



The role of Artificial Intelligence in disaster management: A systematic study of global research progress, collaborations, and thematic shifts

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Abstract

The intersection of artificial intelligence (AI) and disaster management has emerged as a critical and rapidly expanding research frontier, driven by the increasing complexity of global crises and the urgent need for technologically advanced solutions. This study aims to map and analyse the evolution, structure, and collaborative dynamics of scholarly output in this interdisciplinary domain through a comprehensive bibliometric analysis, utilizing a dataset comprising 11,055 documents published between 2000 and 2024 and retrieved from Web of Science and Scopus. The study employs bibliometric tools to evaluate publication trends, authorship patterns, keyword distributions, and citation impact. Analytical tools were used to extract and visualize co-authorship networks, thematic clusters, and keyword co-occurrence maps. The findings reveal a robust annual growth rate of 25.89%, reflecting the intensifying academic and practical interest in leveraging AI technologies such as machine learning, deep learning, natural language processing, and robotics for disaster risk reduction and emergency response. The average document age of 4.76 years indicates the field's recency and dynamism, while an average of 13.64 citations per document indicates moderate scholarly influence. It identifies critical trends, gaps, and opportunities for future research, particularly in enhancing global collaboration and interdisciplinary approaches to disaster resilience and emergency preparedness.

Keywords: Artificial Intelligence, Disaster Management, Bibliometric Analysis, Research Trends, Bibliometrics

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1 Introduction

The increasing frequency, scale, and impact of natural and man-made disasters pose significant threats to human life, infrastructure, and economies worldwide (UNDRR, 2022). Effective disaster management which encompasses mitigation, preparedness, response, and recovery has become a critical priority for governments and international organizations. In recent years, artificial intelligence (AI) has emerged as a powerful tool in enhancing disaster management capabilities. By leveraging techniques such as machine learning, computer vision, natural language processing, and robotics, AI systems have demonstrated effectiveness in tasks ranging from early warning systems and risk prediction to damage assessment and emergency response coordination (Li et al., 2020; Yao et al., 2022).

The integration of AI into disaster management represents a multidisciplinary convergence involving computer science, geospatial studies, public health, environmental science, and emergency policy (Chatterjee et al., 2021; Khodabandelou et al., 2020). Bibliometric analysis a quantitative approach to evaluating scientific literature serves as a valuable method to map the intellectual structure and developmental trajectory of a research domain (Donthu et al., 2021).

AI technologies including advanced algorithms and machine learning enable better forecasting of disasters through the analysis of large datasets and integration with Geographic Information Systems (GIS). This capability allows for real-time monitoring and early warning systems that enhance situational awareness and preparedness measures during emergencies (Puspabhuana, 2025; Pasupuleti, 2024).

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These predictive models not only enhance the accuracy of disaster forecasts but also aid in robust risk assessment, which is critical for effective disaster management (Joel et al., 2025).

AI-powered solutions such as machine learning algorithms play a pivotal role in different phases of disaster management, including anticipation, preparedness, response, and recovery. These technologies harness big data to augment prediction capabilities, risk assessment, and decision-making processes (Yu et al., 2018; Baig et al., 2024). For instance, machine learning models have demonstrated efficacy in predicting natural disasters such as tsunamis, earthquakes, and floods by analysing historical data and utilizing real-time information (Linardos et al., 2022). The findings from these studies reveals the significance of machine learning in providing timely warnings, thereby reducing potential disaster impacts and enhancing community resilience (Sarawagi et al., 2024; Mishra, 2023).

During crises, accurate and timely information dissemination is crucial, and AI tools equipped with natural language processing can mitigate the spread of misinformation, thereby enhancing public trust and community resilience (Wang et al., 2023). These tools can effectively analyze social media and online platforms to identify and correct false narratives that may arise post-disaster (Komendantova and Erokhin, 2025).

The evolution of specific AI applications, such as Disaster Guard AI, addresses the complex and dynamic nature of modern disasters. This AI system adopts cutting-edge technology to promote intelligent disaster preparedness, response coordination, and recovery strategies, overcoming the limitations of traditional methodologies (Kumar et al., 2024). The integration of social media analytics also enhances disaster response, allowing emergency managers to obtain real-time situational awareness and public sentiment during crises (Dong et al., 2021).

This study aims to conduct a comprehensive bibliometric analysis of research on AI applications in disaster management. Specifically, it seeks to examine publication trends, influential authors and institutions, collaboration networks, and thematic developments over time. By offering a macro-level overview of this dynamic field, the study intends to support researchers, policymakers, and practitioners in identifying research gaps, fostering collaboration, and guiding future investigations.

2 Objectives

- To examine the **global growth and publication trends** in artificial intelligence applications for disaster management.
- To identify the **most influential authors, institutions, countries, and journals** contributing to this research field.
- To analyse and map the **co-occurrence of keywords** to reveal the major research themes and knowledge clusters.
- To track the **thematic evolution and emerging**

research hotspots, highlighting shifts in focus areas over time.

- To assess the patterns of **international collaboration and knowledge exchange** in the field.

3 Rationale of the study

As AI technologies evolve and find new applications in crisis response, there has been a surge in academic interest, resulting in a diverse and rapidly expanding body of literature. Despite the growing volume of research, there remains a lack of systematic understanding of the intellectual structure, collaboration networks, and thematic developments in this interdisciplinary field. A bibliometric analysis is essential to map the trajectory of scholarly output, identify the most influential contributors, and uncover research gaps that remain unaddressed. Such an approach not only provides a macro-level overview of the field but also supports evidence-based decisions for future research funding, academic collaborations, and policy formulation. This study is significant because it synthesizes and visualizes global research trends at the intersection of AI and disaster management.

4 Methods

The bibliometric analysis of literature at the intersection of AI and disaster management reveals a rapidly evolving and interdisciplinary research landscape. Bibliometric analysis is a quantitative research method used to evaluate the structure, impact, and trends within a scientific domain through statistical and network-based approaches (Adarsh and Haneena Sulthana, 2025). Covering the timespan from 2000 to 2024, the dataset comprises a total of 11,055 documents sourced from 4,474 unique publication venues, reflecting the widespread academic and practical relevance of this research domain (Fig. 1).

The search was constructed using a dual-topic query to capture relevant literature. The data collection stage involved extracting research articles from Web of Science (WoS) and Scopus using well-defined search queries (queries listed below). To ensure accuracy and avoid duplication, the merged dataset was processed in RStudio, where duplicate records from the two databases were systematically identified and removed using a bibliometric analysis plugin.

