BIBLIOMETRIC ANALYSIS OF GEOSPATIAL TECHNIQUES IN FLOOD RETENTION POND PLANNING

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Abstract. The study focused on an analysis of the flood retention pond in relation to land use changes. This study aims to systematically review and synthesise existing literature reviews on flood retention pond planning using geospatial techniques. Following PRISMA guidelines, a literature search of published studies across the Scopus database from 1981 to 2026. This study uses bibliometric analysis in RStudio and Vosviewer to examine the current research stream and assess trends in this topic. A total of 111 publications were retrieved from the Scopus database to reveal the knowledge structure of the past, current and future trends. The analysis assesses the most influential past publication, determines the structure of co-cited publications, and evaluates trends for future studies. This study performs historical development, keywords, citations and co-citations, institutions, country-wise analyses and future trends. The study produced three ground-breaking research streams evaluated using bibliometric analyses: (i) urban stormwater management and flood mitigation, (ii) macro-environmental flood risk analysis and mapping and (iii) river basin hydrology and natural landscape routing.
Keywords: *retention pond, bibliometric analysis, land use change, flood, geospatial*

Introduction

Rapid urbanisation, population growth, and the accelerating impacts of climate change have drastically altered natural hydrological cycles, leading to an increased frequency and severity of urban flooding worldwide (Dharmarathne et al., 2024). Natural landscapes are replaced by impervious surfaces, stormwater runoff volumes rise, traditional drainage systems are overwhelmed, and socio-economic stability is threatened. The current and future development of water resources is highly sensitive to land use and the intensification of human activities. It is expected that flood risk will continue to rise due to a combination of climate change (Alexakis et al., 2014). The unexpected intensification of rainfall and changes in urban land-use patterns has placed serious pressure on the city's urban flood management system. Changes in urban land-use patterns are a critical factor in increasing flood risk. Alongside economic and population growth, there is a rising demand for infrastructure and housing. However, uncontrolled development often neglects environmental aspects, including drainage systems and water management. Unplanned land-use changes can reduce water infiltration areas, increase surface runoff, and hinder the flow towards drainage channels (Yulianti and Prasetyo, 2024).

Land cover changes influence the conditions for the transformation of precipitation into runoff. The qualitative impact assessment of urbanisation, deforestation, or agrotechnical practices on the size of flood discharge or the volume of flood waves is not a problem. Floods are a natural part of river systems operating within a constantly shifting environment. Driven by the water cycle, they have happened across Earth's

history and will persist in the future. Because streams rely primarily on precipitation, their volume fluctuates constantly based on daily, annual, and long-term rainfall patterns within the drainage basin. Heavy rains, land-use change, including deforestation in basin areas, and various engineering applications along river channels all contribute to the magnitude and frequency of flood events. Lowland areas with poor drainage systems require more attention. Retention ponds play an important role in managing rainwater runoff. Retention ponds offer water quality and flood control through natural processes and provide the most effective stormwater treatment to remove the total mass of pollutants from heavy. Although designed as stormwater control (SCM) systems to collect polluted runoff, stormwater ponds in parks and residential developments are often considered and marketed as aesthetic water features. The distribution of retention pond points is strategic in various areas. In the west and southwest near green areas, retention ponds help manage rainwater. In the densely populated central area, retention ponds help control water runoff because the soil has limited absorption capacity. Points near large rivers help mitigate potential flooding, while points in the east are likely to be located around agricultural land or industrial areas to prevent inundation and maintain environmental quality (Saputra et al., 2025).

Increases in development consistently correspond to an expansion of land use. These changes progressively affect the local hydrological cycle, creating problems with streamflow's, water yields, low or high flows, surface runoff and erosion, soil moisture, and evapotranspiration. Precipitation that falls on developed areas quickly flows into streams, increasing stormwater runoff and erosion (Amini et al., 2011). Retention ponds that cannot adequately handle heavy rainfall can significantly increase the risk of flash flooding in surrounding developed areas. When rainfall intensity exceeds the pond's storage capacity, excess stormwater overflows into nearby residential, commercial, and infrastructure areas. This situation is often exacerbated by dense urban development, where impervious surfaces such as roads and buildings limit natural infiltration. As a result, runoff accumulates rapidly, leading to short duration but severe flash floods around the pond can disrupt daily life, destroy property, and threaten public safety. Accordingly, this paper reviews the existing literature on flood retention ponds and land-use changes using GIS. To ensure a systematic and consistent review process, a bibliometric analysis approach was employed. This study is significant because it addresses the need to identify research trends, uncover the field's intellectual and conceptual structures, and critically assess the current state and depth of scholarly contributions. In the present study, VOSviewer and RStudio were employed as the primary visualisation and analytical tools. Relevant articles were identified by selecting titles containing the terms "retention pond" or "detention pond" in combination with "land use change," "flood," or "geospatial." A total of 111 publications were analysed, representing a comprehensive collection of the most influential and relevant studies within this research domain.

The paper is organised into five sections. Section 1 introduces the study and outlines its core concepts. Section 2 presents the literature review. Section 3 details the research methodology and the construction of the review sample. Section 4 provides an in-depth discussion of the key findings from network and content analyses across the identified research streams. Finally, Section 5 concludes the study and proposes directions for future research.

