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Bibliometric Mapping of Risk Management Practices in High-Emission Industries

Loso Judijanto[1], Indah Oktari Wijayanti[2]
[1]IPOSS Jakarta
[2]Universitas Bengkulu

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ABSTRACT

High-emission industries play a pivotal role in economic development while simultaneously accounting for a disproportionate share of global greenhouse gas emissions. As these sectors face intensifying regulatory, financial, and societal pressure, risk management has expanded from a narrow focus on operational and safety issues toward broader environmental, climate, and sustainability risks. This study conducts a bibliometric mapping of research on risk management practices in high-emission industries using data retrieved from the Scopus database and analyzed with VOSviewer. Co-authorship, co-citation, and keyword co-occurrence networks are employed to identify influential authors, institutions, countries, thematic clusters, and temporal trends. The results show that "risk management" and "sustainable development" form the conceptual core of the field, closely linked to themes such as climate change, carbon emissions, emission control, environmental and health risks, and sector-specific concerns in construction and gas industries. Overlay and density visualizations indicate a shift from early work on air pollution, health risks, and environmental monitoring toward more recent emphasis on carbon accountability and climate-transition agendas. Country collaboration networks reveal a core group of leading contributors (particularly the United States, United Kingdom, China, and India) surrounded by emerging participants. Overall, the study consolidates a fragmented literature, clarifies the intellectual structure and evolution of the field, and highlights opportunities for future research on how risk management can support low-carbon transitions in carbon-intensive sectors.

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Corresponding Author:

Name: Loso Judijanto
Institution Address: IPOSS Jakarta
e-mail: losojudijantobumn@gmail.com

1. Introduction

High-emission industries such as energy production, mining, manufacturing, cement, steel, chemicals, and transportation play a critical role in global economic development. These sectors supply essential goods, infrastructure, and energy that support industrialization, urbanization, and modern lifestyles [1], [2]. However, they are also among the largest contributors to greenhouse gas

emissions, environmental degradation, and climate change. According to global environmental assessments, a small number of carbon-intensive industries account for a disproportionately large share of global emissions, making them central targets of international climate policies, sustainability initiatives, and regulatory frameworks. As pressure intensifies from governments, investors, and society, these industries face growing expectations to manage not only environmental risks but also financial, operational, regulatory, and reputational risks associated with high emissions [3], [4].

Risk management has therefore emerged as a strategic function within high-emission industries [5]. Traditionally focused on financial and operational uncertainties, risk management frameworks have expanded to incorporate environmental, social, and governance (ESG) risks, climate-related financial risks, and transition risks linked to decarbonization [6]. Companies operating in carbon-intensive sectors must now address complex and interconnected risks, including carbon pricing, regulatory changes, technological disruptions, supply chain vulnerabilities, and stakeholder activism. Effective risk management practices are increasingly viewed as essential tools for enhancing organizational resilience, ensuring regulatory compliance, maintaining competitiveness, and supporting long-term sustainability goals in an era of climate transition [7].

Over the past two decades, academic research on risk management in high-emission industries has grown significantly. Scholars from diverse disciplines (such as environmental management, finance, operations management, engineering, and sustainability science) have contributed to this expanding body of literature [8], [9]. Research topics range from enterprise risk management and environmental risk assessment to climate risk disclosure, carbon risk pricing, and mitigation strategies. This growing volume of research reflects the evolving complexity of risks faced by emission-intensive sectors and highlights the importance of integrating risk management into corporate strategy and policy design. However, the rapid expansion of publications has also resulted in fragmented knowledge across disciplines, methodologies, and geographical contexts.

Bibliometric analysis offers a systematic and quantitative approach to understanding the intellectual structure and evolution of a research field. By analyzing publication patterns, citation networks, keyword co-occurrences, and authorship collaborations, bibliometric mapping enables researchers to identify influential studies, emerging themes, research clusters, and knowledge gaps. Unlike traditional narrative reviews, bibliometric methods provide objective insights into how scholarly knowledge develops over time and how different research streams are interconnected. In the context of risk management practices in high-emission industries, bibliometric mapping can reveal dominant theoretical frameworks, methodological trends, and shifts in research focus, such as the growing attention to climate-related financial risks and sustainability-oriented risk management.

