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Review article

Climate Change and Flooding: Bibliometric Analysis to Identify Future Research

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Abstract

Among the various hydroclimatic phenomena, floods occupy a special place due to their environmental and socio-economic impact. However, identifying the main focus of research related to climate change and floods requires the examination of a large number of publications. This article presents a bibliometric analysis of publications on climate change and floods from the Web of Science database during the period 2015 to 2024. The analysis indicates that climate change-induced flood research is a rapidly expanding and increasingly popular field. The majority of publications (94%) were scientific articles, and in the 5 years up to 2024 there has been an improvement in their quality. Much of the research was conducted in China, the US, and EU. The Chinese Academy of Sciences is a leader in this field, and journals such as Science of the Total Environment, Water, and the Journal of Hydrology are active in disseminating research results. Bibliometric analysis using VOSviewer and Bibliometrix found that in the climate change context, the major institutions are studying precipitation changes and water management in catchments. Flood susceptibility and streamflow forecasting are the central topics that need to be studied in-depth in order to develop highly accurate early warning systems. During the process, physically-based hydrological modelling must also be incorporated using advanced soft computing techniques, particularly machine learning, artificial neural networks, and geospatial tools such as geographic information systems and remote sensing.

Keywords: Climate Change; Flash Flooding; River Flooding; Bibliometric Analysis; Web of Science.

1. Introduction

Flooding occupies a prominent place among the various hydroclimatic phenomena due to its significant environmental, economic and social impact (Alfieri *et al.,* 2017; Baldi *et al.,* 2020; Kuntla *et al.,* 2022; Z. Yu, 2015). There are several types of floods: river floods, flash floods, coastal floods and compound flooding, which have been causing damage, harm, and economic and non-economic losses over the past years. According to the United Nations Office for Disaster Risk Reduction (UNDRR), 7,348 major natural disasters were recorded worldwide between 2000 and 2019 (Islam *et al.,* 2021; Quesada-Roman *et al.,* 2022). Among these natural disasters, floods were one of the most common, with the number more than doubling from 1,389 in 1980-1999 to 3,254 in 2000-2019. The Historical Analysis of Natural Disasters in Europe (HANZE) database contains information on floods (Paprotny *et al.,* 2018). Data are available for 1,564 flood events occurring in 37 European countries, of which 56% were flash floods, 29% river floods, and the remainder coastal and compound floods. Notably, 99% of reported cases involved loss of human life. The phenomenon is also outlined in a report by the Intergovernmental Panel on Climate Change (IPCC), which notes that extreme precipitation events that cause flooding will increase globally, with some regions seeing an increase of up to 20% by the end of current century (Alfieri *et al.,* 2017; Barlow *et al.,* 2019). Understanding the causes of floods, flood-associated damage, and modern, high-performance approaches to flood assessment are essential for guiding future research directions.

Coastal flooding is dependent on the characteristics of the regions adjacent to oceans and seas, while floods resulting from the urbanisation of territories are caused by the low capacity of city drainage systems (Azour *et al.,* 2025; Ben Moshe & Lensky, 2024; Han *et al.,* 2022). However, in almost all regions of the globe, flash floods and river floods can be observed (Narangerel & Suzuki, 2024; Paprotny *et al.,* 2018), with global climate change affecting the frequency and duration of such floods. The flash flood that occurred in the state of Louisiana, USA in August 2016 confirmed that due to climate change, the once-in-550-years heavy rainfall that led to the flood event is now occurring every 30 years (Van Der Wiel *et al.,* 2017). According to UNDRR, because of climate change the probability of a once-in-100-years flood increased from 63 percent in 1990 to 86 percent by 2025 (United Nations Office for Disaster Risk Reduction, 2025). Aryal *et al.,* (2022) also considered the frequency of floods, showing that those occurring once in 100-years will increase by up to 2.5 times as a result of climate change in futute. Research results based on the Representative Concentration Pathway 4.5 (RCP4.5) and RCP8.5 climate scenarios also indicate an increase in the severity of annual floods in the future (Edamo *et al.,* 2022).

The occurrence of flash and river floods is influenced not only by the amount of precipitation, but also by the dynamics of snow/glacier melting, the topography of the area, river morphometry, natural and anthropogenic drainage capabilities, and the state of land use in the area (Abd-Elaty *et al.,* 2022; Azour *et al.,* 2025; Garner *et al.,* 2015; Zeleňáková *et al.,* 2019). Due to the complexity of flood forecasting, several assessment methods have been developed, such as flood susceptibility, flood hazard, flood vulnerability and flood risk analysis (Ali *et al.,* 2025; Morelli *et al.,* 2024; Pörtner *et al.,* 2022). These assessments rely on various techniques, including physically-based hydrological modelling, soft computing, and statistical and multi-criteria decision making (MCDM) (Al-Rawas *et al.,* 2024; Kaya & Derin, 2023; Khalid *et al.,* 2023; Morante-Carballo *et al.,* 2022; Patil *et al.,* 2025; Qing-Long *et al.,* 2017; Ulfiana *et al.,* 2023). These assessment methods, which require the consideration of more than ten main, and many other subsidiary conditioning factors, in most cases use hybrid modelling methods (Chapi *et al.,* 2017; Kaya & Derin, 2023). If researchers are familiar with contemporary research directions in climate change-induced flood research and effective methods for implementing these, this would lead to the creation of high-level scientific work linked to specific case studies.

It is necessary to analyse a large volume of studies to identify the most contemporary research direction, the methodologies used in it, and the conditioning factors that should be taken into account. In this case, a systematic literature review alone is not sufficient; instead, bibliometric analysis and meta-analysis are very effective in analysing quantitative literature (Passas, 2024). However, quantitative analysis of the literature does not always yield the expected results. Unlike meta-analysis, bibliometric analysis provides both quantitative and qualitative analysis (Donthu *et al.,* 2021; Passas, 2024). A bibliometric review conducted by Ali *et al.,* (2025) found that the primary focus of climate change-induced flood research was flood susceptibility, flood vulnerability and flood risk analysis. In another, more comprehensive bibliometric review, Hinge *et al.,* (2024) explained that the geographic information system (GIS), machine learning (ML), statistical models and the analytical hierarchy process (AHP) were the main research methods used by researchers in studying flash flood susceptibility. In addition, a review by Madushani *et al.,* (2025) of South Asian research highlighted that climate change, vulnerability and risk assessment were the key concerns of researchers studying the process using GIS and remote sensing (RS) in the area. The above studies demonstrate that bibliometric analysis methods are effective in quantitative literature reviews, but it is unclear what the most prevalent topics in climate change-induced flood research are; what the most valuable investigation methods are; and what tools should be used globally.