Scopus: (TITLE-ABS-KEY("artificial intelligence" OR "AI" OR "machine learning" OR "deep learning" OR "neural network*" OR "natural language processing" OR "NLP" OR "computer vision" OR "predictive model*" OR "reinforcement learning" OR "robotics" OR "autonomous system*")) AND (TITLE-ABS-KEY("disaster management" OR "emergency management" OR "disaster response" OR "disaster recovery" OR "crisis management" OR "emergency response" OR "disaster mitigation" OR "disaster preparedness" OR "resilience planning" OR "hazard prediction" OR "early warning system*"))

Web of Science TS=("artificial intelligence" OR "AI" OR "machine learning" OR "deep learning" OR "neural network*" OR "natural language processing" OR "NLP" OR

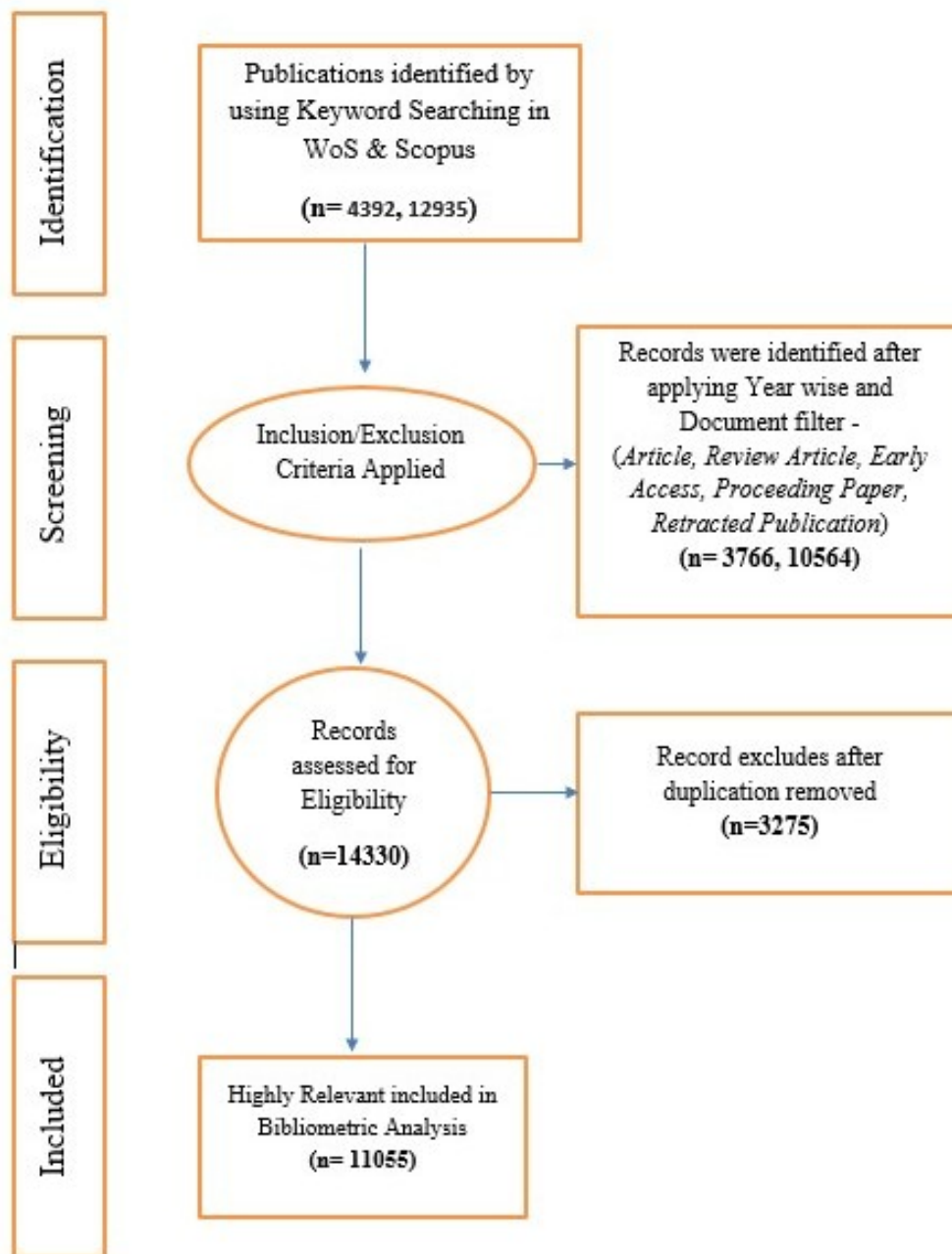


Fig. 1. Methodology flow chart.

"computer vision" OR "predictive model*" OR "reinforcement learning" OR "robotics" OR "autonomous system*") AND TS=("disaster management" OR "emergency management" OR "disaster response" OR "disaster recovery" OR "crisis management" OR "emergency response" OR "disaster mitigation" OR "disaster preparedness" OR "resilience planning" OR "hazard prediction" OR "early warning system*")

4.1 Data Analysis

The analysis was conducted using specialized bibliometric tools, Biblioshiny (an R-based bibliometric package) (Aria and Cuccurullo, 2017). The following techniques were applied:

- **Descriptive Analysis:** This involved the identifica-

tion of publication trends, prominent journals, influential authors, and citation metrics.

- **Co-occurrence Analysis:** Keywords were analysed to visualize the thematic structure of the research field using network maps.
- **Thematic Mapping:** Themes were classified based on relevance and development degree using a two-dimensional analysis, categorizing topics into Basic Themes, Motor Themes, Niche Themes, and Emerging or Declining Themes.
- **Thematic Evolution Analysis:** Temporal changes in research focus were mapped using Sankey diagrams to trace the progression of topics over different time periods

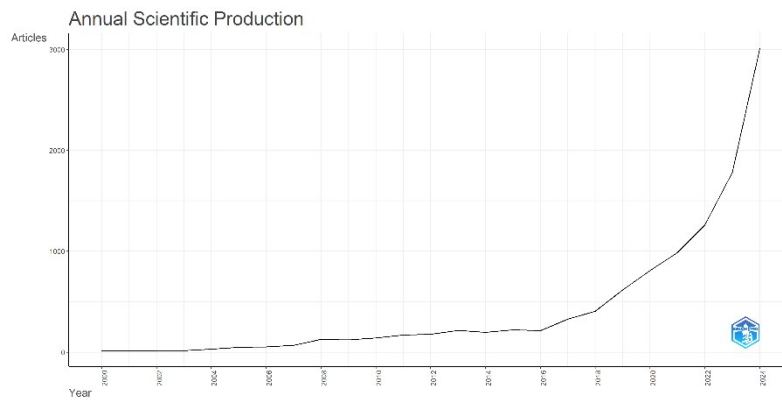


Fig. 2. Annual scientific production (all figures in this paper, except Fig. 6 has been prepared using Biblioshiny (Aria and Cuccurullo, 2017)).

