. The United Kingdom's relatively high link strength indicates extensive international partnerships, possibly bridging collaborations across different regions. Australia, Indonesia, and Thailand, while having fewer documents, still maintain active links, signifying their participation in the broader global research network. Overall, the co-authorship network underscores a geographically diverse and interconnected research landscape, with Asia and Europe playing prominent roles, and a clear trend toward international collaboration that enhances the development and dissemination of Fuzzy Delphi Method research worldwide.

## Conclusion

This study was conducted to examine the research trends and scientific landscape of the Fuzzy Delphi Method (FDM) from 2015 to 2024 through a bibliometric analysis. The main objectives included identifying annual publication growth, mapping subject area contributions, analyzing the most cited works, exploring keyword patterns, and evaluating international research collaboration through co-authorship networks. These questions aimed to provide a comprehensive understanding of how FDM research has evolved over the past decade.

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The findings reveal a substantial and consistent increase in publication output, particularly after 2020, indicating a rising interest in the method. Social sciences, engineering, and business emerged as dominant subject areas, reflecting the method's cross-disciplinary relevance. Highly cited publications show that FDM is often integrated with other decision-making models, especially within sustainability and industrial contexts. Keyword analysis identified sustainability, decision-making, and technological integration as core research themes, while co-authorship mapping highlighted the strong presence of Asian countries in FDM research, with Taiwan, Malaysia, and Iran being among the most active contributors.

This analysis contributes to the broader understanding of FDM's position within academic research by identifying its growth patterns, thematic focus, and collaborative networks. The insights provided help extend the existing literature by offering an updated overview of FDM's evolution and its adoption across diverse domains. These findings may guide researchers and practitioners in recognizing the strategic value of FDM and its potential for addressing complex, uncertain decision environments.

The results carry practical implications by indicating where the method is most applied and where future integration may be beneficial, especially in areas such as sustainability planning, technology adoption, and strategic evaluation. However, the study is limited to a single database (Scopus) and includes only journal articles, which may exclude other relevant outputs such as conference papers or grey literature. Future research could expand the scope by incorporating multiple databases and exploring longitudinal comparisons with related methods.

In conclusion, this bibliometric study provides a structured overview of the Fuzzy Delphi Method's research development over a ten-year period. It highlights emerging themes, leading contributors, and collaboration patterns, offering a foundation for future investigations. The significance of bibliometric analysis in understanding methodological trends is reaffirmed, serving as a valuable tool for identifying research gaps and informing strategic academic planning.

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