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Mapping Research Trends of Entropy-Based Weighting and AHP Integration in Multi-Criteria Decision Analysis for Sustainable Development Applications

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Abstract−The integration of entropy-based weighting and the Analytic Hierarchy Process (AHP) has become an increasingly important strategy for balancing objective and subjective criterion weights in multi-criteria decision-making (MCDM), yet the intellectual structure of this hybrid field remains fragmented and insufficiently mapped. This study aims to systematically chart the global research landscape of entropy-AHP integration in MCDM and to identify its leading contributors, foundational works, and dominant thematic structures. A bibliometric research design guided by the PRISMA protocol was adopted, drawing on 160 English-language documents retrieved from the Scopus database for the period 2001 to 2025. The data were analysed using VOSviewer and Scopus analytical tools to examine annual publication trends, subject-area distribution, leading sources, co-citation networks, and keyword co-occurrence patterns. The results reveal a field that has accelerated sharply since 2021, reaching a peak of thirty-four documents in 2025, with output concentrated in Engineering and Computer Science and disseminated through a diverse ecosystem of energy-oriented journals and conference outlets. Co-citation analysis confirms a theoretical base anchored in the canonical works of Saaty and Zeleny, while keyword mapping shows entropy functioning as a conceptual bridge between expert judgment and data-driven weighting, with TOPSIS emerging as a salient companion technique. The novelty of this study lies in its focused mapping of the entropy–AHP intersection rather than MCDM in general, exposing a loosely integrated thematic structure and a reliance on a narrow citation canon. Its principal contribution is a consolidated knowledge map that clarifies the field's foundations and directs future methodological and interdisciplinary innovation.

Keywords: Multi-Criteria Decision-Making; Analytic Hierarchy Process; Entropy Weighting; Bibliometric Analysis; Science Mapping

1. INTRODUCTION

Global development in the contemporary era is increasingly characterized by complex decision environments that involve interdependent economic, environmental, and social considerations in sustainability planning [1]. The acceleration of industrialization and technological transformation has intensified the need for structured decision-support systems capable of handling multidimensional criteria under uncertainty [2]. In many real-world problems, decision-makers are required to evaluate conflicting alternatives where information is incomplete, dynamic, and often ambiguous in nature [3]. Traditional single-criterion decision approaches are therefore no longer sufficient to address the complexity of modern sustainability challenges [4]. This condition has led to the widespread adoption of Multi-Criteria Decision Analysis (MCDA) or Multi-Criteria Decision Making (MCDM) as a robust analytical framework in operations research and engineering applications [5]. MCDA enables systematic evaluation of alternatives by integrating both quantitative and qualitative factors within a structured decision model [6] . Its flexibility allows application across various domains such as energy systems, environmental management, and infrastructure planning [7]. The increasing global emphasis on sustainable development goals has further strengthened the role of MCDA in supporting policy formulation and strategic decision-making processes [8]. Consequently, MCDA has become a foundational approach in addressing the complexity of sustainability-oriented decision problems worldwide [9].

Within the MCDA framework, the Analytic Hierarchy Process (AHP) has become one of the most widely applied techniques due to its ability to structure complex decision problems into hierarchical levels[10]. AHP facilitates expert judgment through systematic pairwise comparisons, enabling decision-makers to quantify qualitative preferences in a consistent manner [11]. Despite its strengths, AHP is often criticized for its reliance on subjective judgments, which may introduce inconsistency and bias in decision outcomes [3]. To overcome this limitation, entropy weighting methods have been developed as objective alternatives that determine criterion weights based on data variability and information dispersion [12]. Unlike AHP, entropy does not depend on expert opinion, making it suitable for data-driven decision environments [13]. The integration of AHP and entropy has therefore emerged as a powerful hybrid approach that balances subjectivity and objectivity in MCDA applications [6]. This combination enhances decision robustness by leveraging expert knowledge alongside statistical information derived from datasets [14]. Recent empirical studies confirm that AHP-entropy hybrid models are increasingly applied in energy planning, environmental assessment, and

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engineering optimization problems. As a result, hybrid MCDA methodologies have become a dominant trend in contemporary decision science research [15].

The rapid expansion of MCDA-related publications over the past decade indicates a significant growth in academic interest across multiple scientific disciplines [7]. Research evidence shows that MCDA applications are particularly concentrated in sustainability science, environmental engineering, and energy systems optimization [8]. Bibliometric techniques such as co-citation analysis, keyword mapping, and network visualization have been widely employed to explore the intellectual structure of MCDA or MCDM research [9] [16]. However, most existing bibliometric studies treat MCDA as a general methodological category without focusing on specific hybrid integrations [4]. This limitation restricts deeper understanding of how methodological combinations such as entropy and AHP evolve within the broader MCDA domain [11]. Furthermore, previous studies often fail to capture the dynamic evolution of research themes and collaboration structures across global research networks [3]. Evidence also suggests that MCDA research is geographically concentrated in a limited number of countries, leading to uneven knowledge production patterns [1]. In addition, citation network structures reveal strong intellectual linkages among sustainability-oriented decision-making studies, indicating the presence of influential research clusters [2]. Therefore, a focused bibliometric investigation is required to systematically map the integration of entropy and AHP within MCDA literature [6].

