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Analytic Hierarchy Process in Risk Assessment: A Bibliometric Perspective

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ABSTRACT

This study analyses the development of research on the application of the Analytic Hierarchy Process (AHP) in risk assessment through a bibliometric approach. Data were collected from the Scopus database using relevant keyword combinations, yielding 1,685 articles. Analysis was conducted using VOSviewer to examine publication trends, author collaboration networks, and keyword co-occurrence patterns. The findings reveal that AHP in risk assessment has experienced significant growth and exhibits a high degree of international collaboration. The most frequently occurring keywords include "AHP," "risk assessment," and "fuzzy AHP," indicating a paradigm shift towards uncertainty-based and hybrid methodological approaches. This study maps the evolution of research themes and identifies future research directions, particularly concerning the integration of AHP with advanced analytical methods and sustainability issues. The bibliometric patterns identified here complement an expanding body of literature linking decision-science methods with financial management and organisational governance.

Keywords: *Analytic Hierarchy Process; Risk Assessment; Bibliometric Analysis; VOSviewer; Financial Risk.*

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INTRODUCTION

Decision-making in complex organisational environments demands methods capable of integrating multiple, often incommensurable, criteria into a coherent priority structure. The *Analytic Hierarchy Process* (AHP), introduced by Thomas L. Saaty in the late 1970s, fulfils this requirement by decomposing complex problems into systematic hierarchical structures and determining the relative importance of each criterion and alternative through pairwise comparisons (Saaty, 1980). Since its inception, AHP has emerged as one of the most widely applied *multi-criteria decision making* (MCDM) tools across disciplines ranging from engineering and environmental management to financial risk evaluation (Saaty, 1994).

Within financial management, risk assessment occupies a particularly critical position because it directly conditions organisational stability and long-term sustainability. Financial risk evaluation encompasses not only quantitative dimensions such as market, liquidity, and credit risk, but also qualitative dimensions including corporate governance, reputational exposure, and regulatory dynamics. This multidimensionality renders conventional single-criterion approaches inadequate and motivates the use of methods such as AHP that can integrate heterogeneous information systematically. Recent bibliometric explorations of adjacent fields confirm the growing importance of rigorous methodological approaches in financial management research (Wibowo et al., 2026; Yahya et al., 2026; Kesuma et al., 2025).

Despite the proliferation of individual AHP-based risk assessment studies, a comprehensive mapping of the intellectual structure, collaboration patterns, and thematic evolution of this literature remains absent. Existing reviews tend to be domain-specific and lack the systematic objectivity that bibliometric analysis provides. This gap is consequential because it impedes researchers from identifying underexplored directions, prominent contributors, and methodological frontiers. Bibliometric approaches have proven effective in addressing analogous gaps across several management sub-disciplines, including digital business models (Usada et al., 2025), financial literacy (Korip et al., 2025; Kesuma et al., 2025), public financial management (Maulana et al., 2026), and crisis decision-making (Mawadah et al., 2026).

This study therefore employs bibliometric analysis to map the development of AHP-in-risk-assessment research, identify dominant themes and collaboration structures, and delineate prospective research directions. Drawing on 1,685 articles retrieved from Scopus and analysed through VOSviewer, the paper offers three contributions: (1) it provides a comprehensive intellectual map of AHP-based risk assessment research, complementing the growing tradition of bibliometric cartography in management sciences (Ilmahdy et al., 2025; Althaf et al., 2025; Adelia et al., 2025); (2) it reveals the conditional influence of uncertainty-handling extensions such as *fuzzy AHP* and hybrid methods on the evolution of the field; and (3) it identifies actionable future research directions with practical implications for risk managers and policymakers. The remainder of this paper is organised as follows. Section 2 reviews the relevant literature. Section 3 describes the research method. Section 4 presents results and discussion. Section 5 concludes.

METHODS OF RESEARCH

This study employed a bibliometric approach to analyse the development of research on Analytic Hierarchy Process (AHP) in risk assessment. Bibliometric analysis was selected because it enables the

systematic mapping of scientific publications, intellectual structures, collaboration patterns, and emerging research themes within a particular field.