- **Factorial Analysis:** Applied to identify underlying structures within the data by performing multiple correspondence analysis, thereby revealing thematic clusters.
- **Collaboration Network Analysis:** Country-level collaboration networks were assessed to identify leading research hubs and international partnerships.

5 Results and Discussion

5.1 Annual Scientific Production

The *annual scientific production* in the domain of artificial intelligence and disaster management has shown a striking upward trajectory from 2000 to 2024 (Fig. 2). Initial research activity was modest, with fewer than 20 publications annually until 2003. A gradual increase followed, with notable surges beginning in 2008 (129 articles) and 2010 (141 articles), reflecting growing academic interest and technological advancements. From 2017 onwards, the field witnessed exponential growth 328 publications in 2017 rose sharply to 407 in 2018 and nearly doubled to 811 by 2020. This rise continued consistently with 987 articles in 2021, 1262 in 2022, and a significant leap to 1782 in 2023. In 2024, the field has already produced 3010 publications, indicating an unprecedented surge likely fuelled by advancements in AI tools, heightened global disaster risks, and increased policy and research attention. This trend underscores the *maturing and strategic importance* of integrating AI technologies into disaster risk reduction, preparedness, and response frameworks globally.

5.2 Average Citations Per Year

The *average citations per article per year* in the intersection of artificial intelligence and disaster management reveal critical insights into the scholarly impact over time. During the early 2000s, citation averages were relatively high despite the low volume of publications *25.30 in 2001* and *25.06 in 2003* indicating foundational work that attracted significant academic attention.

From 2005 to 2017, the average citations remained consistently strong, fluctuating between *11.33* and *24.70*, peaking in 2018 at 33.76 citations per article, suggesting that this

period yielded particularly influential research. The year 2020 also saw a substantial mean citation rate of *27.51*, despite the pandemic-driven spike in publication volume.

However, a downward trend is evident from 2021 onward, with the citation averages declining to *18.05 in 2021*, *11.97 in 2022*, and further to *6.77 in 2023*. In 2024, the average dropped sharply to *2.38*, likely due to the recency of publications that have not yet accumulated citations. This pattern reflects both the *lag in citation accumulation for newer studies* and a shift toward more rapid, possibly applied research dissemination that may prioritize real-world utility over long-term scholarly referencing.

5.3 Most Relevant Sources

An examination of the most relevant sources contributing to the literature on artificial intelligence (AI) in disaster management reveals a concentration of scholarly output in technologically oriented and interdisciplinary publication venues. Lecture Notes in Computer Science, including its AI and Bioinformatics subseries, leads with 184 articles, followed by Remote Sensing (160) and the ACM International Conference Proceeding Series (137). IEEE Access (126) and the Proceedings of SPIE (112) also contribute significantly, indicating the prominence of engineering and imaging applications. Natural Hazards (90) adds a hazard-specific perspective, while Lecture Notes in Networks and Systems (86) and Applied Sciences–Basel (85) showcase applied research. IGARSS (84) and Sensors (81) emphasize the role of geospatial and sensor technologies. These sources highlight the field's rapid growth and technical orientation.

5.4 Sources by Bradford's Law

The Core Sources by Bradford's Law chart demonstrates the distribution of scholarly articles across various sources, identifying those with the highest concentration of publications in a particular research field. Bradford's Law, introduced by Bradford (1934), describes the dispersion of articles across scientific journals. The shaded region labelled "Core Sources" represents a small set of journals or conference proceedings that contribute disproportionately to the overall literature output. According to Bradford's Law, these sources are the most productive and frequently cited,

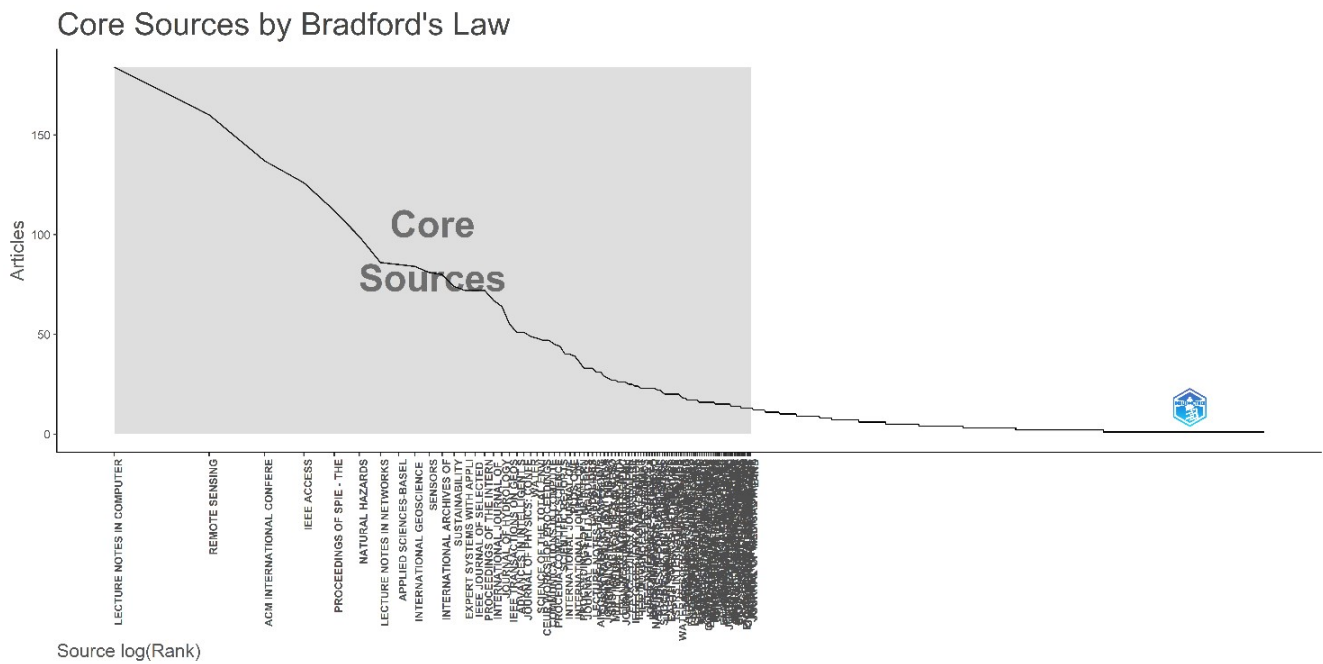


Fig. 3. Sources by Bradford's Law.

forming the nucleus of the knowledge base for the discipline under analysis.