Entropy-based weighting methods have gained increasing attention due to their ability to provide objective criterion weights based on statistical information contained in datasets [12]. In contrast, AHP remains widely used in decision-making contexts because of its simplicity and strong interpretability in expert-based evaluation [17]. The combination of these two approaches has been extensively applied in sustainability-related decision problems to improve model reliability and validity [6]. For instance, hybrid AHP-entropy frameworks have been successfully implemented in waste management, environmental sustainability assessment, and resource optimization studies [14]. In renewable energy planning, such hybrid models have demonstrated superior performance in evaluating alternative energy systems under multiple conflicting criteria. Similarly, infrastructure and engineering studies have shown that integrating entropy and AHP improves decision accuracy compared to single-method approaches [4]. Recent advancements further incorporate fuzzy logic and artificial intelligence techniques to enhance the capability of hybrid MCDA models in handling uncertainty [15]. Nevertheless, methodological fragmentation across different application domains still exists, limiting the consolidation of knowledge in this research area [11]. Therefore, a systematic bibliometric synthesis is essential to provide a comprehensive overview of research trends and developments in this field [8].

Although research on MCDA integrating AHP and entropy weighting has experienced rapid growth, the intellectual structure of this field remains fragmented and not yet fully consolidated [9]. Existing studies tend to emphasize application-based contributions rather than providing a holistic understanding of global research dynamics and knowledge evolution [7]. Furthermore, there is a lack of comprehensive bibliometric analyses that simultaneously examine publication trends, collaboration networks, and thematic structures within this domain [4]. Previous research has also limited its focus to isolated methodological aspects without exploring the co-evolution of entropy and AHP within MCDA frameworks [11]. This gap prevents researchers from identifying emerging trends and future directions in hybrid decision-making methodologies [3]. In addition, the absence of integrated science mapping restricts understanding of how knowledge clusters develop and interact across different research communities [1]. As a result, there is a strong need for a systematic bibliometric study that comprehensively maps the integration of entropy-based weighting and AHP in MCDA literature [2]. Addressing this gap is crucial for advancing theoretical understanding and guiding future research development in decision science [18].

This study aims to systematically map global research trends related to entropy-based weighting and AHP integration within the MCDA domain [4]. It seeks to identify publication performance, influential authors, leading journals, and dominant countries contributing to this research area [11]. The study further analyzes co-authorship networks, keyword co-occurrence patterns, and thematic evolution using advanced bibliometric techniques [9]. In addition, it aims to uncover the intellectual structure and emerging research clusters within sustainability-oriented decision-making studies [12]. The scientific contribution of this research lies in providing a comprehensive knowledge map of hybrid MCDA development at a global scale [17]. It also contributes theoretically by clarifying the complementary roles of subjective and objective weighting approaches in decision science [6]. Practically, the findings are expected to assist researchers and policymakers in identifying future research opportunities in sustainable decision-making systems [14]. Moreover, this study enhances methodological transparency in bibliometric research on MCDA literature. Ultimately, it provides a strong foundation for future innovation in entropy-AHP integrated decision-making models [8].

2. RESEARCH METDHOLOGY

The present study uses a bibliometric research design based on a systematic literature review approach to map the intellectual structure of MCDA research. The analysis concerns the combination of entropy-based weighting and the Analytic Hierarchy Process (AHP) in multi-criteria decision-making studies for sustainable development applications. The methodological framework follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol for transparency and reproducibility. Bibliometric analysis is used for identification of publicaton patterns, research trends and scientific collaboration structures in the selected domain. The flow of general research is illustrated in Figure 1, which represents the PRISMA flow diagram for the study identification, screening, and inclusion

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process. This structured approach allows for systematic reduction of the literature from database extraction to the final preparation of the dataset for analysis.

The primary source of data for the literature search was the Scopus database, as it includes a wide range of peer-reviewed scientific publications. The search strategy involved a structured keyword query to retrieve studies related to multi-criteria decision making, entropy and AHP methodologies. The search string in Scopus was: TITLE-ABS-KEY (mcdm) AND TITLE-ABS-KEY (entropy) AND TITLE-ABS-KEY (ahp) AND (LIMIT-TO (LANGUAGE , "English")). This query was designed to ensure high relevance, but also keeping the dataset focused on the research objectives. Only publications in English language were searched to maintain consistency in the analysis and interpretation of the text. The steps of the search process and filtering criteria are summarized in Figure 1 in the part of the identification phase of PRISMA.

In the identification stage of the PRISMA framework, a total of 161 records were retrieved from the Scopus database on the basis of the predefined search query. Registry sources records were also included in the dataset. The total number of documents before screening was 161. In the first extraction process, no duplicate records were identified, ensuring the uniqueness of the dataset at the identification level. Nor were any records excluded due to technical reasons such as automation filtering. The search was conducted in the publication period of 2001 to 2025, to ensure a comprehensive temporal coverage of the research domain. This identification process is shown in Figure 1, which shows the initial retrieval of records in the PRISMA flow diagram.

All 161 records identified were screened for the relevance and inclusion criteria during the screening phase. One record was excluded because of language restriction (published in Spanish rather than in English). Therefore, after screening, 160 records remained eligible for further analysis. The eligibility assessment was limited to peer-reviewed English language documents in the final dataset. This step was important to maintain the methodological consistency and the reliability of the bibliometric outputs. Figure 1 clearly illustrates the screening and exclusion process, showing the reduction of records from identification to final inclusion.