The data were collected from the Scopus database, which is recognized as one of the most comprehensive and reliable sources of peer-reviewed scientific literature. The search process was conducted using a combination of keywords related to the topic, including "Analytic Hierarchy Process", "AHP", and "risk assessment". To ensure data relevance and consistency, only journal articles, conference papers, and review articles published in English were included in the dataset. Duplicate records and documents with incomplete bibliographic information were excluded from the analysis.

After the screening process, a total of 1,685 publications were retained for further analysis. Bibliographic information, including authors, affiliations, countries, titles, abstracts, keywords, citations, and references, was exported in CSV format from Scopus. The dataset was subsequently processed using Microsoft Excel for data cleaning and preparation.

The bibliometric analysis was conducted using VOSviewer software version 1.6.20. Several analytical techniques were employed, including co-authorship analysis, co-authorship network analysis by country, keyword co-occurrence analysis, and text-based co-occurrence analysis. Co-authorship analysis was used to identify collaboration patterns among researchers, while country-level analysis examined international research networks. Keyword co-occurrence analysis was applied to identify dominant themes and research clusters, whereas text-based co-occurrence analysis explored conceptual structures derived from article titles and abstracts.

The visualisation results generated by VOSviewer were interpreted through three complementary perspectives: network visualisation, cluster visualisation, and overlay visualisation. Network visualisation was used to examine relationships among research elements, cluster visualisation identified thematic groupings within the literature, and overlay visualisation revealed the temporal evolution of research topics. Through these analytical procedures, this study provides a comprehensive overview of the intellectual development, collaboration structure, and emerging trends in AHP-based risk assessment research.

RESULT AND DISCUSSION

The results and discussion section presents the findings of the bibliometric analysis of research on the application of the Analytic Hierarchy Process (AHP) in risk assessment. Using data retrieved from the Scopus database and analysed through VOSviewer, this study explores the intellectual structure, collaboration patterns, and thematic evolution of the field. The findings are organised into several analytical dimensions, including co-authorship networks, country collaboration networks, keyword co-occurrence patterns, and text-based thematic mapping. These analyses provide a comprehensive understanding of the development of AHP-based risk assessment research and highlight emerging trends that may shape future scholarly investigations.

Co-authorship Analysis of Authors

The author co-authorship network visualised in Figure 1 reveals the formation of several relatively small and internally cohesive clusters, each representing a research group characterised by high intra-cluster publication intensity. Inter-cluster connectivity, however, remains limited, indicating that collaboration

tends to be confined within established research circles rather than extending across broader scholarly networks. Several authors occupy more central network positions, identifying them as bridging actors capable of integrating diverse research streams. This fragmentation pattern is consistent with findings from bibliometric analyses in adjacent management sub-disciplines, where collaborative networks similarly exhibit cluster-centric structures in their formative stages (Ilmahdy et al., 2025; Rafasya et al., 2026).