Despite the relevance of bibliometric approaches, existing reviews on risk management and high-emission industries have largely relied on qualitative or thematic literature reviews. While these studies provide valuable conceptual insights, they often lack a comprehensive overview of the field's structure and evolution. Moreover, many reviews focus on specific industries or isolated risk categories, such as environmental risk or financial risk, rather than offering an integrated perspective across multiple high-emission sectors. As a result, there is limited understanding of how risk management research in high-emission industries has developed over time, which topics dominate the field, who the key contributors are, and where future research opportunities lie. Addressing this gap is essential for advancing both academic

scholarship and practical risk management applications.

Although research on risk management practices in high-emission industries has expanded considerably, the literature remains fragmented and lacks a comprehensive, systematic mapping of its intellectual landscape. There is insufficient clarity regarding the main research themes, influential authors and institutions, collaboration patterns, and emerging trends shaping this field. Without a bibliometric overview, researchers and practitioners may struggle to identify knowledge gaps, avoid duplication of efforts, or align future studies with evolving risk management challenges, particularly those related to climate change and sustainability transitions. The objective of this study is to conduct a bibliometric mapping of research on risk management practices in high-emission industries.

2. Method

This study employs a bibliometric research design to systematically map the scientific literature on risk management practices in high-emission industries. The bibliographic data were retrieved from the Scopus database, selected due to its comprehensive coverage of peer-reviewed journals and high-quality scholarly publications across multidisciplinary fields. Relevant documents were identified using a structured search strategy combining keywords related to risk management, high-emission industries, carbon-intensive sectors, and environmental and climate-related risks. The search was limited to journal articles and reviews published in English to ensure consistency and relevance. The retrieved records, including information on authors, titles, abstracts, keywords, citations, and references, were exported in a compatible format for bibliometric analysis. The analysis and visualization of the bibliographic data were conducted using VOSviewer, a widely used software tool for constructing and visualizing bibliometric networks. VOSviewer was utilized to perform co-authorship analysis, co-citation analysis, and keyword co-occurrence analysis, enabling the identification of influential authors, collaborative networks, major research clusters, and emerging themes within the literature [10].

3. Result and Discussion

Co-Authorship Analysis

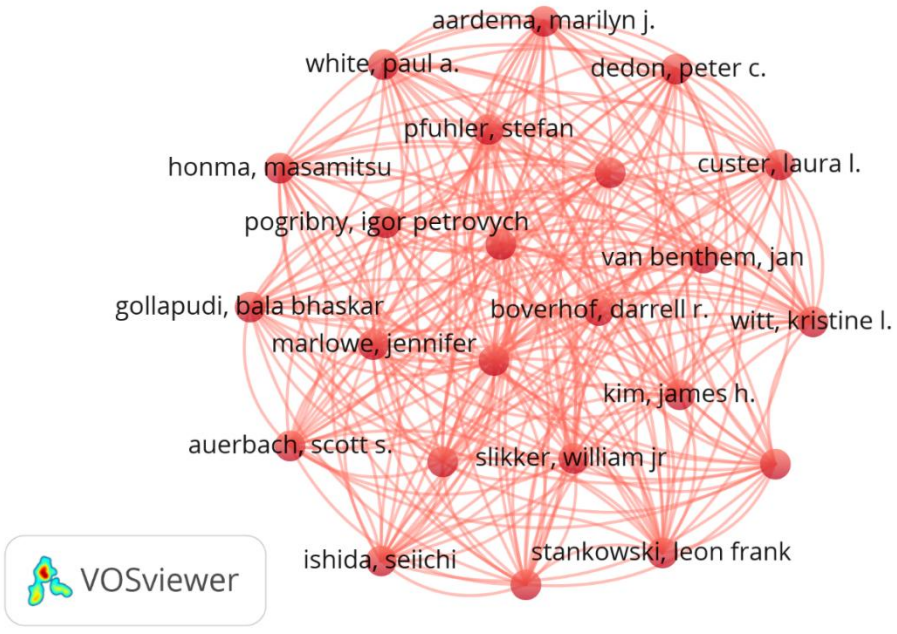

Figure 1. Author Visualization

Source: Data Analysis

Figure 1 shows a very dense network of authors who are strongly connected through either co-authorship or co-citation relations. Almost all nodes are linked to one another, indicating that this group of researchers forms a tightly knit core community that frequently collaborates or cites each other's work. The slightly larger nodes in the middle of the map (such as Boverhof, Pogribny, Pufhler, or Kim) represent authors with higher weight so they can be seen as central figures or intellectual anchors in this field. The absence of clearly separated color clusters suggests that research in this area is relatively integrated, with overlapping themes and shared references rather than fragmented sub-communities.