The graph plots the number of articles on the y-axis against the logarithmic rank of the sources on the x-axis. The steep initial slope within the shaded area highlights the presence of a few highly productive journals or conferences such as Lecture Notes in Computer Science, IEEE Transactions, ACM International Conference Proceedings, and Remote Sensing that dominate the publication landscape in this domain (Fig. 3). As the curve progresses beyond this core zone, the slope flattens significantly, indicating a long tail of less frequent contributors that together form the periphery of the literature base. This visualization effectively captures the core-periphery structure typical of academic publishing, reinforcing the idea that a limited number of sources are essential for gaining comprehensive coverage of high-impact research in fields intersecting artificial intelligence, disaster management, and information systems. Identifying these core sources is crucial for researchers seeking to access seminal work and contribute to the most influential platforms in the discipline.

5.5 Sources' Local Impact

The local impact of sources publishing on *artificial intelligence in disaster management* reveals a notable blend of high productivity and citation performance. Remote Sensing leads with the highest *h-index* (36) and *total citations* (*TC*) (4297) across 160 papers, reflecting its strong influence since 2010. Expert Systems with Applications follows with an *h-index* of 28 and 2332 citations, indicating steady contributions since 2004. IEEE Access, despite starting in 2016, has rapidly gained prominence with 126 papers and 2571 citations, showcasing fast-growing relevance. Journals such as the Journal of Hydrology, Natural Hazards, and Science of the Total Environment all share an *h-index* of 26.

underlining their balanced impact in hydrological, hazard, and environmental contexts. The IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing shows a robust presence with 72 papers and 2376 citations. Newer entrants like the International Journal of Disaster Risk Reduction and Sensors, both beginning in 2017, have quickly established themselves, with 65 and 81 publications respectively.

The Journal of Field Robotics, though smaller in volume (33 papers), holds an *h-index* of 19, suggesting specialized but impactful contributions. Overall, these sources underscore a diverse and interdisciplinary research base, merging AI, environmental science, engineering, and applied robotics in the service of disaster resilience.

5.6 Most Relevant Authors

The most relevant authors in the domain of *artificial intelligence and disaster management* are characterized by high publication productivity, often with significant collaborative contributions. Wang Y emerges as the most prolific author, with 170 articles and a fractionalized count of 39.22, indicating extensive collaboration. Zhang Y follows closely with 157 articles and 32.31 fractionalized contributions, while Li Y also demonstrates substantial output (151 articles, 32.10 fractionalized).

Other prominent contributors include Wang J (145 articles), Li J (130), and Wang X (121), all with notable co-authorship levels, suggesting active involvement in team-based, interdisciplinary research. Authors such as Liu Y, Wang H, Zhang H, and Wang Z also feature prominently, reflecting a strong representation of Chinese scholars in this field. The repeated surnames and initials suggest commonality in authorship across institutions, highlighting a potentially concentrated research network driving advancements at the intersection of AI and disaster resilience.

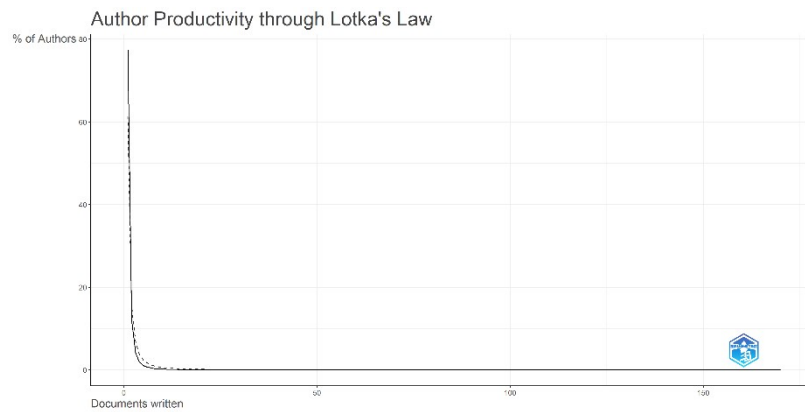


Fig. 4. Author productivity through Lotka's Law.

5.7 Author Productivity through Lotka's Law

The graph titled “*Author Productivity through Lotka's Law*” visually demonstrates the skewed distribution of scholarly output, where a small proportion of authors contribute the majority of publications. Lotka (1926) defines authors productivity, a principle in bibliometrics, most authors publish only one paper, while very few produce a high volume of work. This pattern is clearly evident in the steep initial decline of the curve, where over 60% of authors have written just one document, as seen on the y-axis. As the number of documents written increases along the x-axis, the percentage of contributing authors drops sharply and flattens out, reinforcing the *inverse square relationship* central to Lotka's theory (Fig. 4). This suggests that in any scientific field, research is predominantly driven by a small group of highly productive individuals, while the vast majority contribute occasionally. The curve's sharpness and long tail reflect the *inequitable but consistent nature* of academic productivity across disciplines.

5.8 Authors' Local Impact

The local impact of the most relevant authors in the field of *artificial intelligence and disaster management* is underscored by both publication volume and citation strength. Wang Y leads with the highest *h-index* (26), *total citations (TC)* of 2646, and an extensive publication count of 170 since 2006, reflecting both productivity and sustained influence. Wang J and Li J also demonstrate strong academic presence, each with an *h-index* of 23, but Wang J shows higher citation impact (2410 TC) across 145 papers, compared to Li J's 1627 TC over 130 publications.

Li Y and Zhang Y maintain similar influence levels with over 150 publications each and *h-indices* in the low twenties, indicating consistent scholarly contributions. Pradhan B, though with only 24 papers since 2013, stands out for his high citation count (2432) and *h-index* of 19, pointing to significant impact per publication. Other notable authors include Li X, Liu X, and Zhang H, all showing solid metrics in terms of both quantity and quality. These authors form the intellectual core of the domain, pushing the frontiers of AI applications in disaster risk reduction and resilience.