As the climate changes, flood research is also becoming increasingly important. There are a variety of research areas and methodologies in climate change-induced flood studies, so to conduct a comprehensive review demands a sufficiently large sample of scholarly works. The objective of this review study is to identify a primary research area, and the approaches and tools used in the study of climate change-induced flood research using bibliometric analysis tools, together with identification of future research directions. To achieve this objective the following research questions were addressed:

1 – What is the current publication trend, and which countries, institutions and key authors are having the most impact in the field of climate change-induced flood research?

2 – Citations and CiteScore: What topics and methods are attracting academic attention? The role of the journal in popularizing research in this area.

3 – What are the emerging topics amongst researchers, and in the evolution in the field of climate change-induced flood research?

2. Methods

Bibliometric analysis was used to identify a primary research area, and the approaches and tools used in studying floods under the climate change context, in order to guide future research directions. Scopus and Web of Science (WoS) databases are considered main sources for both scientometrics and bibliometrics (Mongeon & Paul-Hus, 2016). This review study was conducted using WoS, a highly selective and trusted source for research on earth and environmental sciences (Li *et al.,* 2018; Mongeon & Paul-Hus, 2016), while Scopus boasts extensive coverage and advanced indexing capabilities in this field (Li *et al.,* 2018) . The methodological framework of the review study consisted of three parts: data collection, cleaning and preprocessing, and analysis (Figure 1).

In the data collection process, the keywords “climate change”, “flash flooding”, “river flooding” and “modeling” were used to search works published between January 1, 2015, and December 31, 2024. In the process, the WoS Categories Water Resources, Environmental Science, Geoscience Multidisciplinary, Meteorology Atmospheric Science, Engineering Civil, Environmental Study, Geography Physical and Remote Sensing were selected as potential categories. As a result, based on the search engine, 233 publications in the English language were downloaded for analysis. Mendeley was used as a data collection tool and for preprocessing.

In the data cleaning and preprocessing stage, the abstracts of all the downloaded publications were screened for their relevance to the topic of climate change and floods. Mendeley found no duplicates, but after screening ten publications were found to be outside the topic. These articles investigated the impact of the population rate on ecology (Vincenzi *et al.,* 2016); water quality in coastal zones (Robins *et al.,* 2019); geospatial modelling of large wood supplies (Steeb *et al.,* 2023); coastal and urban flood resilience (Han *et al.,* 2022; Yuan *et al.,* 2024); suspended sediment transport (Nerantzaki et al., 2015); and projection of flash droughts in headstream areas (X. Yu *et al.,* 2023) amongst others.

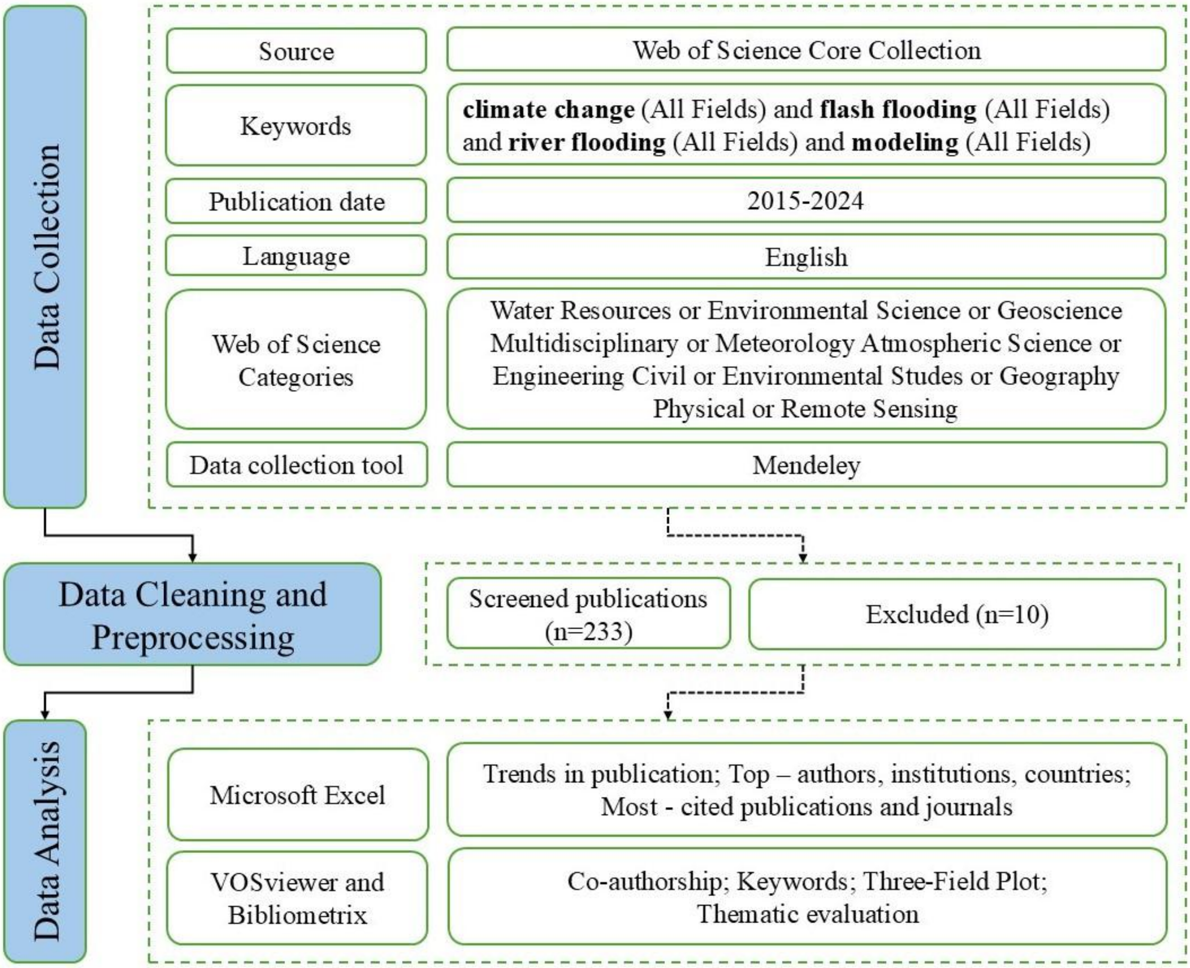

Figure 1. Methodological Framework of the Study.

In the final stage, to achieve the research objective and address the research questions tagged, the 223 selected publications were categorised and analysed numerically, based on the annual number of publications that showed a trend related to the topic; a list of top authors who have been conducting quantitative work on this field; the top institutions specialised in climate and flood-related research; the top countries fighting to reduce the socio-economic and environmental impact of disasters; the most cited publications that have been the focus of academic communities; and the most cited journals active in popularising articles over the last decade. Using bibliometric tools, the co-occurrence of authors, co-occurrence of keywords, thematic evolutions and Three-Field Plot analysis were tested by VOSviewer software (version 1.6.17) and Bibliometrix to explore the knowledge components and novelty of the research. These are well-developed tools for research mapping and bibliometric analysis, with a variety of analytical and visualisation capabilities(Allayorova *et al.,* 2025; Aria & Cuccurullo, 2017; Morante-Carballo *et al.,* 2022; Salokhiddinov *et al.,* 2025).