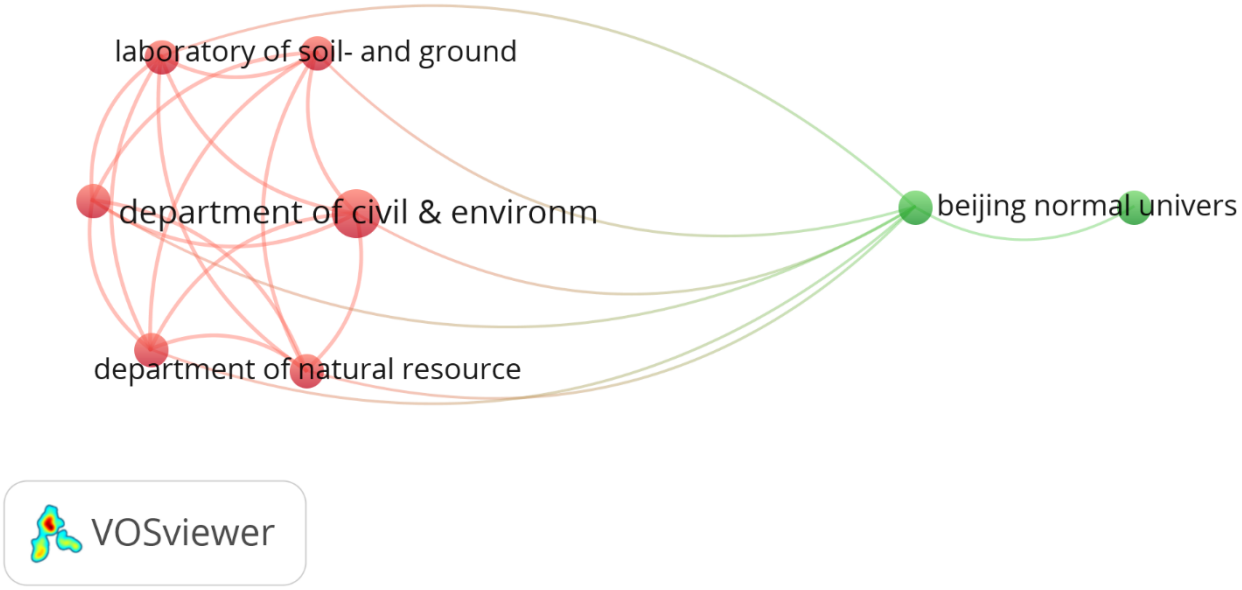

Figure 2. Affiliation Visualization

Source: Data Analysis

Figure 2 illustrates institutional collaboration patterns, showing two distinct but interconnected clusters. On the left, several departments such as the Laboratory of Soil and Ground, Department of Civil & Environment, and Department of Natural Resource, form a tightly linked group, indicating strong internal collaboration and shared research agendas within the same institutional or disciplinary environment. On the right, Beijing Normal University stands out as the primary external collaborator, connected to each of those departments through multiple linking lines. This suggests that Beijing Normal University plays a bridging role, acting as an international or cross-institutional partner that channels knowledge exchange and joint research with the cluster on the left. The relatively fewer nodes on the right compared to the dense cluster on the left implies that while internal collaboration is strong, external partnerships are more selective and focused, with Beijing Normal University serving as the key gateway in this collaborative network.