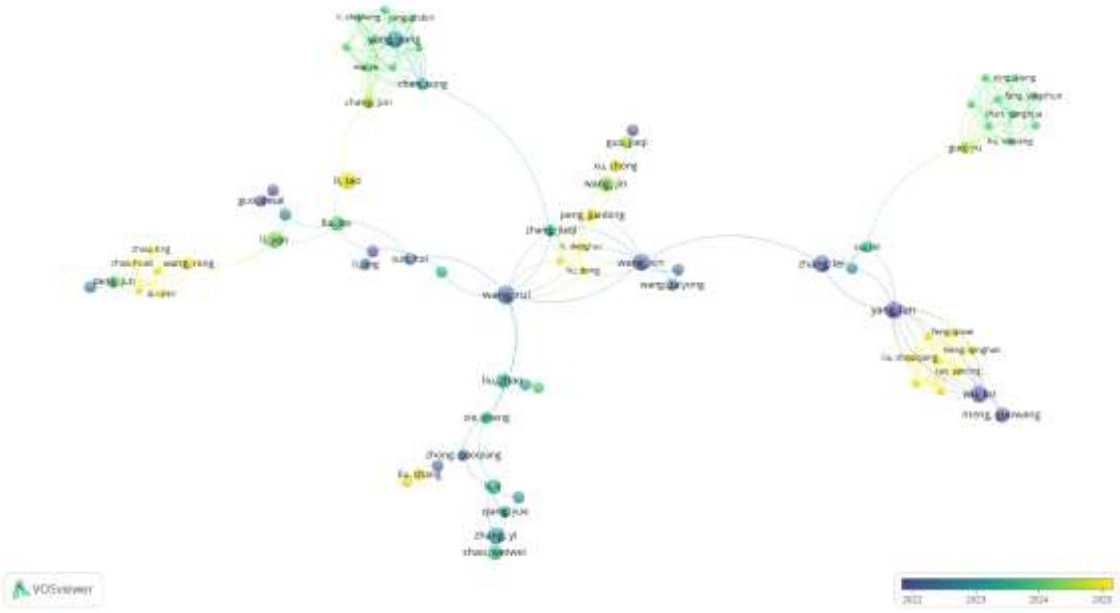

Figure 1. *Co-authorship Network of Authors*

The overlay visualisation reveals temporal variation in authorial activity, with lighter-coloured nodes representing more recent publications. This temporal gradient indicates an acceleration of collaborative activity in recent years, suggesting that the field is entering a phase of more active network expansion. Nonetheless, the persistently fragmented structure highlights ongoing opportunities to cultivate inter-cluster collaboration, which would facilitate broader knowledge integration and dissemination.

Co-authorship Network of Countries

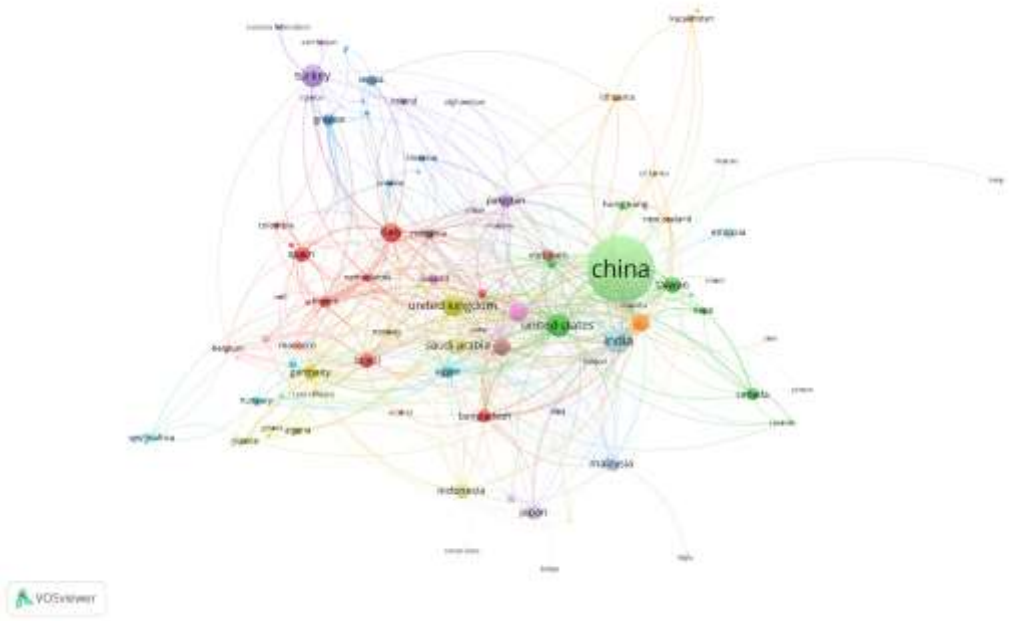

Figure 2. *Co-authorship Network of Countries*

Figure 2 demonstrates that AHP-in-risk-assessment research is characterised by global collaboration, with China emerging as the dominant contributor, evidenced by its large node size and central network position. The United States, India, and the United Kingdom also contribute substantially to the international collaboration network. The density of inter-country connections confirms that research in this domain has transcended geographical boundaries, forming a genuinely transnational scholarly community.