3. Results and Discussion

3.1. Trends in Climate Change-Induced Flood Research Publications

The data show that out of the 223 publications, the vast majority of 210 (94%) were scientific articles. These were followed by six (3%) proceeding papers and four (2%) review articles, while only three (1%) were book chapters. In terms of article coverage, they were mainly devoted to the following four categories: 50.4% of the publications dealt with water resources; 44.4% environmental sciences; 37.1% multidisciplinary geosciences; 22.6% meteorology atmospheric sciences. The quantity and trajectory of the publications over the given time period indicate the importance of a certain research field within the scientific community. Natural logarithmic trend analysis of the number of publications indicates two phases (Figure 2).

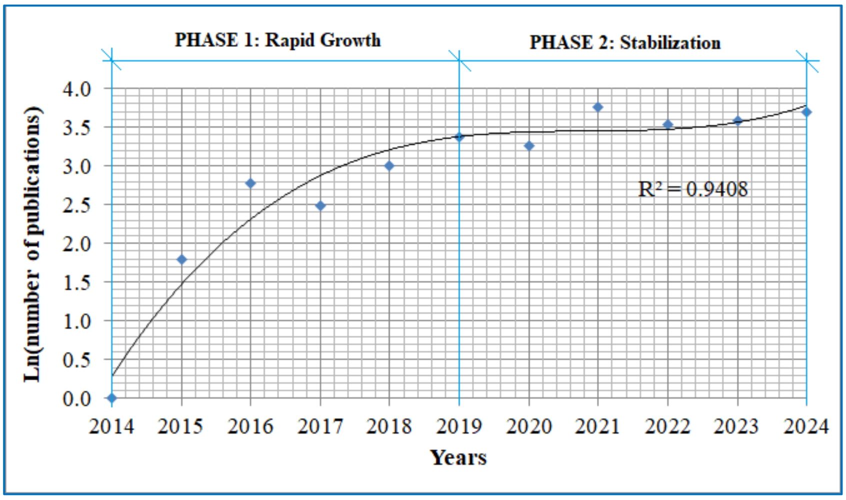

Figure 2. Trend Analysis of Publication Number.

There was a rapid growth in the number of publications from 2014 to 2019. The strong upward trajectory increased from near 0 to around 3.4, indicating exponential growth in publication activity. This phase represents the emergence and rising interest in flood-related research in the climate change context (Figure 2). On the other hand, there is a flattening of the curve and small fluctuations in values in the second phase. However, this phase may indicate that the research community were focusing on deeper specialisation or applications, rather than volume growth (Table 1). This two-phase development trajectory is also very useful for thematic evolution (Figure 10).

3.2. Authors and Their Affiliated Institutions

In the process of analysing the publications, a total of 1076 authors were identified. The eight most prolific ones (with at least four publications) are shown in Figure 3. These authors accounted for around 15% of the publications. Among them, Stoffel from the University of Geneva had the highest rating with six (almost 3%) articles. Costache, Li, Lu, Pham, Wang, Xiong and Zhang followed, with four scientific articles each. It should be noted that almost half of the leading authors were from China.

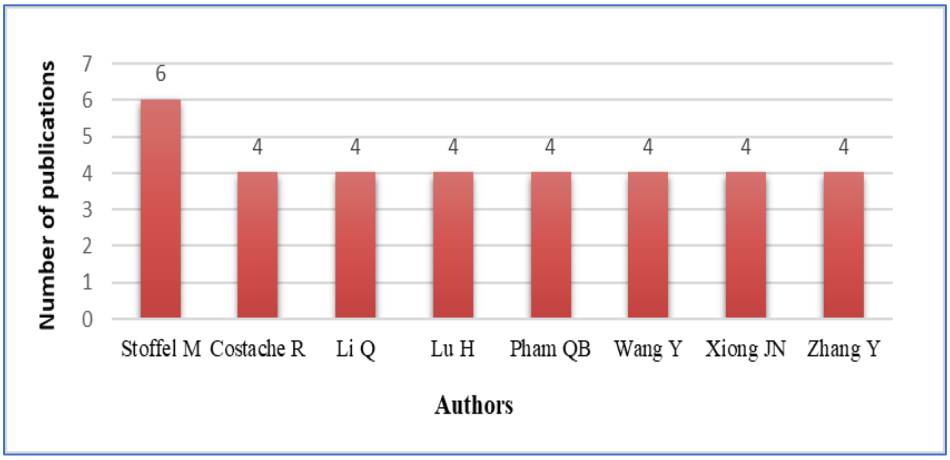

Figure 3. List of Top Authors Conducted Research on Climate Change-Induced Flood.

Figure 4 shows the ten most productive institutions by number of publications over the 10-year period. During this time, 573 different institutions collaborated, publishing 210 articles on climate change and floods. The results show that more six of the ten most productive institutions were from China, with the Chinese Academy of Sciences taking first place (12 publications), followed by Beijing Normal University (nine publications); the Egyptian Knowledge Bank (nine publications); China Meteorological Administration; Hohai University, China; University of Chinese Academy of Sciences; and University of Geneva (seven publications each); Indian Institutes of Technology, Sun Yat-sen University, and University of Texas System (six publications each).

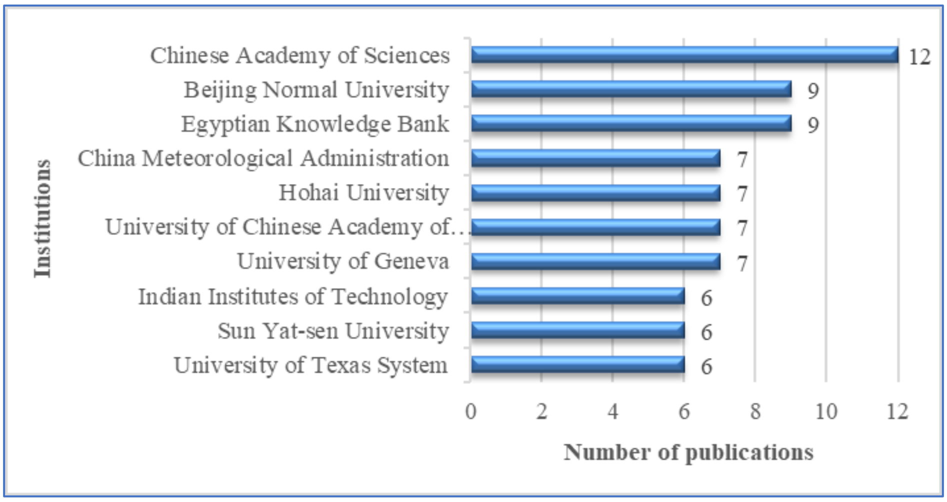

Figure 4. List of Top Institutions Specializing in Climate Change-Induced Flood Research.