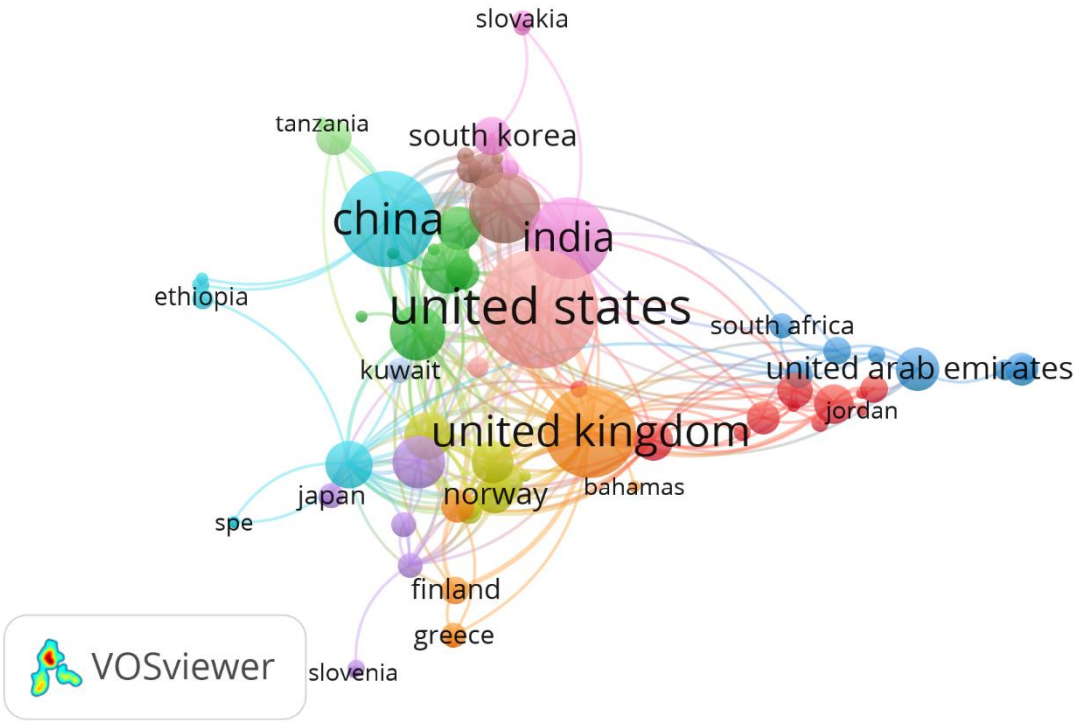

Figure 3. Country Visualization
Source: Data Analysis

Figure 3 highlights a global research landscape dominated by several central hubs, with the United States, United Kingdom, China, and India appearing as the most influential contributors based on node size and connection density. These countries act as the primary anchors of international cooperation, forming strong and multi-directional research linkages with both developed and developing nations. Surrounding clusters show regionally concentrated collaboration patterns, for example, Japan, South Korea, and Kuwait are closely linked with China, while South Africa, Jordan, and the United Arab Emirates form a secondary collaborative corridor connected to the UK and US. The presence of smaller nodes such as Tanzania, Ethiopia, Slovenia, and Greece illustrates emerging participation, though with more limited global reach.

Co-Citation Analysis

Table 1. Top Cited Literature

Citations	Authors and year	Title
2300	[11]	Managing the health effects of climate change. Lancet and University College London Institute for Global Health Commission
1334	[12]	2024 ESC Guidelines for the management of chronic coronary syndromes
834	[13]	Threats to the running water ecosystems of the world
734	[14]	Responding to public and private politics: Corporate disclosure of climate change strategies
663	[15]	A review of waste management practices and their impact on human health

Citations	Authors and year	Title
334	[16]	Impacts of climate change on the fate of contaminants through extreme weather events
314	[17]	Characterization of heavy metal concentrations in the sediments of three freshwater rivers in Huludao City, Northeast China
245	[18]	Influence of green and lean upstream supply chain management practices on business sustainability
198	[19]	Sustainable oil palm industry: The possibilities
184	[20]	Building pathology, investigation of sick buildings ĝ€ voc emissions