At the same time, the network exhibits regional clustering tendencies: Asian countries cluster strongly around China, while European countries form an internally connected sub-network. Several developing countries exhibit nascent participation, though their connectivity levels remain substantially below those of established research centres. This asymmetry parallels disparities documented in bibliometric reviews of other management disciplines (Wibowo et al., 2026; Maulana et al., 2026) and underscores the need for deliberate strategies to increase research equity and the representativeness of emerging-market perspectives.

Co-occurrence of Keywords

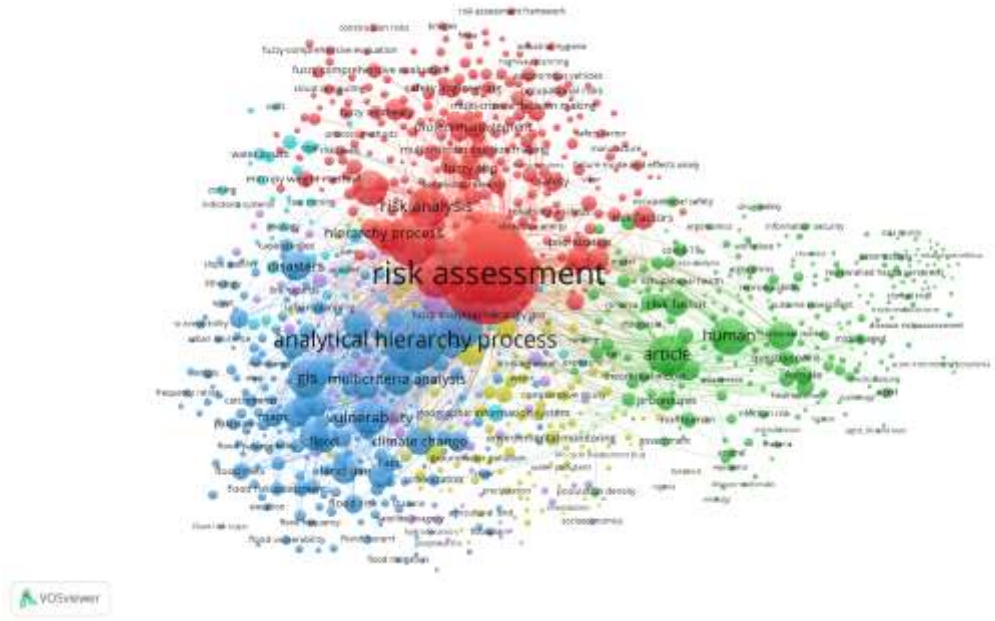

Figure 3. *Co-occurrence Network of Keywords (Cluster Visualisation)*

The keyword co-occurrence map presented in Figure 3 positions "risk assessment" as the central node of the network, reflecting its role as the overarching organising concept across the analysed literature. The network is partitioned into four distinct thematic clusters. The red cluster encompasses methodological development and the application of AHP in risk management, as evidenced by the co-occurrence of terms such as "risk analysis," "project management," and "fuzzy AHP." The blue cluster reflects AHP applications in environmental and disaster risk contexts, marked by terms including "GIS," "flood," and "vulnerability." The green cluster is associated with human and health dimensions, as indicated by terms such as "human," "article," and "risk factor." The yellow cluster represents environmental concerns, notably "climate change" and "environmental monitoring."

The high density of inter-keyword linkages confirms the multidisciplinary character of AHP-based risk assessment research, mirroring the cross-disciplinary patterns identified in bibliometric studies of related decision-science and financial management literatures (Mawadah et al., 2026; Azmi et al., 2026). Notably, the prominence of the "fuzzy AHP" node within the red cluster corroborates the methodological evolution observed in the literature review, signalling that uncertainty-handling extensions have become mainstream rather than peripheral.