3.3. Top Countries Concerned Socio-Economic and Environmental Impact of Flood under Climate Change Context

Among all hydroclimatic hazards, floods are considered the most severe, often resulting in significant loss of human life and significant socio-economic damage. For this reason, countries are paying close attention to the socio-economic and environmental impact of flooding in the climate change context. Global research conducted by Chen *et al.,* (2023) shows that countries mostly located in the southern regions of the world, in Southeast Eurasia, Africa and South America, should reinvestigate their flood defence standards and mitigation strategies to prepare themselves for an increasing magnitude of 50-year floods from 16.4% to 30.6% at the current global warming level. Figure 5 shows the number of publications on climate change-induced flood research from the ten countries most concerned about this issue. China with 60 publications, the US with 52, India with 22, Spain with 20, England and Italy with 15 each, Pakistan with 12, and France, Iran and Switzerland with 11 are among the leaders.

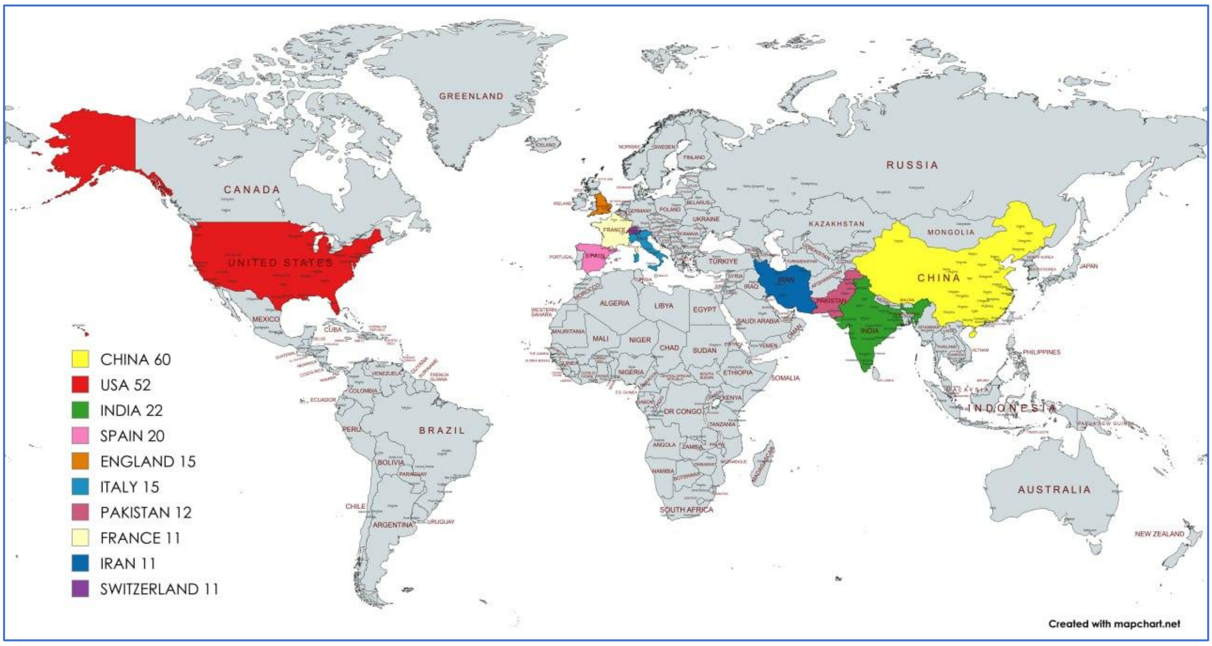

Figure 5. List of Top Countries Concerned Impact of Climate Change and Flooding.

The above countries have established funds to finance research on flood assessment, sufficient mitigation, and the development of early warning systems. The Natural Science Foundation of China, the National Basic Research Development Program of China, the European Union, and the United States Department of Energy are the leading sponsoring organisations. They both directly and indirectly funded around 35 percent of the research in the 223 publications. According to the authors, based on their affiliations, countries and sponsoring funds, China, Europe and the United States are leading regions in addressing the socio-economic and environmental impacts of climate change-induced floods.

3.4. Most Cited Scientific Art and Journals on Climate Change-Induced Flood Research

A high number of citations often reflects the significance and originality of particular research. It suggests that the work has made a meaningful contribution to the field and has been widely referenced by other scholars. Total citation (TC) and average annual citation (AAC) serve as common indicators that have continuously changed over time. Table 1 lists the top 10 articles with an AAC of 13 or more.

Table 1. List of Top Cited Publications on Climate Change-Induced Flood Research.

No.	Title	Journal	Corresponding author	PY	TC	AAC	Doc. Type
1	Flood susceptibility modelling using advanced ensemble machine learning models	Geoscience Frontiers	Islam, ARMT	2021	318	80	Article
2	Comparison of urbanization and climate change impacts on urban flood volumes: Importance of urban planning and drainage adaptation	Science of the Total Environment	Zhou, QQ	2019	285	48	Article
3	Flood susceptibility assessment in Hengfeng area coupling adaptive neuro-fuzzy inference system with genetic algorithm and differential evolution	Science of the Total Environment	Hong, HY	2018	313	45	Article
4	Rapid attribution of the August 2016 flood-inducing extreme precipitation in south Louisiana to climate change	Hydrology And Earth System Sciences	van der Wiel, K	2017	163	20	Article
5	Application of stacking hybrid machine learning algorithms in delineating multi-type flooding in Bangladesh	Journal of Environmental Management	Rahman, M	2021	79	20	Article
6	Flash Flood Susceptibility Assessment and Zonation Using an Integrating Analytic Hierarchy Process and Frequency Ratio Model for the Chitral District, Khyber Pakhtunkhwa, Pakistan	Water	Waqas, H	2021	75	19	Article
7	North American extreme precipitation events and related large-scale meteorological patterns: a review of statistical methods, dynamics, modeling, and trends	Climate Dynamics	Barlow, M	2019	107	18	Review Article
8	An overview of studies of observed climate change in the Hindu Kush Himalayan (HKH) region	Advances in Climate Change Research	You, QL	2017	115	14	Review Article
9	Towards Real-Time Continental Scale Streamflow Simulation in Continuous and Discrete Space	Journal of the American Water Resources Association	Salas, FR	2018	100	14	Article
10	Applicability of ε-Support Vector Machine and Artificial Neural Network for Flood Forecasting in Humid, Semi-Humid and Semi-Arid Basins in China	Water	Bafitlhile, TM	2019	76	13	Article

* PY – Published Year, * TC – Total Citation, * AAC – Average Annual Citation

These articles were published during the period 2017 to 2021. The article the most frequently cited is "Flood susceptibility modelling using advanced ensemble machine learning models "by Towfiqul Islam (2021). This novel research demonstrated the implementation and measurement of two hybrid ensemble models—Dagging and Random Subspace—integrated with three advanced ML techniques (Artificial Neural Network (ANN), Random Forecast, Support Vector Machine) for flood susceptibility mapping. Table 2 shows the top approaches and techniques used in the articles above, which may guide future research directions (Table 2).