Source: Data Analysis

Keyword Co-Occurrence Analysis

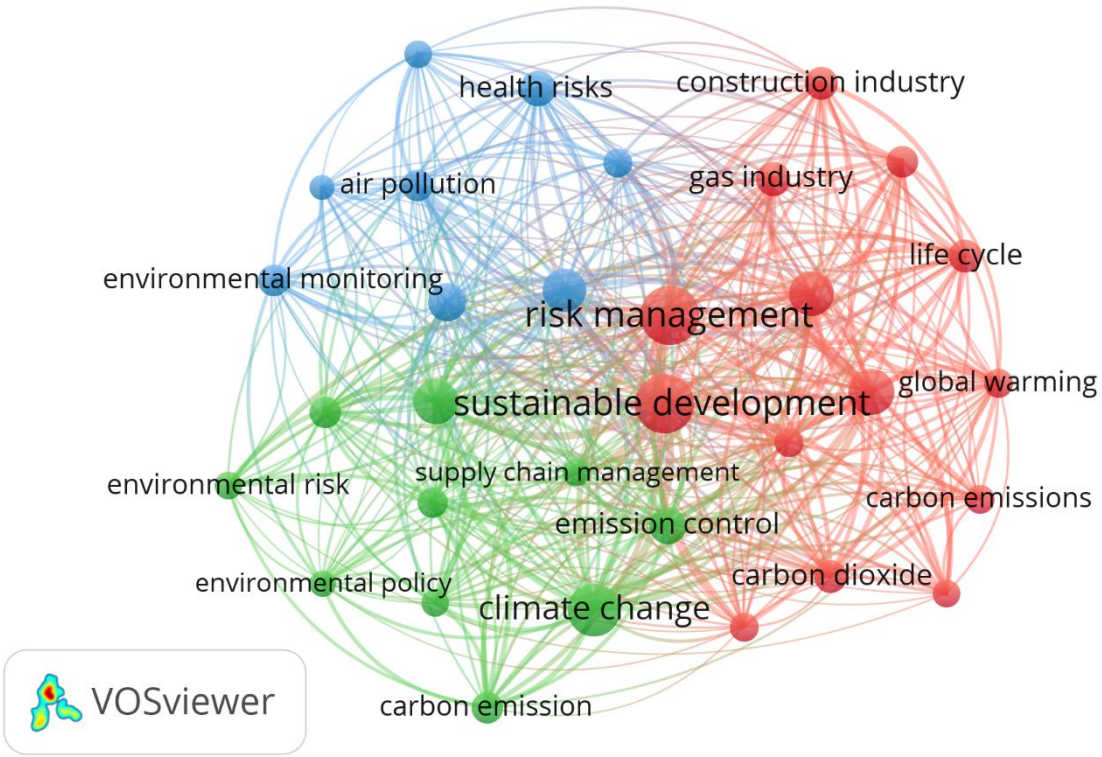

Figure 4. Network Visualization of Keyword
Source: Data Analysis

Figure 4 reveals that risk management and sustainable development sit at the core of the research landscape, acting as bridging concepts across several thematic clusters. Almost all other terms connect back to these two nodes, which indicates that discussions of high-emission activities are rarely framed only as technical or environmental problems. Instead, authors tend to link emission issues to broader agendas of managing risk and steering industries toward more sustainable trajectories. The red cluster is dominated by terms such as construction industry, gas industry, carbon emissions, carbon dioxide, global warming, and life cycle. This cluster reflects work that deals directly with sector-specific emission sources

and life-cycle assessments of carbon-intensive activities. In the context of your topic, this group represents the "hard" industrial side of risk management, where researchers examine how particular industries contribute to greenhouse gases and how risk tools are used to assess and reduce that impact over the project or product life cycle.

The green cluster, which includes climate change, carbon emission, emission control, environmental risk, environmental policy, and supply chain management, points to a second stream of literature focused on governance and operational responses. Studies in this space typically explore how firms design control mechanisms, policies, and supply-chain strategies to deal with climate-related risks. The presence of supply chain management shows that risk management is not confined to single plants or facilities but extends along value chains, connecting upstream and downstream actors in high-emission sectors. The blue cluster with terms such as health risks, air pollution, and environmental monitoring links industrial emissions and climate change to human and ecological consequences. Research grouped here tends to look at local air-quality impacts, exposure risks, and monitoring systems that track pollutants over time. The strong links from this cluster to risk management and sustainable development suggest that health-related evidence is increasingly used to justify stricter risk controls and more ambitious sustainability targets in carbon-intensive industries.