In this study, the bibliometric analysis was done by VOSviewer software and Scopus analytical tools for comprehensive scientific mapping. The dataset was analyzed using VOSviewer to construct and visualize co-occurrence networks, co-authorships and keyword clustering maps. Furthermore, Scopus Analysis Tools were employed to analyze publication trends over time, subject area distribution and citation-based performance indicators. The analysis was specifically focused on the publications yearly trends, publications distribution by subject area, top sources, top documents, and networks of keyword co-occurrence. The analytic outputs provide a comprehensive understanding of the development and structure of research in the MCDA domain including entropy and AHP. Figure 1 summarizes the general analytical workflow and stages of processing of the dataset with the complete PRISMA process from identification to analysis preparation.

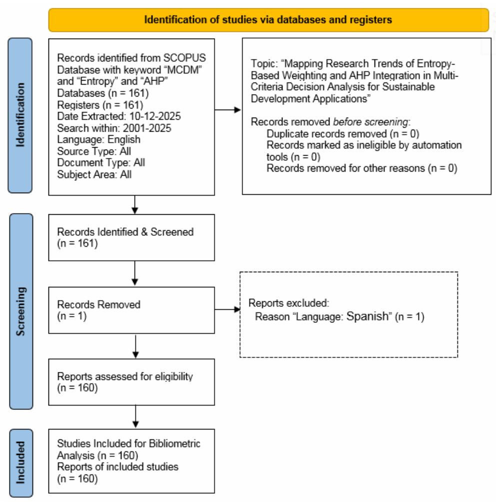

Figure 1. PRISMA flow diagram

3. RESULT AND DISCUSSION

3.1 Meta Analisis

3.1.1 Publication Trend by Year

The temporal distribution of scientific output offers one of the most direct indicators of how a research field matures, gains legitimacy, and attracts sustained scholarly attention. Examining the number of documents produced in each year makes it possible to trace the rhythm of intellectual activity surrounding the integration of entropy-based weighting and the Analytic Hierarchy Process within multi-criteria decision-making. Across the retrieved corpus of 160 documents, scholarly production spans a twenty-five-year window from 2001 to 2025, which provides sufficient temporal depth to observe both the emergence and the consolidation of the field. Figure 2 presents the annual publication count for this period, allowing the underlying growth pattern to be read at a glance. The visualization reveals a trajectory that begins modestly, with only a single document recorded in 2001, and culminates in a pronounced surge during the most recent years. Rather than expanding in a smooth linear fashion, the field appears to have evolved through several distinct developmental stages separated by periods of relative stability. The earlier portion of the timeline is marked by sporadic and low-volume activity, suggesting that the methodological combination remained a niche concern among a limited circle of researchers. The later portion, by contrast, displays a steep upward gradient that signals a clear movement toward mainstream adoption. Interpreting these dynamics therefore requires distinguishing the formative years from the acceleration phase, since each reflects a different set of drivers behind the growth shown in Figure 2.

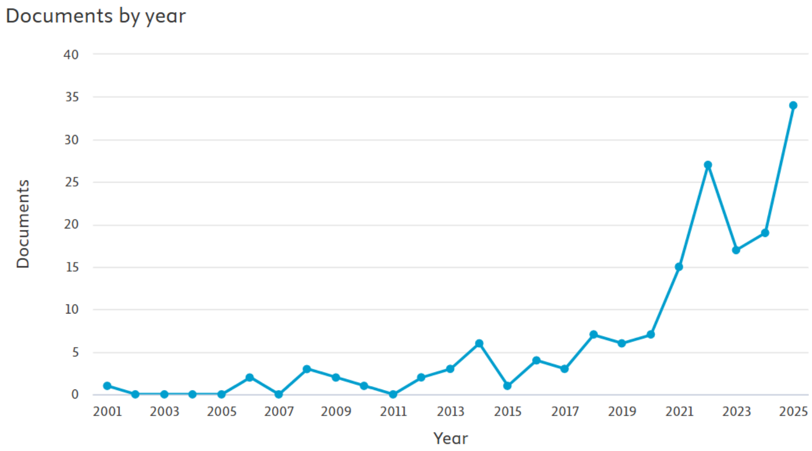

Figure 2. Annual distribution of publications on entropy–AHP integration in MCDM (2001–2025)