Table 2. Method and Techniques of Top Cited Publications.

Investigated parameter	Method and techniques	Article number in Table 1
Flood susceptibility	Hybrid modeling: ML, Digging and Random Subspace, GIS	1
Flood susceptibility	Hybrid modeling: Adaptive neuro-fuzzy inference system (ANFIS), GIS	3
Flood susceptibility	Hybrid modeling: AHP, Frequency ratio (FR) model, GIS	6
Flood probability	Soft computing model: ML	5
Flood volume (forecasting streamflow)	Physically based hydrological modeling: Hydrological model: RCP2.6 and 8.5, SWMM urban drainage model	2
Forecast streamflow	Physically based hydrological modeling: NFIE-Hydro Streamflow Simulation System	9
Forecast streamflow	Soft computing model: ML	10
Flood-inducing extreme precipitation	Statistical modeling: Statistical analysis of observational data	4
Review of statistical methods, dynamics, modelling, and trends		7
Review of recent climate change		8

The fact that an article receives the most citations indicates that this type of scientific research is becoming more popular. In the context of climate change, investigating "flood susceptibility" with hybrid modeling and "forecast streamflow" with physically based hydrological modeling are becoming more common topics. In studying these, it appears that the use of GIS, hydrological models, and the analysis of various climate databases through ML algorithms are yielding better results than measurement and observation data.

A high citation rate for an article is also directly related to its quality and novelty, with publication in a prestigious journal increasing the rate even further. According to the analysis results, the 223 publications were cited a total of 5,368 times across 99 journals. Figure 6 shows the top 14 journals that received more than 100 citations published between 2015 and 2024. Nearly 45 percent of the citations are cited in the top five journals: Science of the Total Environment (989 citations), Water (429 citations), Journal of Hydrology (355 citations), Natural Hazards (324 citations), and Geoscience Frontiers (318 citations) (Figure 6).

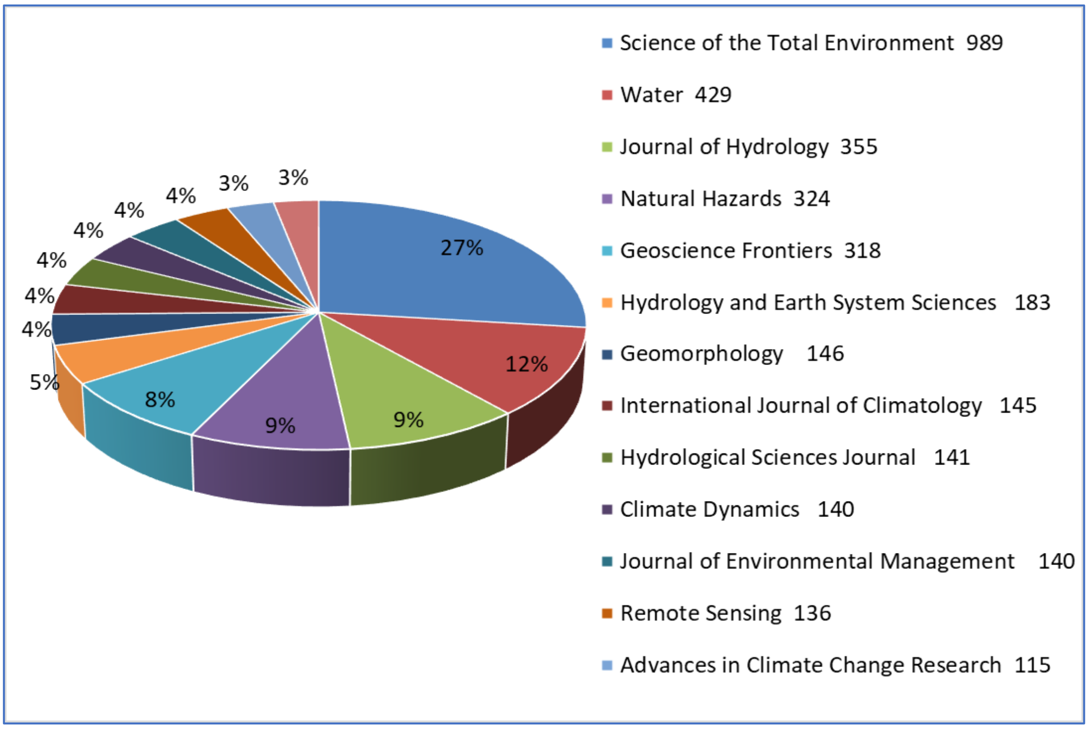

Figure 6. Cited Journals on Climate Change-Induced Flood Research.

The journals Science of the Total Environment (Netherlands), Water (Switzerland), and Geoscience Frontiers (China), also shown in Table 1, demonstrate strong performance in both impact metrics and indexing. They are considered Q1 in their category.

3.5. Analysis of Co-Authorship and Keywords

Co-authorship and keyword co-occurrence maps were created using data downloaded from WoS via VOSviewer software (version 1.6.17). In bibliometric research, co-authorship analysis examines collaborative relationships between scientists, institutions and countries, as well as between those who work together on scientific projects and publications. It reveals patterns and relationships between authors based on the number of jointly published works and also illuminates the structure and developmental processes of these relationships.

Analysis of the input data resulted in a network of 1,054 authors. Those with at least two publications on the topic of climate change and flooding were included. Twenty-nine elements were distributed across five clusters: cluster 1 (seven items) in red; cluster 2 (seven items) in green; cluster 3 (six items) in blue; cluster 4 (five items) in black; and cluster 5 (four items) in yellow (Figure 7). The figure reveals that Huang, Yang, Lu, Chen and Wang may serve as network hubs with their interdisciplinary and inter-group collaboration, while the green cluster appears to be a central bridge linking several clusters, showing that its members may play key roles. The figure also reveals that Chinese academic communities have strong internal collaboration networks, as all the researchers who link clusters are from China: Pengnian Huang from Nanjing University of Information Science & Technology, China; Hui Lu from Tsinghua University, China; and Jing Wang from the Hydrological Survey Bureau of Tibet Autonomous Region, China.