Overlay Visualisation of Keywords

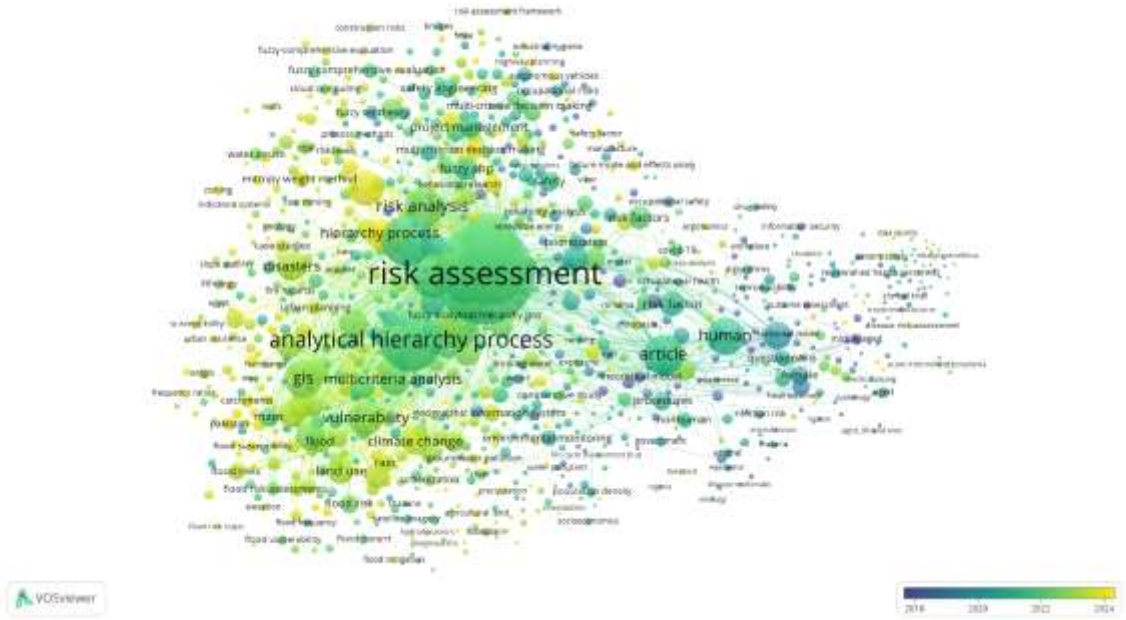

Figure 4. *Co-occurrence Network of Keywords (Overlay Visualisation)*

Figure 4 presents the temporal dynamics of keyword emergence, using a colour gradient from dark blue (earlier publications) to yellow (more recent publications). Early-phase research is anchored by terms such as "analytical hierarchy process," "GIS," and "flood," reflecting the foundational methodological and applied work in environmental and geographical risk contexts. As the field matured, the emergence of "risk assessment," "risk analysis," and "fuzzy AHP" in progressively lighter hues indicates a deepening and broadening of analytical approaches. The most recent thematic frontiers, marked by the brightest tones, include climate change, environmental monitoring, and health-related dimensions, reflecting the contemporary integration of sustainability concerns into AHP-based risk frameworks.

This temporal trajectory is consistent with trends identified in parallel bibliometric surveys of management and economics research (Althaf et al., 2025; Chairani et al., 2026; Simangunsong et al., 2026), which similarly document a progression from methodological establishment towards applied and contextually embedded inquiry. The expanding scope of AHP applications toward sustainability and ESG risk dimensions is particularly noteworthy, given the increasing relevance of these concerns to financial management and corporate governance (Widaryo et al., 2025; Kesuma et al., 2025).