A closer reading of Figure 2 indicates that the field passed through three identifiable phases of development between 2001 and 2025. The first phase, extending roughly from 2001 to 2017, can be described as a nascent and intermittent stage, during which annual output rarely exceeded six documents and several years registered little or no activity at all. This irregular pattern implies that the coupling of entropy weighting with AHP was, at that time, an exploratory idea applied only occasionally and without a coherent research community behind it. A second, transitional phase becomes visible between 2018 and 2020, when annual production stabilized at around six to seven documents per year and hinted at the gradual formation of a more consistent scholarly base. The third and most striking phase unfolds from 2021 onward, where the curve climbs sharply from fifteen documents in 2021 to twenty-seven in 2022, marking the onset of a rapid expansion. Although a temporary contraction to seventeen documents occurred in 2023, the field quickly regained momentum, rising to nineteen documents in 2024 and reaching its highest recorded level of thirty-four documents in 2025. This rebound suggests that the brief decline reflected ordinary year-to-year fluctuation rather than any genuine loss of interest in the topic. The accelerating momentum observed after 2020 is plausibly driven by the growing demand for objective and data-driven weighting techniques, the increasing complexity of energy- and sustainability-related decision problems, and the rising popularity of hybrid and fuzzy extensions that combine AHP with entropy and complementary ranking methods. The wider availability of decision-support software and open datasets has likewise lowered the barrier to applying these approaches across diverse application domains, as reflected in the upward slope at the right-hand end of Figure 2. Taken together, the pattern displayed in Figure 2 portrays a field that has moved decisively from the margins toward the mainstream of decision-science research, and should the prevailing trajectory persist, annual output is expected to continue its upward course, with hybrid entropy–AHP frameworks likely to diversify further into emerging areas such as artificial-intelligence-assisted decision-making and large-scale sustainability assessment.

3.1.2 Publication by Subject Area

Beyond the temporal dimension, the disciplinary composition of a corpus reveals where a methodological approach finds its most fertile ground and how widely its relevance extends across the scientific landscape. Mapping the distribution of documents across subject areas therefore helps clarify whether the integration of entropy weighting and AHP is confined to a single discipline or, instead, functions as a cross-cutting analytical tool. Within the present corpus, Scopus classifies the retrieved documents into a broad spectrum of fields, and the resulting proportions are summarized in Figure 3. The distribution shown there is notably uneven, with a small number of technical disciplines accounting for the majority of scholarly output. Engineering emerges as the single most prominent field, representing 24.4 percent of all documents and confirming that decision problems involving multiple conflicting criteria are deeply rooted in engineering practice. Computer Science follows closely at 18.5 percent, which reflects the computational nature of weighting algorithms, ranking procedures, and the software implementations that operationalize hybrid MCDM models. Environmental Science contributes 8.2 percent, while Energy accounts for 7.6 percent, signalling that resource allocation and sustainability-oriented evaluation problems form an important application context. Mathematics, at 7.1 percent, underlines the formal and quantitative foundations on which both entropy measures and the pairwise-comparison logic of AHP are built. Read collectively, the leading shares in Figure 3 suggest that the field is anchored in technically intensive disciplines while still maintaining visible connections to environmental and managerial concerns.

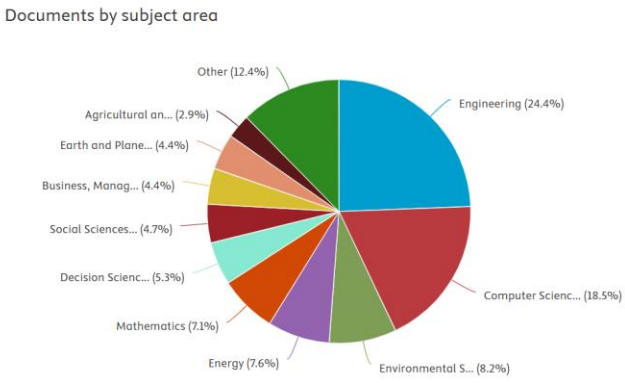

Figure 3. Distribution of publications by subject area

A more detailed inspection of Figure 3 highlights the inherently multidisciplinary character of research on entropy–AHP integration, since the remaining documents are dispersed across a wide range of complementary fields. Decision Sciences accounts for 5.3 percent of the output, a share that is conceptually significant because it represents the disciplinary home of multi-criteria decision-making itself and confirms that the methodological core of the field remains actively cultivated. Social Sciences contribute 4.7 percent, while Business, Management and Accounting together with Earth and Planetary Sciences each represent 4.4 percent, indicating that the same weighting and ranking techniques are readily transferred to organizational, strategic, and geoscientific decision contexts. Agricultural and Biological Sciences add a further 2.9 percent, and the residual category labelled "Other" comprises 12.4 percent, which captures the long tail of niche applications scattered across numerous additional disciplines. This dispersion demonstrates that the entropy–AHP combination is not the property of any single domain but rather a portable methodological framework adaptable to heterogeneous problem settings. The dominance of Engineering and Computer Science is academically meaningful because these fields supply both the practical decision problems that demand structured evaluation and the computational machinery required to solve them efficiently. The substantial presence of Environmental Science and Energy, meanwhile, reinforces the growing alignment between hybrid MCDM methods and the evaluation of complex sustainability and resource-management challenges. The coexistence of these technical, environmental, and managerial fields illustrates a productive interdisciplinary convergence in which objective and subjective weighting approaches are jointly mobilized to address real-world decisions. Taken as a whole, the subject-area profile portrayed in Figure 3 positions entropy–AHP integration as a versatile and discipline-spanning methodology whose continued diffusion across emerging fields is likely to deepen its multidisciplinary footprint in the years ahead.

3.1.3 Top Sources and Documents

Identifying the outlets that publish most actively in a given field clarifies where its scholarly conversation is concentrated and which venues shape the diffusion of its core ideas. Figure 4 compares the annual document counts of the leading sources between 2020 and 2025, making the relative momentum of each outlet directly observable.