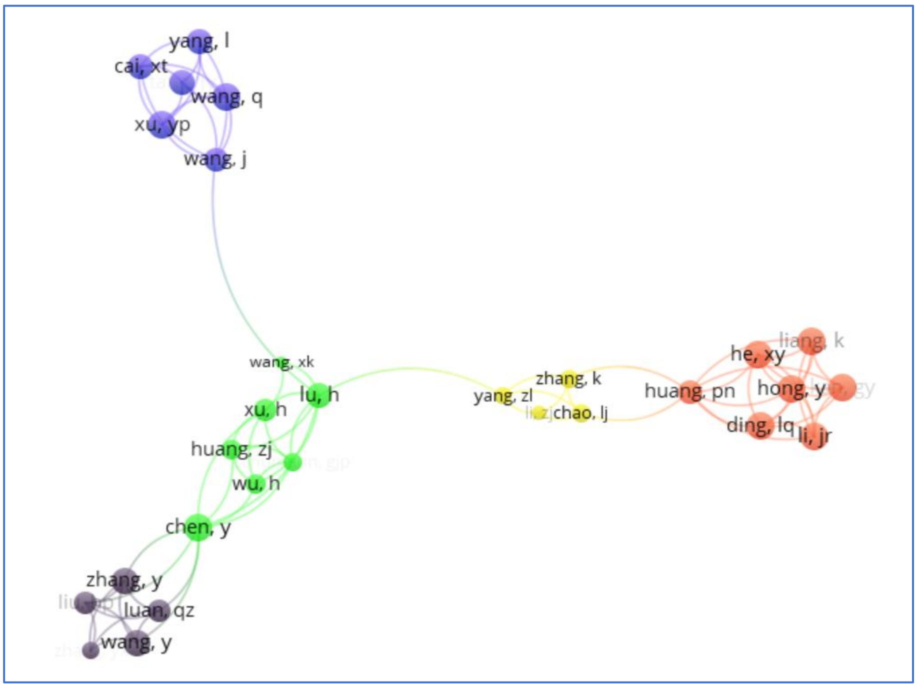

Figure 7. A Network Map of Top Co-Authors Based on Overall Link Strength.

As a result of the analysis, 1483 keywords were identified, and 51 elements with at least seven occurrences were selected from these. Low-value and rarely used elements were not taken into account. Based on the overall connection strength, four clusters were formed, each selected keyword was matched to a node, and a network map of all the keywords was constructed (Figure 8). The size of the nodes corresponds to how many times they appear, or their frequency. However, the proximity of a node to others indicates certain related topics that frequently occur alongside the subjects being studied.

In Figure 8, showing the co-occurrence of keywords, the network is heavily centralised around the keywords “climate change” and “flash flood”. This indicates that a significant portion of the research in the dataset focuses on these topics and how they relate to other concepts. These keywords are divided into 51 elements across four clusters: cluster 1 in red, with the main keyword being “flash flood”, includes the following words - catchment, China, climate change, disaster, dynamics, Europe, frequency, impact, land-use, management, risk, river, sensitivity, soil-erosion, variability. Cluster 2 in green is primarily focused on “river-basin” with the following topics - AHP, flood hazards, flood risk, flood susceptibility, FR, GIS, hazard, HEC-RAS, ML, RS, risk-assessment, special prediction). Cluster 3 in blue is the "model", which includes the keywords basin, calibration, climate, flood, HEC-HMS, hydrology, runoff, soil-moisture, system, urbanization, vulnerability. Finally, cluster 4 in yellow, "precipitation", includes the following: events, extreme precipitation, performance, prediction, simulation, streamflow, temperature, trends, uncertainty. This analysis shows that the main focus of climate change-induced flood research is on the interrelationship between river basins and precipitation, and the application of models (physically-based hydrological, statistical, and soft computing) to management (Figure 8).

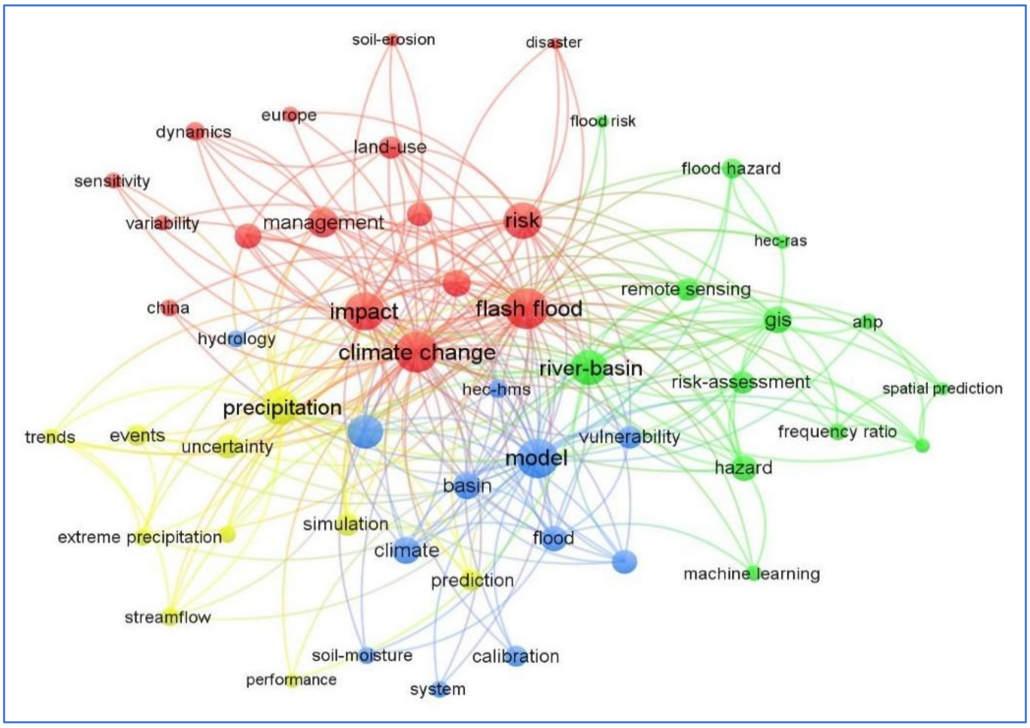

Figure 8. A Network Map of Keywords Based on Total Link Strength.

3.6. Identifying National Research Specializations and Thematic Focuses

The three-field plot provides a clear visualisation of the current academic landscape in flood-related research in countries and their institutions. The analysis confirmed that China is overwhelmingly the most significant contributor. The primary institutions associated with climate change-induced flood research are Beijing Normal University and Hohai University. In terms of geography, China is the dominant country, but there is also notable participation from researchers affiliated with institutions in the United States, Switzerland and Romania (Figure 9).