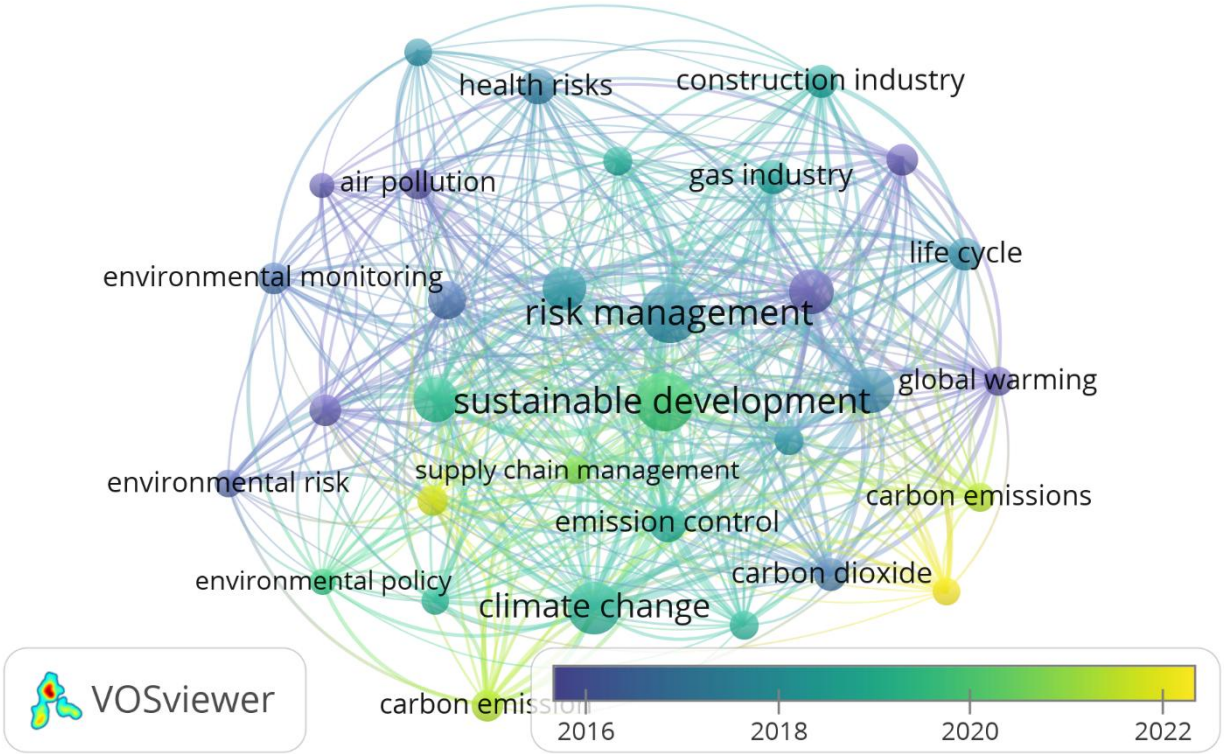

Figure 5. Overlay Visualization
Source: Data Analysis

Figure 5 above illustrates how research focus has evolved over time within the intersection of risk management and high-emission industries. Keywords shaded in darker blue and purple, such as health risks, air pollution, environmental monitoring, and life cycle, reflect themes that were more prominent in earlier years (around 2016–2018). These earlier studies tended to emphasize foundational assessments of pollution impacts, risk identification, and monitoring frameworks as researchers sought to understand the scale of

industrial risks and their implications for environmental and human health. In contrast, keywords moving toward greener and yellow tones such as carbon emissions, carbon dioxide, and carbon emission represent more recent interest (2019–2022). Their position and color indicate a shift from general pollution and risk analysis toward more targeted discussions on greenhouse gas mitigation, climate responsibility, and alignment with global carbon reduction agendas. Meanwhile, central terms like risk management and sustainable development remain consistently influential throughout the timeline, reinforcing their role as enduring anchors of the field rather than short-term research trends.

The map shows a chronological progression from early-stage concern with pollution and health impacts to a more strategic focus on carbon accountability, emission control, and sustainability integration. The increasing prominence of terms linked to policy, supply chains, and sustainability suggests that risk management in high-emission industries is no longer perceived as an operational or compliance task alone, but as a critical driver of long-term climate strategy and organizational transformation.