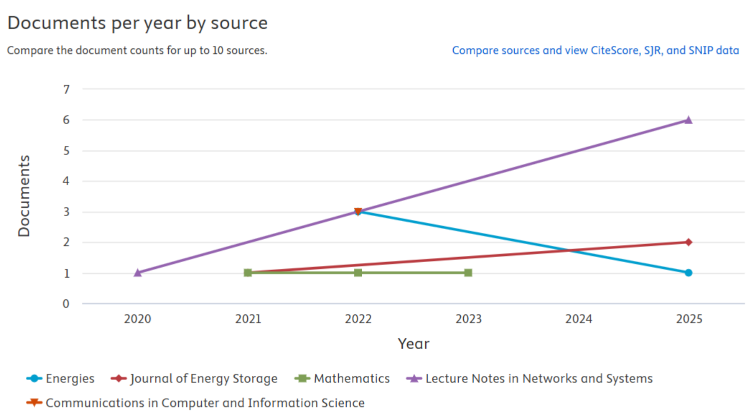

Figure 4. Annual document output of the leading publication sources (2020–2025)

As shown in Figure 4, the publication of research on entropy–AHP integration is distributed across a comparatively wide set of outlets rather than being dominated by a single flagship journal, which is characteristic of an interdisciplinary and still-consolidating field. The most productive source overall is the *Lecture Notes in Networks and Systems* series, which contributes seven documents and displays the steepest upward trajectory in Figure 4, rising to six documents in 2025 alone. Because this series is a conference-based outlet, its prominence indicates that a substantial share of the field's recent activity is being channelled through fast-moving conference venues that favour rapid dissemination of methodological applications. Among peer-reviewed journals, *Energies* leads with four documents, followed by a cluster of established titles—including *Mathematics*, *Journal of Energy Storage*, *Scientific Reports*, *Soft Computing*, and *Sustainability*—each accounting for three documents. The recurring presence of energy-oriented journals such as *Energies* and *Journal of Energy Storage* reinforces the earlier finding that energy and resource-allocation problems constitute a major application context for hybrid weighting methods. At the same time, the appearance of *Mathematics* and *Soft Computing* signals sustained interest in the formal and computational underpinnings of these techniques, while *Scientific Reports* and *Sustainability* extend the field's reach toward broad multidisciplinary and sustainability-focused readerships. The reputational profile of these outlets is generally favourable, as several are well-indexed international journals with solid standing in their respective domains, which lends credibility to the body of work and supports its further circulation. The coexistence of high-throughput conference proceedings alongside reputable journals suggests a dual publication culture in which preliminary and applied contributions are introduced through conferences before more developed studies migrate to archival journals. Taken together, the source distribution portrayed in Figure 4 indicates that the development of entropy–AHP research is driven less by a single dominant venue and more by a diverse ecosystem of technically oriented outlets, a pattern that typically accompanies a field still expanding its disciplinary boundaries.

3.1.4 Co-citation Network

Co-citation analysis examines how frequently pairs of references are cited together across a corpus, thereby revealing the foundational works that collectively define a field's intellectual base. Figure 5 presents the co-citation network generated from the retrieved documents, in which node size reflects citation influence and colour denotes distinct clusters of jointly cited references.

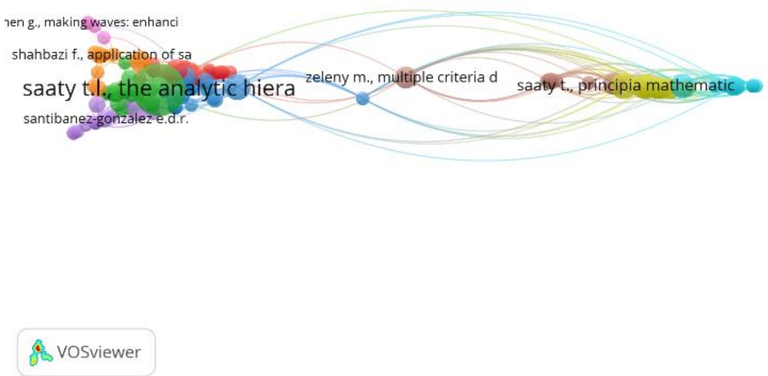

Figure 5. Co-citation network of cited references

The co-citation map displayed in Figure 5 makes clear that the intellectual foundation of entropy–AHP research rests on a relatively small set of seminal contributions that anchor the entire field. The most influential node by a considerable margin is the foundational work of Saaty on the Analytic Hierarchy Process, whose label dominates the central-left region of the network and confirms that the AHP remains the theoretical cornerstone on which the literature is built. A closely related node corresponding to Saaty's later formulation of the analytic logic appears prominently on the right-hand side of the map, indicating that successive refinements of the same methodological lineage continue to be cited together as a coherent canon. The presence of Zeleny's work on multiple-criteria decision-making in the central bridging position is equally significant, since it represents the broader conceptual framework within which the AHP and entropy weighting are situated and connects otherwise separate citation neighbourhoods. Around these core references, several distinct colour-coded clusters can be discerned, each grouping together works that are habitually cited in combination and therefore reflect identifiable streams of theoretical and applied scholarship. The tightly bound cluster surrounding the principal Saaty node suggests a dense methodological core in which foundational and applied studies reinforce one another, whereas the more peripheral nodes—such as those associated with Shahbazi and Santibanez-Gonzalez—represent emerging or specialized lines of inquiry that extend the established base. The spatial separation between the left-hand methodological cluster and the right-hand theoretical node, linked by the bridging reference in the centre, illustrates how the field integrates a foundational decision-theoretic tradition with more recent hybrid and application-driven developments. This structure indicates an intellectual base that is simultaneously concentrated, in that a few canonical works command disproportionate co-citation influence, and diversified, in that multiple satellite clusters elaborate distinct thematic directions. Such a configuration is characteristic of a maturing research domain whose theoretical foundations are firmly settled while its application frontiers continue to expand. Overall, the co-citation