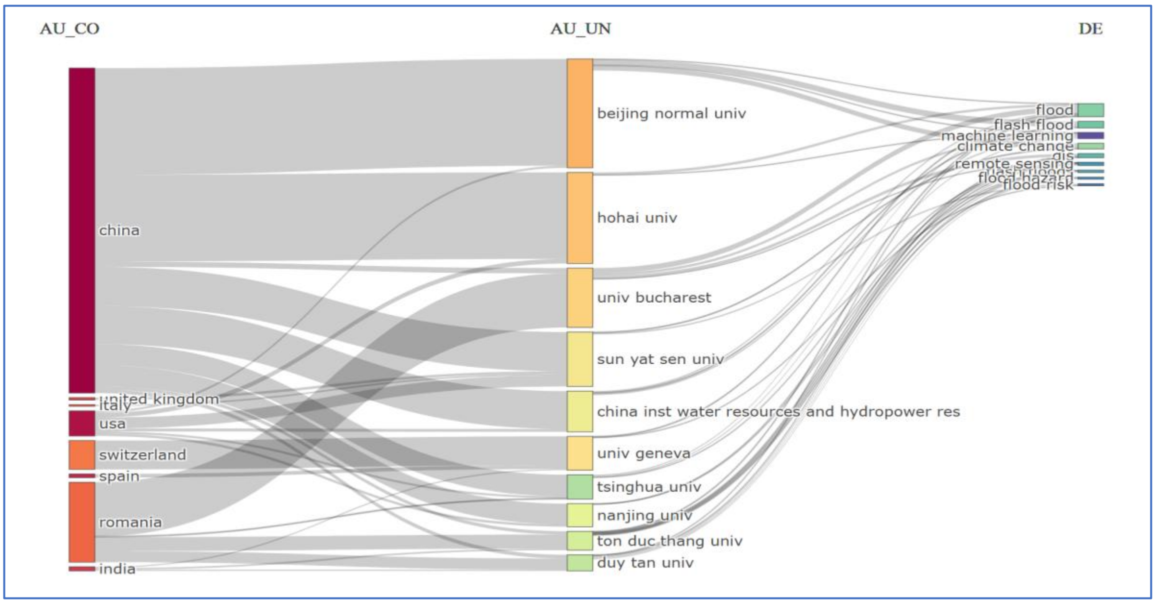

Figure 9. Three-Field Plot – Identifying National Research Specializations: AU_CO – Author Coun-try, AU_UN – Author University, DE – Keywords.

The three-field plot clarifies and confirms that the main research topics are strongly directed toward "climate change", "flood", "flash flood", "ML", "GIS", "RS", "flood hazard" and "flood risk". Another method that helps researchers to establish the centre of academic attention is the evolution of research topics, which aids in identifying current and future research directions in their field.

A trend analysis of the number of publications revealed two phases: a rapid growth phase and a stabilisation phase (Figure 2). Referring to these trend phases, ten years of publications were examined in two stages (2015-2019 and 2020-2024) (Figure 10). The analysis revealed that the scientific community focus had moved from broader climate change impacts to more specific and localised issues such as flash floods, precipitation patterns, and the use of advanced modelling and forecasting techniques.

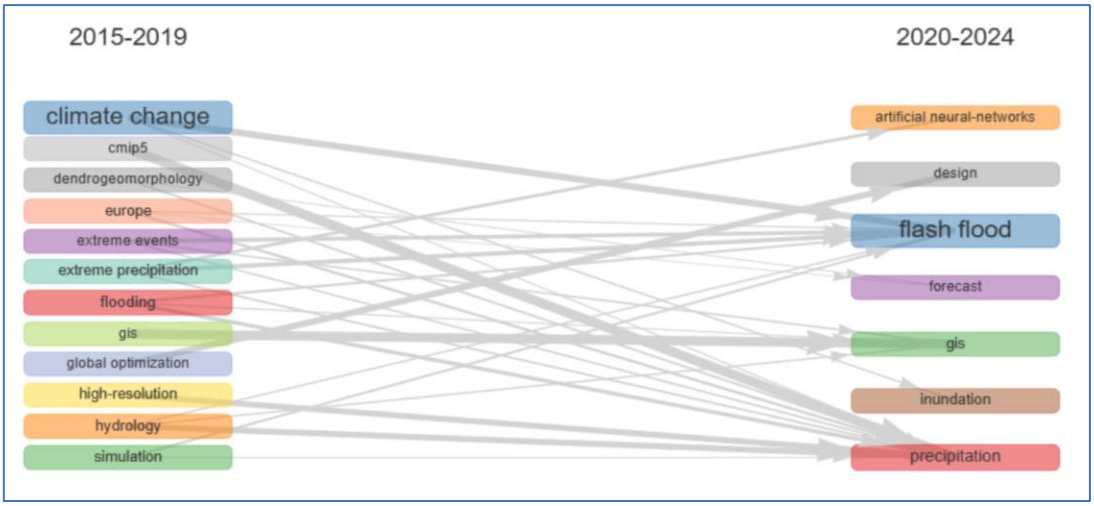

Figure 10. Thematic Evolutions in 10 Years.

In the second phase of evolution, "precipitation", "management" and "catchment" were central and well-developed topics, as there is strong interest in connecting "precipitation" to "catchment" and "management", while "forecast", "cover change" and "land use" were niche themes during this time period. However, "climate change", "flooding" and "model" remained as basic themes during the 2020-2024 period. In addition, as an emerging topic, ANN has developed interest in applying ML algorithms to flood-related problems, primarily for forecasting and risk assessment (Figure 11).

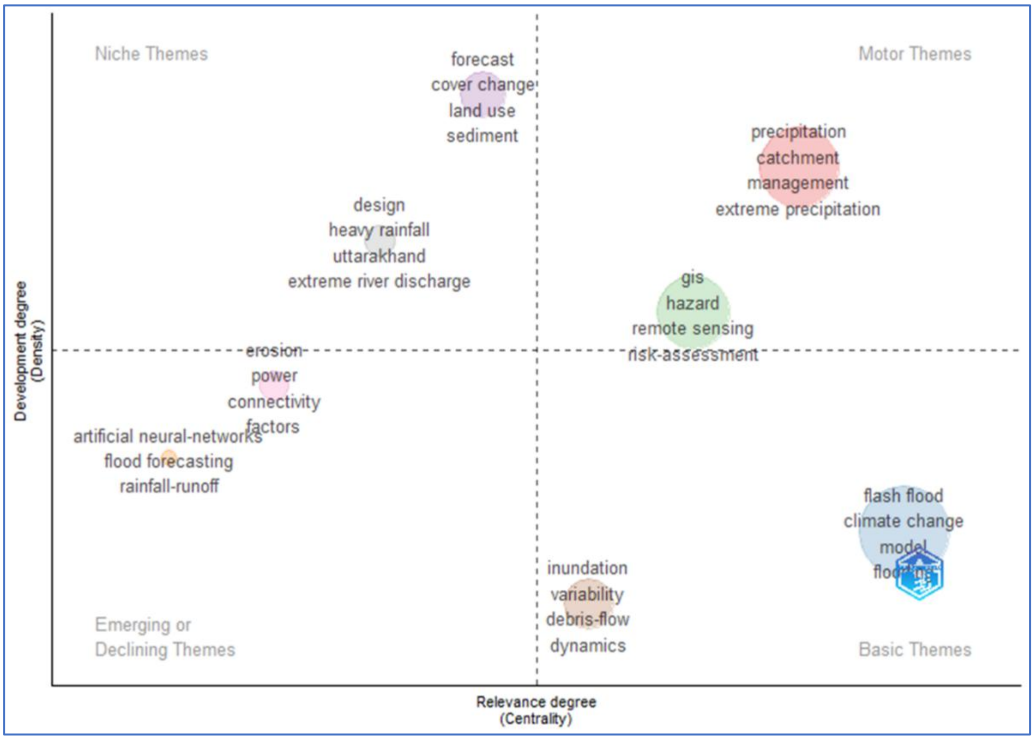

Figure 11. Thematic Formation between 2020 and 2024.