Co-occurrence Map Based on Text Data

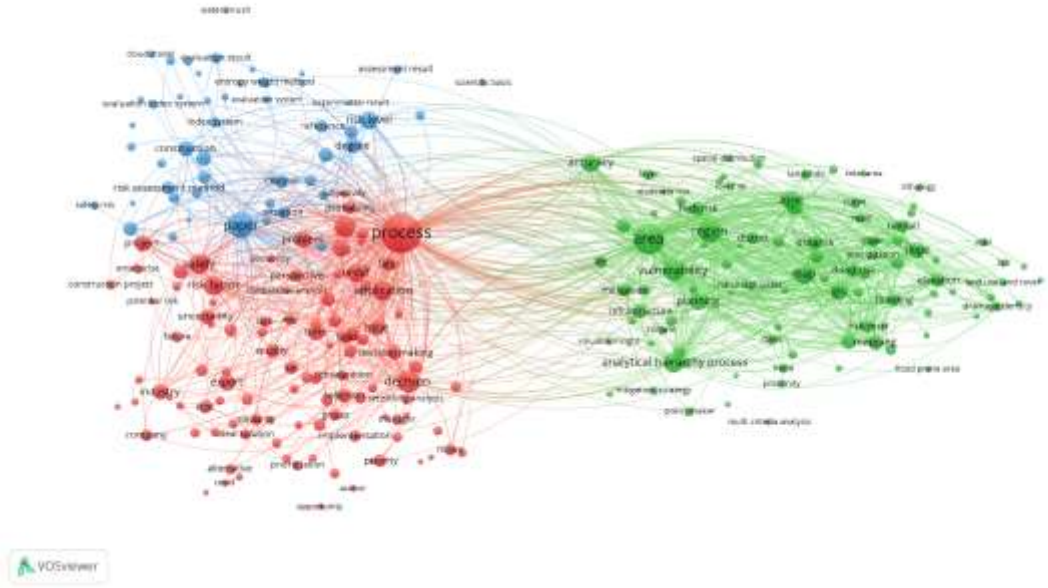

Figure 5. *Co-occurrence Map Based on Text Data (Cluster Visualisation)*

The text-based co-occurrence analysis visualised in Figure 5 identifies three primary conceptual clusters from article titles and abstracts. The red cluster, anchored by terms such as "process," "decision," "application," and "risk factor," indicates that a substantial portion of the literature focuses on the decision-making process and the broader application of AHP across risk contexts. The density of this cluster underscores the centrality of process-oriented frameworks in the field. The green cluster, characterised by spatial and environmental terms including "area," "region," "mapping," "flood risk," and "slope," confirms the prominence of geographically embedded risk analysis, particularly natural disaster and land-use risk assessment. The blue cluster, organised around "evaluation system," "risk level," and "assessment method," reflects the technical and evaluative strand of the literature, in which AHP serves as a structured instrument for systematically determining risk levels.

The positioning of "process" at the centre of the network is theoretically significant: it confirms that the majority of AHP-based risk assessment research is fundamentally concerned with structured analytical and decision-making processes, rather than with any single substantive risk domain. This structural centrality parallels observations made in bibliometric analyses of decision-making in crisis management (Mawadah et al., 2026) and bounded rationality (Azmi et al., 2026), which similarly highlight the enduring salience of process-oriented frameworks in management research.

Overlay Visualisation Based on Text Data

The overlay visualisation in Figure 6 maps the temporal evolution of conceptual themes across the text-based dataset. Foundational methodological concepts such as "process," "evaluation," and "risk assessment" appear in the earliest publications, providing the conceptual bedrock upon which subsequent research has been constructed. Over time, the literature has shifted toward more applied and spatially specific contributions, as evidenced by the lighter hues associated with "flood risk," "mapping," "GIS," and "spatial analysis." The most recent conceptual additions, appearing in the brightest zones of the map,

include "accuracy," "zone," and "land use," indicating the field's progressive integration of data-driven and spatially precise analytical techniques.