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structure visualized in Figure 5 demonstrates that the scholarly identity of entropy–AHP integration is firmly rooted in the classical decision-theoretic contributions of Saaty and Zeleny, which together supply the conceptual scaffolding upon which contemporary hybrid methodologies are constructed.

3.1.5 Co-Occurrence Network

Keyword co-occurrence analysis maps the terms that authors use together within their publications, thereby exposing the conceptual structure of a field and the thematic relationships that bind its sub-topics. Figure 6 displays the co-occurrence network of author keywords, where node size represents the frequency of each term and colour distinguishes the thematic clusters into which related concepts are grouped.

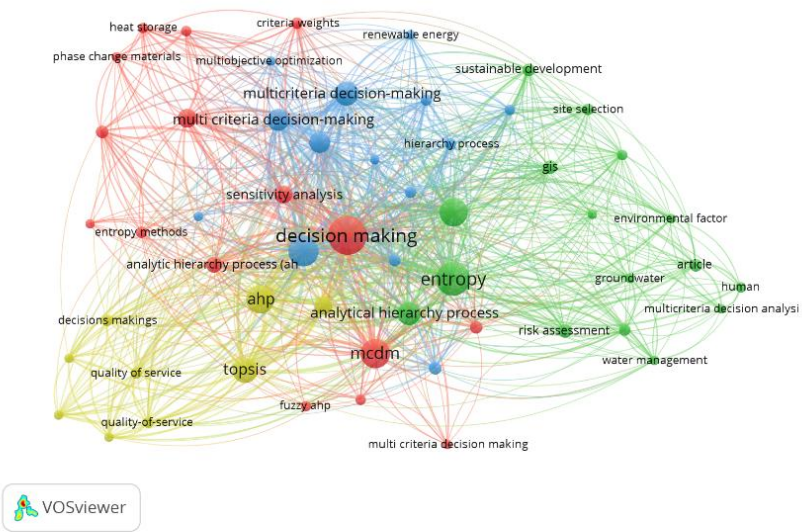

Figure 6. Co-occurrence network of author keywords

The keyword network presented in Figure 6 reveals a densely interconnected conceptual structure organized around a small number of high-frequency anchor terms that collectively define the field. The most influential keywords, indicated by the largest nodes, are "decision making", "entropy", "mcdm", "ahp", and "topsis", which together confirm that the literature is built upon the joint use of objective entropy weighting and subjective pairwise-comparison logic within multi-criteria evaluation. It is analytically important to note that "topsis" appears as one of the dominant terms despite not being emphasized in the field's framing, which signals that ranking procedures such as TOPSIS are integral companions to entropy and AHP rather than peripheral techniques. The network resolves into roughly four thematic clusters, each occupying a distinct region of the map and representing a coherent line of inquiry. The red cluster, centred on "decision making", "ahp", "sensitivity analysis", and "entropy methods", captures the methodological core concerned with weighting, robustness testing, and the mechanics of hybrid evaluation. The yellow cluster, anchored by "mcdm", "topsis", and "quality of service", reflects an applied stream oriented toward ranking and performance assessment, including service- and engineering-related applications. The blue cluster, organized around "multi-criteria decision-making", "criteria weights", and "multiobjective optimization", represents the broader optimization and problem-structuring perspective that situates these methods within formal decision frameworks. The green cluster, encompassing "entropy", "sustainable development", "gis", "site selection", and "risk assessment", denotes a spatial and sustainability-oriented application domain in which entropy weighting supports environmental and location-based decision problems. The bridging position of "entropy" between the methodological and application-oriented clusters is particularly telling, as it demonstrates that entropy weighting functions as the conceptual connective tissue linking abstract decision theory to concrete real-world deployment. Taken together, the thematic configuration portrayed in Figure 6 indicates that the field is structured around a stable methodological nucleus surrounded by application-driven branches, and the prominence of ranking, optimization, and spatial-sustainability themes suggests that future research is likely to deepen the integration of entropy–AHP frameworks with allied ranking methods and geospatial decision-support applications.