3.7. Discussions and Answers to Research Questions

Global climate change is affecting the duration and frequency of flash and river floods. A number of authoritative organisations, such as UNDRR and IPCC, and numerous research studies confirm that the negative impact of climate change on the magnitude of floods is inevitable (Nakaegawa & Kobashi, 2025). Research conducted in several of the largest river basins around the world shows that at a 3.0°C warming level, the magnitude of 100-year floods will increase in the Rhine (Europe), Mississippi (US), and Yellow River (China) basins by 13%, 16% and 31% respectively (Huang *et al.* 2018). Due to the complexity of flood forecasting, several assessment methods and techniques have been developed (Ali *et al.,* 2025), with bibliometric analysis providing both quantitative and qualitative analysis to identify the most modern research directions and methodologies.

Based on the research methodology developed, a bibliometric analysis of works devoted to the topic of climate change-induced flood over a period of ten years was conducted. From 2015, there was a sharp increase in interest in such research, with the annual number of publications stabilising after 2019. This shows that researchers were focusing on deeper specialisation or application development rather than the number of articles over the last five years of the study period (Towfiqul Islam *et al.,* 2021). Most of the publications in this area are scientific articles on water resources and environmental sciences. Among the authors, Costache, Li, Lu, Pham, Wang, Xiong and Zhang are also on the list of most productive researchers, but Stoffel from the University of Geneva has been making significant contributions to research on climate change impacts on floods (Gobiet *et al.,* 2014). Notably, almost half of the lead authors are from China, and the Chinese Academy of Sciences is also a leader in the field, including water resources, earth and environmental science, although the United States and European countries also make significant contributions.

In the context of climate change, in-depth research on the topics “flood susceptibility” and “forecasting streamflow” is being conducted. Physically-based hydrological modelling (Salas *et al.,* 2018; Zhou *et al.,* 2019) and soft computing models (Bafitlhile & Li, 2019; Rahman *et al.,* 2021) of streamflow forecasting research, and statistical (van der Wiel *et al.,* 2017) and hybrid modelling (Hong *et al.,* 2018; Towfiqul Islam *et al.,* 2021; Waqas *et al.,* 2021) in flood susceptibility assessment research are commonly used, giving reliable results. In the early stabilisation stage, the most frequently cited article was by Towfiqul Islam *et al.,* (2021). Their novel research generalised and demonstrated hybrid ensemble ML models for flood susceptibility mapping. This is one of the significant signs that using advanced soft computing and statistical models for flood susceptibility assessment has been introduced into the field. A high citation rate for an article is directly related to its quality and novelty; publication in a prestigious journal increases the citation rates even further. According to the analysis results, the journals Science of the Total Environment (Netherlands), Water (Switzerland) and Geoscience Frontiers (China) are foremost in popularising high-level scientific research on climate-induced flood science.

The network map of keywords shows that there are four clusters, all of which are centralised around flash flooding and climate change. The analysis shows that the main focus of research on climate change-induced flood is geared towards river basins, precipitation prediction, and the use of soft computing model applications (GIS, AHP, ML). Although the results of the three-field plot analysis show that “flood risk” and “flood hazard” are the main research topics, it also confirms that the use of tools such as ML, GIS and RS in the field of climate change-induced flood research is widespread. In addition, the time series evolution of research topics identified that the focus of the scientific community is moving from broader climate change impacts to more specific and localised issues such as changes in precipitation patterns, and the use of advanced models and forecasting techniques (ANN, GIS). A separate analysis of the research directions formed in the five years up to the end of 2024 indicates that in climate change-induced floods, modeling remains a basic theme, and that “precipitation”, “management” and “catchment” are also central and well-developed topics. However, the results also indicate that ANN should be introduced as an emerging tool for forecasting and risk assessment.

4. Conclusion

Climate change, in particular global warming, is affecting the amount and patterns of precipitation and their magnitude, causing a sharp increase in flood-related events around the world. Despite the stability of the volume of publications in recent years, there is in general a positive trend in scientific research in this area. In the context of climate change, flood susceptibility assessment and streamflow forecasting during flooding are key research areas in the field of climate-induced flood. Hybrid modelling methods, in particular physically-based hydrological modeling integrated with advanced soft computing techniques such as ML and ANN, and geospatial tools (GIS, RS), are the main approaches shown to produce improved results. Today, flood susceptibility assessment cannot be performed without utilising geospatial tools and statistical models, just as streamflow forecasting cannot be performed without physically-based hydrological or hydraulic modeling. However, it should not be ignored that research in this area requires dense and real time topographic, meteorological and hydrological data.

Research into the susceptibility of specific regions to floods and the assessment of runoff volumes during floods are important areas of research for developing the early warning systems needed worldwide. Today, developing more reliable ones requires Internet of Things (IoT) systems connected to ML-based AI algorithms that integrate hydrological models with geospatial data. In this regard, leading countries in this field, China, European ones and the US, should create the necessary conditions for the development of global research. Funding for research in climate-induced floods and creating collaborative pathways between major institutions specialised in the field is of particular importance. Finding solutions to climate change-induced hydro-climatic phenomena should not remain the problem of a single country or organisation.

As with any research study, ours has certain limitations. The authors used the WoS database, which includes journals with high impact factors in earth and environmental sciences, but working with two databases can also be highly effective in research. In the data collection, by using the 'AND' operator between keywords, an attempt was made to discuss all the fields related to climate change-induced flood research. However, for research focused on a single topic, it is recommended to use the 'Title' or 'Topic' operator instead of the 'All Fields' one, with the 'Not' operator between keywords.

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Author Contributions

Conceptualization: Allayorov D., Allayorova D.; **methodology**: Rakhimov K., Shaymardonov S.; **investigation**: Umarov U., Allayorova D.; **writing—original draft preparation**: Allayorov D., Atakulov D.; **writing—review and editing**: Allayorov D.; **visualization**: Allayorova D., Shaymardonov S. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

All authors declare that they have no conflicts of interest.

Data availability

The author confirms that all data generated or analysed during this study are included in this article.

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