5.9 Most Relevant Affiliations

The most relevant institutional affiliations in research on *artificial intelligence and disaster management* are predominantly concentrated in East Asia, with a strong representation from China. The Chinese Academy of Sciences leads with 240 articles, underscoring its central role in driving innovation and interdisciplinary studies in this domain. China University of Geosciences (157 articles) and Wuhan University (140 articles) follow, both renowned for their geospatial and earth sciences research capacities.

Tsinghua University and the Ministry of Education – China also contribute significantly, reflecting strong governmental and academic integration in AI-driven disaster studies. Internationally, Tohoku University (Japan) and National Taiwan University stand out with 79 and 75 articles respectively, pointing to regional collaboration and excellence. The presence of the Egyptian Knowledge Bank (EKB) indicates emerging contributions from the Middle East, suggesting expanding global interest and involvement. Collectively, these institutions form the academic backbone of the field, facilitating major scientific outputs and cross-sectoral partnerships.

5.10 Corresponding Author's Countries

The geographic distribution of corresponding authors in the field of *artificial intelligence and disaster management* highlights the global scope and collaboration patterns within this research domain. China leads substantially, contributing 22.8% of all articles, with a dominant share of single-country publications (SCP) at 89.5%, reflecting strong institutional capacity and internal collaboration. The United States ranks second (9.3%), with a slightly higher multiple country publication (MCP) rate of 9.9%, indicating robust international partnerships alongside domestic research (Fig. 5).

India, contributing 8.1%, has one of the highest SCP percentages (95%), emphasizing its largely independent research output. Korea contributes 2.9% of articles, with 18.9% MCP, suggesting a moderate balance between domestic and international research. Italy (2.2%) and Germany (1.9%) exhibit notable international engagement, with MCP rates of 14.7% and 19%, respectively.

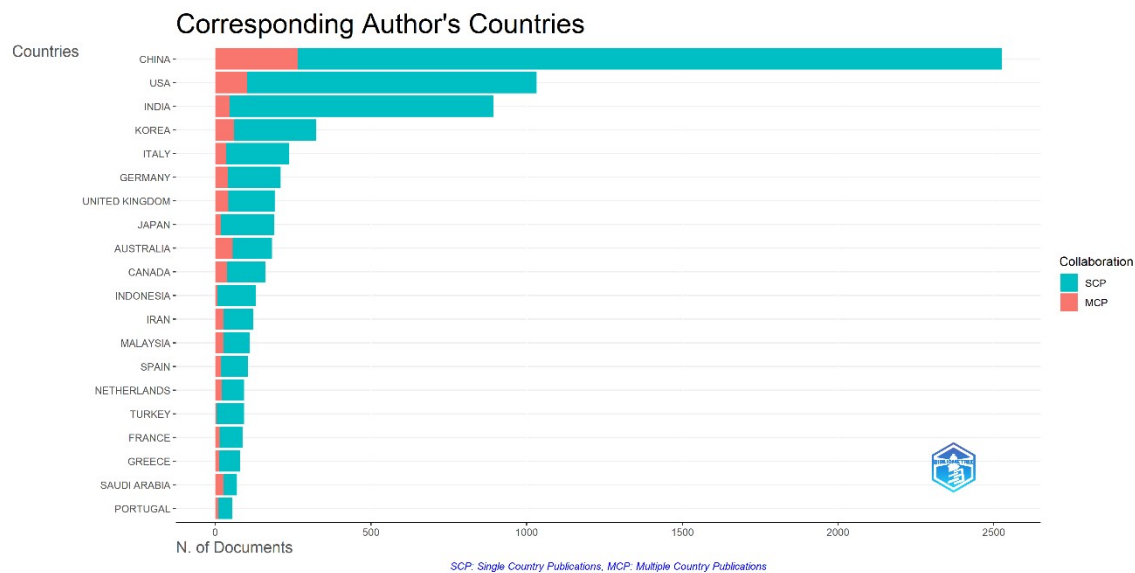


Fig. 5. Corresponding author's countries.

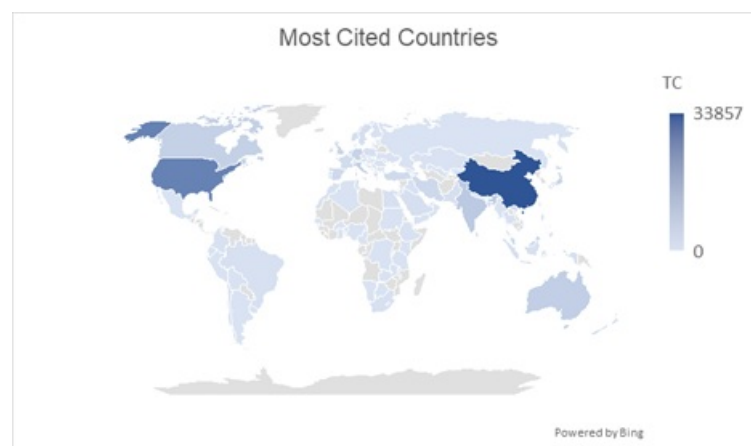


Fig. 6. Most cited countries.

The United Kingdom, while contributing a smaller portion (1.7%), stands out for its high MCP rate (22%), underlining its commitment to international collaboration. Similarly, Australia (1.6%) shows the highest MCP value (30.8%), reflecting its global research orientation. Japan, also at 1.7%, maintains a primarily national focus with 91% SCP, while Canada (1.4%) demonstrates strong international collaboration (23.1% MCP). These patterns reveal a research ecosystem where countries like China, India, and Japan focus on domestic productivity, while others like Australia, Canada, and the UK emphasize global cooperation, collectively advancing the field through both independent innovation and cross-border collaboration.

5.11 Countries' Scientific Production

In terms of *scientific production* on artificial intelligence applications in disaster management, China leads significantly with 5,186 publications, reflecting its dominant research output. The United States follows with 2,884 publications, marking its strong presence in the field. India ranks third with 1,792 documents, showing notable engagement,

though with relatively lower citation impact. Other key contributors include South Korea (586), Italy (557), Germany (534), the United Kingdom (521), Australia (511), Japan (474), and Canada (418). These figures highlight the global interest and research momentum in leveraging AI for disaster-related challenges.

5.12 Most Cited Countries

In the domain of *artificial intelligence and disaster management*, China leads with 33,857 total citations, reflecting a high volume of research (Fig. 6). However, the United States has a higher average citation per. article at 22.20, indicating more influential publications. Canada and Australia top the average citation metric with 26.5 and 26.3 respectively, suggesting impactful but fewer studies. India ranks third in total citations (5,933) but has a lower average citation of 6.6 per article, indicating moderate impact. Other notable contributors include South Korea, Italy, Germany, the United Kingdom, and Japan, all with average citations ranging from 17.5 to 19.8, highlighting consistent research quality. This data reveals variations in both



Fig. 7. Most frequent words.

productivity and influence across leading countries in this research field.