3.2 Research Implications and Future Research Directions

From a theoretical standpoint, the patterns across Figures 2 to 6 reshape how entropy–AHP integration should be understood within decision science. The co-citation structure in Figure 5 confirms a stable foundation dominated by the canonical works of Saaty and Zeleny, implying that future conceptual work must engage this lineage rather than treat hybrid weighting as an isolated novelty. The keyword network in Figure 6 further shows that entropy operates as a bridge

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linking subjective expert judgment to objective data-driven weighting, reframing the combination not as competing paradigms but as complementary parts of a single evaluation logic. This complementarity supplies a coherent justification for hybrid models by reconciling the interpretability of expert-based methods with the impartiality of information-theoretic measures. On the practical side, the dominance of Engineering, Computer Science, and Energy in Figure 3, together with the energy-oriented journals in Figure 4, indicates that the most immediate beneficiaries are practitioners engaged in resource allocation, supplier and material selection, and infrastructure planning. The accelerating trajectory in Figure 2 suggests that decision-support tools embedding entropy–AHP logic are becoming increasingly relevant wherever transparent and defensible weighting is required, enhancing the credibility of contested decisions. The prominence of TOPSIS as a companion term in Figure 6 also signals, in practical terms, that entropy–AHP weighting performs best when paired with a robust ranking procedure rather than used alone. Together, these implications position the field as one whose conceptual maturity now provides a solid basis for more deliberate methodological and applied innovation.

The same evidence simultaneously exposes research gaps and opportunities for genuine novelty. The thematic fragmentation visible in Figure 6, where methodological, optimization, ranking, and spatial-sustainability clusters remain loosely integrated, indicates that the field still lacks a unifying framework governing how entropy and AHP weights should be combined and reconciled. The narrow canon in Figure 5 shows limited theoretical diversification beyond the classical AHP tradition, leaving room for principled fuzzy, interval-valued, or probabilistic extensions. The source profile in Figure 4, dominated by a few conference outlets and prolific contributors, also raises the question of whether the observed growth reflects broad scholarly diffusion or the concentrated activity of a few groups. These gaps point to concrete novelty: developing standardized, reproducible protocols for aggregating subjective and objective weights would address the ad hoc hybridization that currently varies across studies. Coupling entropy–AHP frameworks with artificial-intelligence and machine-learning techniques represents an emerging frontier hinted at by the trend in Figure 2 but not yet consolidated as a cluster in Figure 6. Extending these methods into under-represented domains such as healthcare, public policy, and climate adaptation offers further high-value directions. Pursuing them would move future research beyond replicating established applications toward advances the current literature has not yet delivered, so the fragmentation revealed by the maps becomes the clearest signpost toward where original contributions can be made.

These contributions are nonetheless bounded by limitations intrinsic to bibliometric inquiry, which must be stated transparently. The analysis relies on a single database and a deliberately restrictive query, so relevant studies indexed elsewhere or phrased differently may have been excluded, and the resulting corpus of 160 documents is modest by bibliometric standards. This relatively small dataset limits the robustness of the co-citation and co-occurrence structures, which become more sensitive to outliers and threshold choices. Author and affiliation disambiguation poses a further risk, since name-indexing variation can inflate the apparent productivity of particular authors or countries and distort the patterns underlying Figure 4. Including conference proceedings alongside journal articles broadens coverage but introduces heterogeneity in quality and citation behaviour, while citation-based measures inevitably favour older work, leaving the recent studies in the latter years of Figure 2 underrepresented in Figures 5 and 6. The framing also emphasizes entropy and AHP, whereas the keyword evidence reveals the comparable salience of TOPSIS, so the analytical lens may not perfectly mirror the field's true centre of gravity. To mitigate these constraints, future work should integrate multiple databases such as Scopus and Web of Science, apply rigorous disambiguation, and complement frequency-based mapping with longitudinal thematic-evolution and qualitative content analysis of the most influential documents. Addressing these limitations directly would yield a more comprehensive and methodologically resilient account of how entropy–AHP integration continues to evolve.

4. CONCLUSION

This study set out to map the global research landscape on the integration of entropy-based weighting and the Analytic Hierarchy Process within multi-criteria decision-making, and the bibliometric evidence fulfils that aim by revealing a field that has shifted decisively from sporadic early activity to rapid expansion, peaking at thirty-four documents in 2025. The analysis shows that scholarly output is anchored in technically intensive disciplines, led by Engineering and Computer Science, and is disseminated through a diverse ecosystem of energy-oriented journals and conference outlets rather than a single dominant venue. The co-citation structure confirms that the field rests on the canonical foundations of Saaty and Zeleny, while the keyword network demonstrates that entropy operates as a conceptual bridge between subjective expert judgment and objective data-driven weighting, with TOPSIS emerging as a salient companion technique. Theoretically, these findings reframe entropy and AHP as complementary rather than competing components of a unified evaluation logic, and practically they indicate that hybrid weighting enhances the transparency and credibility of decisions in resource allocation, selection, and infrastructure planning. The evidence also exposes a loosely integrated thematic structure and a reliance on a narrow citation canon, signalling that the field still lacks a unifying framework for systematically combining and reconciling subjective and objective weights. These results must be interpreted in light of several limitations, namely the reliance on a single database, a deliberately restrictive search query, a modest corpus of 160 documents, and the disambiguation and heterogeneity issues that accompany mixed document types. Future research should therefore integrate multiple databases such as Scopus and Web of Science, apply rigorous author disambiguation, and develop standardized protocols that couple entropy–AHP frameworks with artificial-intelligence techniques while extending them into under-represented domains such as healthcare, public policy, and climate adaptation. By consolidating its fragmented themes and diversifying both its methods and its application contexts, the field is well positioned to evolve from established applications toward genuinely novel theoretical and methodological contributions.