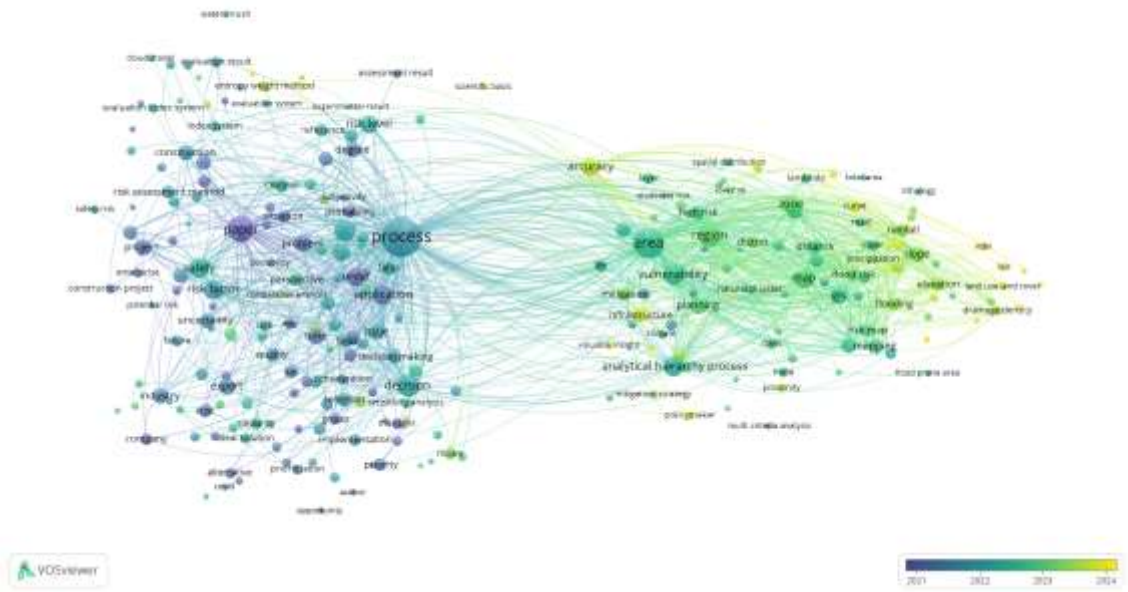

Figure 6. *Co-occurrence Map Based on Text Data (Overlay Visualisation)*

Taken together, these findings describe a field in transition: from conceptually grounded, process-centred inquiry toward empirically rich, context-specific, and technologically enhanced applications. AHP has evolved from a general-purpose decision-support tool into a versatile analytical instrument deployed across highly specialised risk domains, including environmental hazards, financial systemic risk, and data-intensive real-time risk monitoring. This trajectory mirrors the broader disciplinary evolution documented in bibliometric studies of financial management and organisational governance (Yahya et al., 2026; Ariswati et al., 2025; Irianto et al., 2025).

CONCLUSION

This study provides a comprehensive bibliometric overview of research on the application of the Analytic Hierarchy Process (AHP) in risk assessment. The findings indicate that scholarly interest in this field has grown significantly over time, reflecting the increasing importance of structured decision-making approaches in managing complex risks across various sectors. The co-authorship analysis reveals the existence of collaborative research networks, although opportunities remain to strengthen cooperation among different research clusters and geographical regions.

The keyword and text-based co-occurrence analyses demonstrate that risk assessment, AHP, and fuzzy AHP constitute the core themes of the literature. Furthermore, the overlay visualisations reveal an evolution from foundational methodological studies toward more applied and interdisciplinary research areas, particularly those related to environmental sustainability, climate change, health risk management,

and spatial analysis. These trends indicate that AHP continues to evolve as a versatile decision-support tool capable of addressing increasingly complex and uncertain risk environments.

This study contributes to the literature by mapping the intellectual structure, collaboration patterns, and thematic development of AHP-based risk assessment research. However, the analysis is limited to publications indexed in the Scopus database and may not capture relevant studies from other databases. Future research may expand the scope of data sources and explore the integration of AHP with emerging analytical approaches, including artificial intelligence, machine learning, and sustainability-oriented decision frameworks.

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