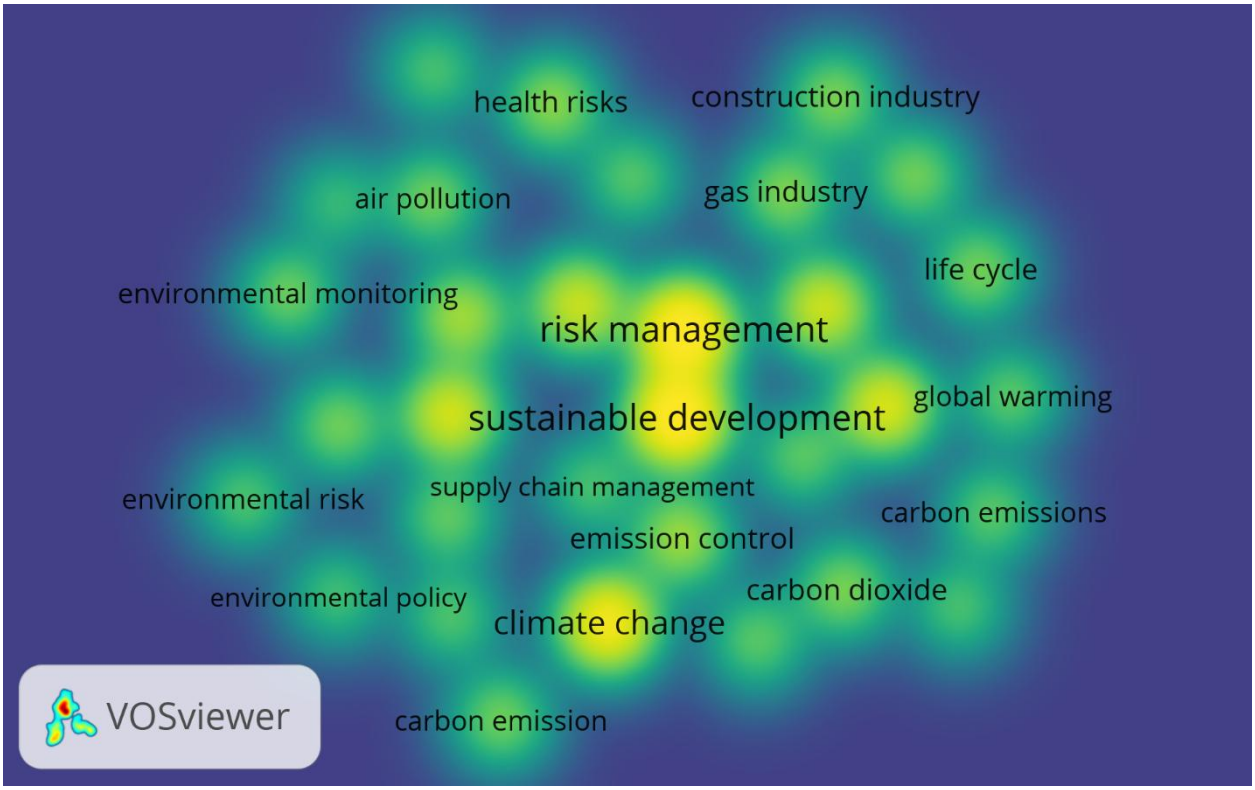

Figure 6. Density Visualization
Source: Data Analysis

Figure 6 highlights the most frequently occurring and thematically central concepts in the literature on risk management within high-emission industries. The bright yellow areas around risk management, sustainable development, and climate change indicate that these concepts consistently appear at the core of scholarly discussions, serving as conceptual anchors that connect operational risks to broader sustainability and climate agendas. Surrounding nodes like global warming, carbon emissions, and emission control also show relatively high density, suggesting that carbon-related topics are becoming increasingly integrated into risk management discourse rather than being treated as separate environmental concerns. Meanwhile, the slightly dimmer but still active green regions

such as environmental risk, supply chain management, life cycle, air pollution, and industry-specific terms like gas industry and construction industry, reflect supporting research streams that contribute context and sectoral depth. Their distribution around the central cluster indicates that scholars are widening their scope, linking risk management to specific industrial processes, operational strategies, and externalities.

Discussion

The findings highlight that risk management in high-emission industries is increasingly framed together with sustainable development, climate change, and carbon emissions rather than as a narrow compliance activity. For practitioners in carbon-intensive sectors (power generation, oil and gas, construction, heavy manufacturing), this implies that risk management systems need to move beyond traditional safety and operational risk registers. Firms are expected to integrate climate-related and environmental dimensions (such as emission control, life-cycle impacts, and supply-chain exposure) into enterprise risk management frameworks, performance dashboards, and board-level reporting. The strong presence of keywords like sustainable development, global warming, and emission control suggests that investors, regulators, and rating agencies are already shaping this broader risk agenda.