5.13 Most Global Cited Documents

Among the most globally cited documents in the field, Ferentinos K's 2018 paper in *Computers and Electronics in Agriculture* leads with 2,166 total citations and 270.75 citations per year. Following this, Reichenbach P's 2018 review in *Earth-Science Reviews* has garnered 1,289 total citations. Other highly cited works include Mishra A's 2011 article in *Journal of Hydrology* (962 citations) and Cully A's 2015 paper in *Nature* (815 citations). Recent influential contributions such as Amani M's 2020 publication in *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* and Chamola V's 2020 article in *IEEE Access* also stand out with over 550 citations each. Additional notable documents come from Devkota K (2013), Yin J (2012), and Govindan K (2020), all surpassing 500 citations, demonstrating sustained impact across diverse journals.

5.14 Most Frequent Words

The most recurrent keywords in the literature examining the convergence of *artificial intelligence* and *disaster management* illuminate the thematic landscape of this growing research domain. The word “*disasters*” appears most frequently with 1708 occurrences, highlighting the broad scope of the field. This is followed closely by “*artificial intelligence*” with 1402 mentions, establishing its centrality in the discourse (Fig. 7). Key subdomains such as “*disaster prevention*” (1339) and “*deep learning*” (1303) underscore the integration of intelligent systems for anticipatory action. The term “*disaster management*” registers 1196 occurrences, emphasizing the application-focused nature of the field.

Technological priorities are evident in the high frequency of “*early warning system*” (1057) and “*machine learning*” (1044), reflecting efforts to automate and improve forecasting accuracy. Strategic aspects are captured by “*risk management*” (789) and “*decision making*” (779), pointing to the field’s relevance in policy and planning. Lastly, “*learning systems*” with 678 mentions signals an emphasis on adaptive, evolving models for complex disaster environments.

5.15 Trend Topics

The *Trend Topics* offers a comprehensive view of how research interests have evolved in the field of artificial intelligence and disaster management over the past two decades. From 2004 to 2024, there is a visible transition from traditional concepts to more advanced, data-driven methodologies. Early years focused on foundational themes such as “*estuaries*”, “*radiation effects*”, “*mathematical models*”, and “*international conferences*”, reflecting a broader scope of environmental and theoretical considerations. These topics, although significant in the past, have gradually given way to more technology-centric terms.

In recent years, especially from 2020 onwards, the focus has shifted heavily toward “*machine-learning*”, “*real-time*”, “*deep learning*”, and “*early warning system*”. These terms indicate a rising interest in applying cutting-edge artificial intelligence tools for predictive analytics, quick response, and automated decision-making in disaster scenarios. The prominence of “*disaster prevention*”, “*disaster management*”, and “*emergency services*” throughout the timeline shows that these remain central pillars of the field, albeit increasingly supported by AI innovations.

Moreover, technical and computational aspects such as “data mining”, “neural networks”, “algorithms”, and “decision support systems” have become integral to research in this domain. These terms highlight the ongoing efforts to develop intelligent systems capable of managing complex datasets and improving decision-making under uncertainty. Over time, research has moved from general environmental and theoretical areas to sophisticated AI-based approaches, emphasizing machine learning, deep learning, and real-time systems. This evolution highlights the growing role of artificial intelligence in enhancing disaster management to be more proactive, efficient, and responsive rather than merely reactive.

5.16 Co-occurrence Network

The *Co-occurrence Network* graph visualizes the interconnections among key terms in the research domain, reflecting thematic associations based on their frequency of appearing together in literature. At the heart of the network lies the dominant theme of “*disasters*”, marked by the largest node, indicating its central role in the discourse. Closely linked to it are major clusters such as “*disaster prevention*,” “*artificial intelligence*,” “*disaster management*,”

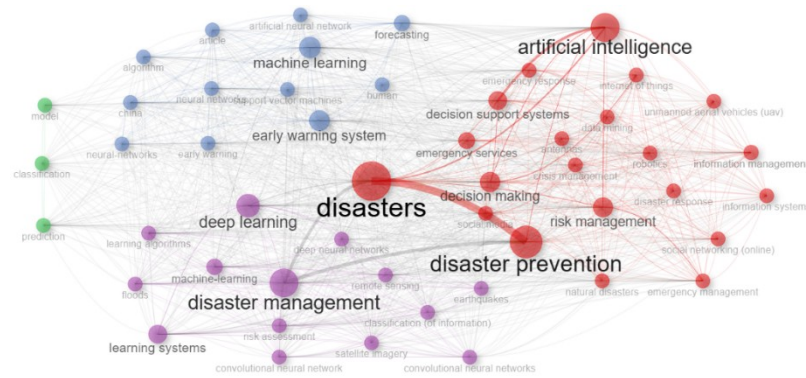


Fig. 8. Co-occurrence network.

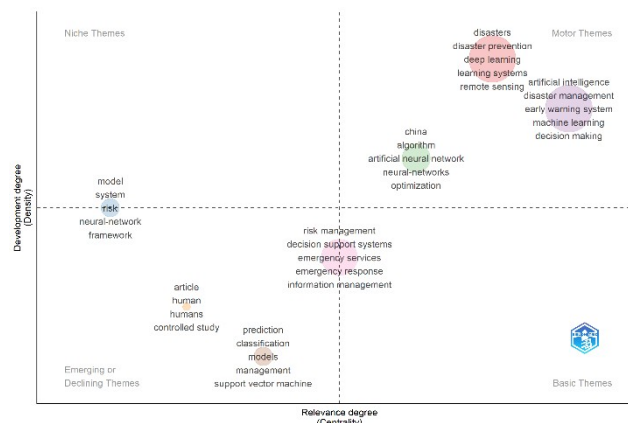


Fig. 9. Thematic map.

and “*decision making*,” illustrating a multi-dimensional approach to disaster studies

where strategic planning, technology, and governance converge. The *red cluster* on the right prominently features “*artificial intelligence*”, “*decision support systems*,” and “*risk management*,” suggesting a strong correlation between AI-based solutions and decision-making processes in the context of disaster prevention and mitigation (Fig. 8). This cluster also integrates terms like “*information systems*,” “*social networking*,” and “*internet of things*,” signifying the growing reliance on digital infrastructure and data systems for emergency preparedness and response.