REFERENCES

[1] S. Abdullah, H. Ali, A. A. Rahimzai, and S. Khan, "Novel concept of linguistic fractional fuzzy information for effective water filtration decision-making problem based on WASPAS method," *Sci. Rep.*, vol. 15, no. 1, 2025, doi: 10.1038/s41598-025-15817-9.
[2] A. Vashistha, A. Dashora, and A. A. Shah, "Assessing glacial lake outburst flood risk in the Eastern Himalayas: a Bayesian neural network framework," *Natural Hazards*, vol. 121, no. 18, pp. 21861–21890, 2025, doi: 10.1007/s11069-025-07668-4.
[3] E. Turan and A. Özkan, "Prioritization of amine-based solid sorbents for post-combustion CO2 capture using different multi-criteria decision-making tools," *International Journal of Environmental Science and Technology*, vol. 22, no. 10, pp. 9129–9140, 2025, doi: 10.1007/s13762-024-06181-8.
[4] B. Li *et al.*, "Multicriteria Decision-Making Model for Assessing the Aging Condition of Composite Insulators Using AHP-Entroped TOPSIS," *IEEE Trans. Instrum. Meas.*, vol. 74, 2025, doi: 10.1109/TIM.2025.3547502.
[5] M. Zeleny, *Multiple Criteria Decision Making*. New York: McGraw-Hill, 1982.
[6] A. H. Shahbakhsh Razavi and E. Kheirkhah, "Providing a framework for determining important dependability parameters for web services using multi-criteria decision-making methods and neural networks," *Intelligent Decision Technologies*, vol. 19, no. 5, pp. 2847–2866, 2025, doi: 10.1177/18724981251364492.
[7] K. T. John, V. Chawla, S. K. Mathew, M. Mathew, and K. D. Goepel, "Can business school ranking method be improved? a novel method of multi-criteria decision-making, employing inputs from management theories," *OPSEARCH*, 2025, doi: 10.1007/s12597-025-01038-1.
[8] M. Yu, L. Zhao, Z. Chen, and J. Wu, "Balancing Solar Potential and Environmental Risk: A GIS-Based Site-Selection Approach for Concentrated Solar Power in Tibet," *Sustainability (Switzerland)*, vol. 17, no. 11, 2025, doi: 10.3390/su17114895.
[9] Ü. Pala, "Evaluating the competitive edge of electric and hybrid powertrain architectures through MCDM," *J. Energy Storage*, vol. 111, 2025, doi: 10.1016/j.est.2024.115047.
[10] T. L. Saaty, *The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation*. New York: McGraw-Hill, 1980.
[11] X. Wei, M. Wang, Q. Wei, and X. Ma, "Piping Material Selection in Water Distribution Network Using an Improved Decision Support System," *Water (Switzerland)*, vol. 17, no. 3, 2025, doi: 10.3390/w17030342.
[12] I. Boukrouh, F. Tayalati, and A. Azmani, "A Comprehensive Framework for Supplier Selection: Using Subjective, Objective, and Hybrid Multi-Criteria Decision-Making Techniques With Sensitivity Analysis," *IEEE Access*, vol. 12, pp. 145550–145569, 2024, doi: 10.1109/ACCESS.2024.3462348.
[13] M. H. Do, T. T. Nguyen, and U. Grote, "Insights on household's resilience to shocks and poverty: evidence from panel data for two emerging economies in Southeast Asia," *Clim. Dev.*, vol. 17, no. 8, pp. 684–698, 2025, doi: 10.1080/17565529.2024.2446358.
[14] M. K. Srivastava, S. Gaur, and A. Ohri, "Analysing the Effectiveness of MCDM and Integrated Weighting Approaches in Groundwater Quality Index Development," *Water Conservation Science and Engineering*, vol. 9, no. 2, 2024, doi: 10.1007/s41101-024-00267-7.
[15] F. Bashir, S. H. A. Shah, and J. Iqbal, "Exponential Weighting based Network Ranking for Heterogeneous Wireless Networks," in *2025 27th International Multitopic Conference, INMIC 2025*, 2025. doi: 10.1109/INMIC65900.2025.11348401.
[16] J. Ismail, A. Aristo Jansen Sinlae, Y. Saputra, R. Anan Nasution, and E. Rahajeng, "Mapping the Research Landscape of Multi-Objective Optimization by Ratio Analysis (MOORA) within Multi-Criteria Decision-Making: A Comprehensive Bibliometric and Science Mapping Analysis from 2012 to 2024," *Bulletin of Information System Research (BIOS)*, vol. 3, no. 2, pp. 1–7, 2025, doi: 10.62866/bios.v3i2.191.
[17] N.-M. Nguyen *et al.*, "Ranking Sub-Watersheds for Flood Hazard Mapping: A Multi-Criteria Decision-Making Approach," *Water (Switzerland)*, vol. 15, no. 11, 2023, doi: 10.3390/w15112128.
[18] M. M. Shahsavar *et al.*, "Bio-recovery of municipal plastic waste management based on an integrated decision-making framework," *Journal of Industrial and Engineering Chemistry*, vol. 108, pp. 215–234, 2022, doi: 10.1016/j.jiec.2022.01.002.