The country collaboration map shows that the United States, United Kingdom, China, and India act as global hubs in this field, often collaborating with emerging economies. This pattern has practical consequences for knowledge transfer. Companies and regulators in regions that are less represented in the network can strategically connect to these hubs through joint projects, standards initiatives, or capacity-building programs. For multinational firms operating across jurisdictions, the map also signals where expertise and potential partners are concentrated, which can guide the selection of benchmarking peers, research alliances, or pilot locations for new risk tools and climate-related disclosure practices. The keyword clusters and density maps additionally indicate that supply-chain issues, environmental monitoring, and health risks are closely linked to risk management in high-emission industries. Managers can use this insight to prioritize cross-functional coordination: risk teams should work more closely with sustainability, procurement, engineering, and occupational health departments. For example, decisions on supplier selection, logistics design, and plant technology now have to be evaluated not only in terms of cost and reliability, but also in terms of climate exposure, air-pollution impacts, and long-term health risks to workers and surrounding communities. This integrated view supports more resilient strategies in the face of tightening environmental regulations and growing stakeholder scrutiny.

The study offers a systematic overview of how risk management for high-emission industries has evolved into an inherently interdisciplinary research domain. By mapping co-occurring keywords, the analysis clarifies that the intellectual core of the field lies at the intersection of risk management, sustainable development, and climate change, with sub-streams focusing on industrial processes, governance and policy, and health and environmental outcomes. This helps to consolidate a literature that has been fragmented across environmental science, engineering, management, and public policy, and provides a clearer picture of how these strands relate to each other. Second, the overlay visualization reveals a temporal shift from early work on air pollution, health risks, and environmental monitoring toward more recent emphases on carbon emissions and carbon dioxide. Theoretically, this shift can be interpreted as a move from a pollution-control paradigm toward a climate-transition paradigm, in which risks are framed not only as local environmental or health problems but also as strategic, regulatory, and reputational threats

connected to global climate governance. The study therefore contributes to the literature on climate-related financial and operational risk by showing how these concepts have been progressively embedded within risk management discourse in high-emission sectors.

Third, the collaboration networks among countries and institutions support a richer understanding of how knowledge on industrial risk and sustainability is produced. The concentration of influential work in a small number of countries, combined with growing participation from emerging economies, suggests a core-periphery structure with increasing cross-regional integration. This pattern informs theoretical debates on knowledge diffusion and the geopolitics of climate and sustainability research: high-emission risk management is not only a technical field but also a site of uneven power relations, where certain regions set standards and others adapt or contest them. The bibliometric evidence presented here offers a starting point for more critical theoretical work on how these dynamics shape the agenda and priorities of the field.

This study has several limitations that should be acknowledged when interpreting the results. First, the analysis is constrained by the choice of database and search strategy (e.g., using only Scopus or Web of Science and a specific combination of risk- and emission-related keywords). Relevant studies that use different terminology, are indexed in other databases, or appear in grey literature, policy reports, and industry documents may have been omitted. Future research can broaden coverage by combining multiple databases, experimenting with alternative search strings, and including non-journal sources that often contain important practical insights on risk management in high-emission industries. Second, the study focuses primarily on English-language publications, which may create a bias toward research produced in Anglophone and highly internationalized academic environments. Given that many high-emission industries operate in non-English-speaking regions, important local or regional debates might not be fully represented in the maps. Subsequent studies could conduct parallel bibliometric analyses in other languages or integrate regional databases to capture a more diverse set of perspectives, especially from countries where emissions are growing rapidly and institutional contexts differ from the global North.

4. Conclusion

This bibliometric study shows that research on risk management in high-emission industries has developed into a dense, interconnected field that links industrial operations, climate change, and sustainable development. The maps indicate that "risk management" and "sustainable development" form the conceptual core, surrounded by themes such as climate change, carbon emissions, emission control, environmental and health risks, and sector-specific concerns in the construction and gas industries. Over time, the focus of the literature has shifted from general pollution and health impacts toward carbon-related issues and climate-transition agendas, reflecting growing regulatory pressure and investor interest in decarbonisation. Collaboration patterns reveal a network led by countries such as the United States, United Kingdom, China, and India, with increasing participation from both developed and emerging economies. Together, these findings suggest that risk management in high-emission sectors is no longer treated as a narrow compliance activity but as part of a broader strategic response to sustainability and climate challenges. The study therefore provides a structured overview of the intellectual landscape, highlights where knowledge and collaboration are concentrated, and offers a basis for future empirical and conceptual work aimed at deepening understanding of how risk management can support low-carbon transitions in carbon-intensive industries

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