The *purple cluster* emphasizes technological interventions with keywords such as “*deep learning*,” “*learning systems*,” “*remote sensing*,” and “*satellite imagery*,” revealing a focus on geospatial technologies, AI-driven modelling, and predictive analytics. These are crucial for early warning, monitoring, and post-disaster assessment. The *blue cluster* is centered around “*machine learning*” and “*early warning systems*,” linking to terms like “*support vector machines*,” “*forecasting*,” and “*algorithm*,” which reinforce the analytical and algorithmic backbone of disaster informatics. The *green nodes* represent relatively isolated themes such as “*model*,” “*prediction*,” and “*classification*,” which, though not highly central, provide essential technical methods supporting the broader disaster-AI framework. The co-occurrence network identifies “disasters” as the core focus, surrounded by clusters emphasizing

ing AI, decision support systems, machine learning, and geospatial tools, demonstrating how technology, analytics, and strategic planning converge in disaster management research. Overall, it highlights a tightly connected research landscape where AI, decision-making, and technological advancements collectively guide the field's development.

5.17 Thematic Map

The *Thematic Map* presents a strategic diagram categorizing keywords into four quadrants based on their development degree (density) and relevance degree (centrality) (Fig. 9). The *Motor Themes* terms like *disaster prevention*, *deep learning*, *remote sensing*, and *machine learning* appear as both well-developed and crucial for the research field, indicating core and influential areas of study. The *Basic Themes* hosts terms like *risk management*, *emergency services*, and *decision support systems*, which are fundamental but not yet fully developed, suggesting they form the groundwork of ongoing studies. The *Niche Themes* includes terms such as *model*, *system*, and *risk*, reflecting highly specialized but less influential areas. Meanwhile, the *Emerging or Declining Themes* contains terms like *article*, *human*, *controlled study*, and *support vector machine*, which may represent topics either gaining initial interest or fading in relevance. Overall, this map offers a comprehensive view of thematic dynamics, highlighting which concepts are central, peripheral, established, or emerging within the analysed literature.

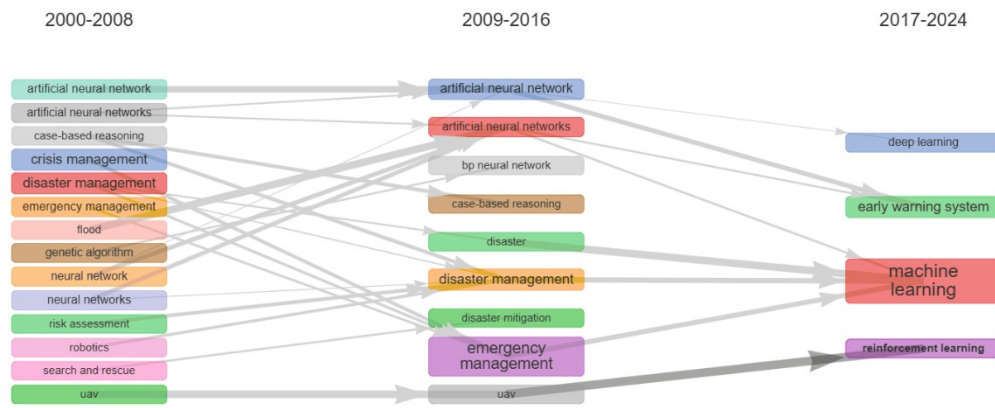


Fig. 10. Thematic evolution.

5.18 Thematic Evolution

The *Thematic Evolution* map highlights the progression and transformation of key research themes in the domain of artificial intelligence and disaster management from 2000 to 2024. In the initial phase (2000–2008), the field was dominated by foundational concepts such as “artificial neural network”, “disaster management”, “emergency management”, “crisis management”, “neural networks”, and “uav”. These terms reflect early research efforts to apply basic AI models and technologies to disaster-related challenges, focusing largely on assessment, rescue, and response mechanisms (Fig. 10).

During the mid-phase (2009–2016), some of these early concepts persisted, but the field began to see a convergence of themes. For instance, “disaster management” continued as a central pillar, while more nuanced terms such as “disaster mitigation”, “case-based reasoning”, and “bp neural network” emerged. Notably, “emergency management” became a more prominent and distinct theme, indicating a shift toward structured, system-level approaches to handling emergencies. At the same time, the concept of “artificial neural networks” evolved with deeper investigations into specialized AI models.

From 2017 to 2024, the thematic landscape underwent a significant transformation with the rise of cutting-edge AI technologies. “Machine learning” emerged as the dominant theme, absorbing earlier neural network-related research and extending its applications across disaster scenarios. This period also introduced “deep learning”, “early warning system”, and “reinforcement learning” as key areas, showcasing a clear transition from theoretical models to high-performance, predictive systems. These developments reflect the current focus on automation, real-time decision-making, and proactive disaster risk reduction, marking a major evolution in the research community’s approach to addressing disasters using artificial intelligence. Thematic evolution shows a shift from early AI applications like neural networks and emergency management (2000–2008) to more advanced, predictive technologies such as machine learning, deep learning, and early warning systems (2017–2024), highlighting a transition toward automation and proactive disaster risk reduction.

5.19 Factorial Analysis

The *Factorial Analysis* map presents a conceptual structure of the research field through Multiple Correspondence Analysis (MCA), revealing how keywords are distributed and associated within the domain. The visual layout is shaped by two primary dimensions, Dim 1 (horizontal) and Dim 2 (vertical), capturing the variance among conceptual clusters (Fig. 11). On the left side of the map, keywords such as “emergency management”, “risk management”, “decision support systems”, and “crisis management” dominate, reflecting a strong thematic focus on policy-oriented and system-level disaster response mechanisms. These terms also align with “information systems” and “artificial intelligence”, signifying the integration of technology into strategic decision-making frameworks.

In the central region, keywords like “disaster management”, “data mining”, “unmanned aerial vehicles (uav)”, and “internet of things” highlight the operational and technological nexus of disaster monitoring and real-time intelligence gathering. This area bridges the gap between high-level policy frameworks and ground-level applications. Closer to the right side of the map, a clear cluster emerges around advanced AI methodologies, including “machine learning”, “deep learning”, “support vector machines”, and “convolutional neural networks.” This cluster signifies a shift towards automation, prediction, and data-driven modelling in disaster scenarios. Keywords like “prediction”, “early warning”, and “classification” are strongly associated with this end, showcasing the application of AI in proactive disaster mitigation.

At the extremes of the right-hand side, terms such as “China”, “human”, and “article” may indicate dominant regional contributions or metadata-related tags. Meanwhile, the lower section, characterized by terms like “satellite imagery”, “remote sensing”, and “antennas”, points to geospatial and sensor-based technologies. Factorial analysis uncovers a conceptual framework spanning policy-oriented areas, including emergency and risk management, to technology-driven clusters like machine learning, deep learning, and predictive analytics, showcasing the blend of governance, technological solutions, and geospatial tools in disaster management. Overall, the factorial map highlights

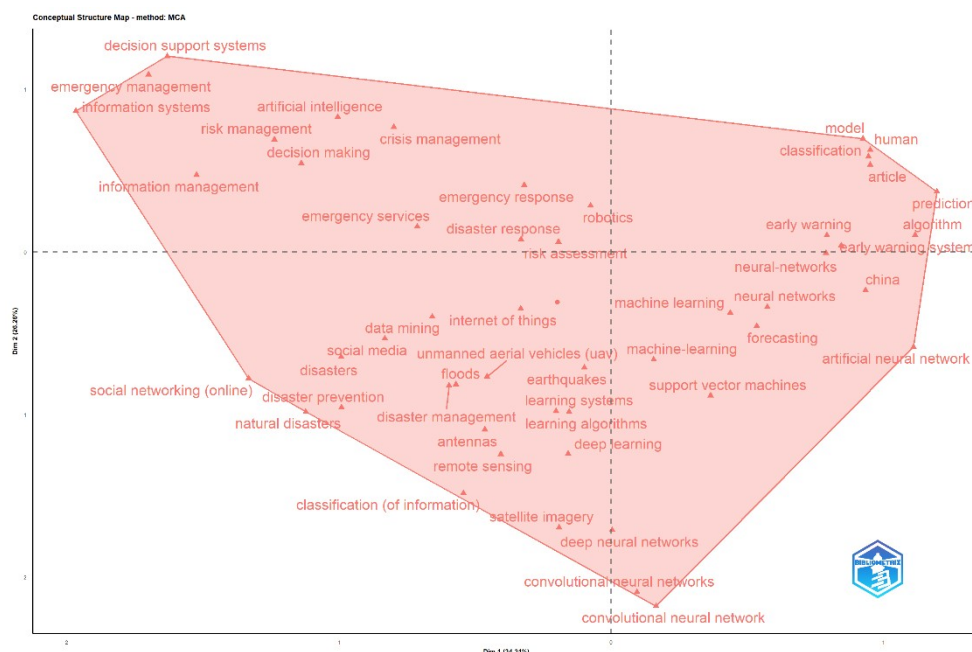


Fig. 11. Factorial analysis.

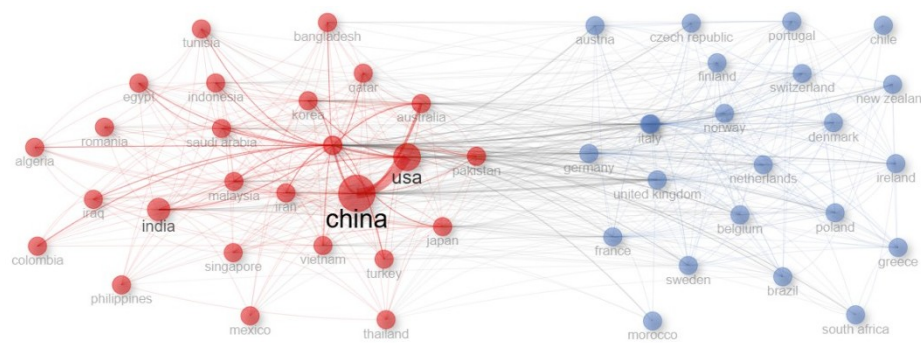


Fig. 12. Collaboration network.

the comprehensive and evolving knowledge base of the field, integrating both strategic oversight and AI-powered predictive capabilities.

5.20 Collaboration Network

The *collaboration network graph* illustrates the global pattern of research partnerships, with countries represented as nodes and their collaborative ties shown through connecting lines. Larger nodes like *China* and the *USA* dominate the visualization, highlighting their pivotal roles in international research, especially in fields such as *artificial intelligence*, *disaster management*, and *risk reduction* (Fig. 12). These two countries form the core of a dense red cluster, which also includes India, Iran, Malaysia, and several other *Asian* and *Middle Eastern* nations, indicating strong regional collaborations.

In contrast, a blue cluster features *European* and *developed nations* like the United Kingdom, Germany, France, the Netherlands, and the *Scandinavian countries*, which primarily collaborate within their group but also maintain links with the *USA*. *Bridging countries* such as Germany and the UK appear to connect the two major clusters, facil-

itating *cross-regional academic interactions*. Notably, an *unnamed but prominently positioned node near China* is likely to be Canada, given its usual collaborative relationships with both *China* and the *USA*.

6 Conclusions

The bibliometric analysis reveals a sharp and sustained growth in research at the intersection of artificial intelligence and disaster management, with publication output peaking at over 3,000 in 2024. This surge reflects both technological advancement and increasing global recognition of AI's role in disaster risk reduction. China leads in research volume, while countries such as the U.S., Canada, and Australia demonstrate higher citation impact, pointing to influential contributions. Keyword and thematic analyses identify core focus areas including deep learning, early warning systems, and disaster prevention, along with emerging areas like remote sensing and geospatial intelligence. Co-occurrence and thematic maps emphasize the central role of AI in predictive modelling, decision-making, and real-time response. Although collaborative efforts are present, international partnerships remain limited, highlighting the

potential for expanded global cooperation. Overall, the study presents a dynamic and evolving field with substantial practical relevance, encouraging greater cross-border collaboration and integration into disaster resilience strategies.

Conflict of Interest

The authors declare that there is no conflict of interest.

CRediT statement

Adarsh T.: Conceptualization, Methodology, Data Collection, Bibliometric and Factorial Analysis, Visualization, Writing – Original Draft, Writing – Review & Editing.; **Haneena Sulthana K.P.:** Assisted in Data Collection, Contributed to Writing – Review & Editing.; Both authors discussed the results together and approved the final version of the manuscript.

Data Availability

This study is based on bibliometric data retrieved from the Scopus and Web of Science databases. Due to licensing restrictions of the databases, the full datasets cannot be shared publicly; however, processed data and analytical outputs used in the study are available from the corresponding author upon reasonable request.

AI-Assistance Disclosure

No AI tool was used for data analysis, interpretation, or drawing of conclusions. All responsibility for the content rests with the authors.

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