Literature review

Flood retention ponds

Flood retention ponds are engineered stormwater management facilities designed to capture and temporarily store excess runoff during rainfall events, thereby reducing peak discharge rates and mitigating downstream flooding. They play a crucial role in urban flood control by attenuating surface runoff and slowing water movement through a drainage system, helping minimise the risk of flood damage to infrastructure and communities. For example, Birkinshaw and Krivtsov (2022) found that properly located and designed retention ponds in peri-urban catchments can significantly reduce downstream flooding by optimising peak flow attenuation and storage capacity, highlighting the importance of pond siting and design in flood risk management. In addition to their hydrological functions, retention ponds also contribute to stormwater quality improvement by allowing sediments and attached pollutants to settle out as water is held within the pond, enhancing the environmental performance of urban drainage systems. Empirical research has demonstrated that such ponds can effectively reduce total suspended solids (TSS) and other pollutants, though seasonal variations and design features influence treatment efficiencies. For instance, a study monitoring a retention pond in the U.S. reported notable reductions in TSS and phosphorus during warmer months due to enhanced biological activity and settling processes (Nayeb Yazdi et al., 2021). Overall, the literature underscores that flood retention ponds are integral components of contemporary stormwater management and flood mitigation strategies, particularly in rapidly urbanising regions where impervious surfaces exacerbate runoff and flood risks.

Impact of land use changes on flooding

Land-use changes, particularly those driven by urbanisation, significantly alter hydrological processes and intensify flood risk by increasing surface runoff and reducing infiltration capacity. When natural landscapes such as forests, grasslands, and agricultural areas are converted into built-up surfaces (e.g., roads, buildings, and parking lots), the percentage of impervious land increases, leading to decreased infiltration and higher runoff volumes during rainfall events, which in turn elevate peak discharge and flood frequency in downstream areas. Such transformations disrupt the natural water balance and shorten the time between rainfall and runoff peak, resulting in greater flood vulnerability in urban and peri-urban regions (Bashar and Uddin, 2025). Research has shown that urban expansion intensifies stormwater runoff and amplifies flood hazards by increasing the proportion of impermeable surfaces, which limit soil absorption and groundwater recharge (Bai et al., 2018). In rapidly urbanising contexts, these land-use transitions exacerbate surface runoff, elevate flood peaks, and often overwhelm existing drainage systems, highlighting the need for integrated landuse planning and flood management strategies (Oo and Humphries, 2025). Collectively, the literature underscores that understanding the hydrological impacts of land-e change is essential for effective flood mitigation, as it directly influences runoff generation, flood magnitude, and the spatial distribution of flood risk across watersheds (Blöschl, 2022).

GIS in flood and land use analysis

Geographic Information Systems (GIS) are widely recognised as essential tools for flood risk assessment and land-use analysis because they enable the integration, visualisation, and analysis of diverse spatial datasets, including land-use/land-cover,

elevation, drainage networks, and rainfall patterns. GIS enables researchers and planners to detect land-use changes over time, map flood-prone areas, and model hydrological responses to landscape dynamics, supporting informed decision-making for flood mitigation and urban planning. For example, Leeonis et al. (2025) highlight that GIS applications are effective for producing flood risk maps, assessing vulnerability, and contributing to natural hazard management by enabling visualisation and analysis of spatial risk factors (Leeonis et al., 2025). The model incorporates six factors: river system, elevation, depression area, ratio of impermeable area, detention ponds, and precipitation. A hazard map for 2004, for example, was obtained. The analytic hierarchy process was applied to calculate the weighting values for each factor (Chen et al., 2015). In practical applications, GIS-based flood risk mapping has been used to classify areas into susceptibility zones by overlaying multiple criteria such as land cover, slope, rainfall, and proximity to water bodies. Studies employing GIS spatial analysis functions demonstrate its capability to assess flood hazard and support proactive planning by identifying vulnerable communities and directing mitigation efforts. For instance, flood hazard mapping using GIS in Bandung, Indonesia, produced multi-level risk classifications that informed recommendations for early warning systems and collaborative disaster management strategies (Perdana et al., 2019). Together, these studies show that GIS not only facilitates the detection of land use changes but also enables comprehensive flood analysis by linking environmental and hydrological variables to spatial patterns of flood risk, making it a crucial tool in flood management research and practice (Leeonis et al., 2025).

Integration of retention pond analysis with land use changes

Integrating flood retention pond analysis with land-use changes in GIS enables a more comprehensive assessment of how spatial planning and landscape dynamics affect the performance and placement of stormwater infrastructure. Several studies have applied GIS-based spatial analysis to optimise retention pond siting by overlaying land use, terrain, hydrological networks, and socio-economic data to identify suitable locations that balance flood mitigation effectiveness with environmental and social considerations. For example, Yusop et al. (2025) developed a GIS-MCDA (Multicriteria Decision Analysis) framework to select optimal sites for flood retention ponds in Rembau, Malaysia, by combining high-resolution spatial datasets including land use and elevation with decision criteria to generate suitability maps that improve stormwater capture while minimising construction and ecological impacts (Yusop et al., 2025). In addition, several studies demonstrate that integrating GIS with retention pond analysis and land-use assessments supports flood mitigation planning in urban and peri-urban environments. GIS enables the spatial overlay of land-use change data, hydrological factors, and infrastructure elements to evaluate how urban growth affects stormwater retention systems and identify areas where retention ponds can most effectively reduce flood risk. For example, (Permanasari et al., 2025) combined GIS and remote sensing techniques to evaluate the performance and spatial distribution of retention ponds in South Bandung, finding that retention ponds contribute to reducing flood impacts when their design and placement account for evolving land cover and urban patterns, while also emphasising the need to link GIS-based insights with broader planning strategies for resilience.

Low Impact Development (LID) techniques, such as green roofs, bioretention cells, and rainwater harvesting, are small-scale controls designed to reduce stormwater runoff

and pollution by retaining, infiltrating, and evaporating water. While highly viable for flood mitigation in challenging tropical and coastal environments, their performance is deeply sensitive to rainfall patterns and intensities, suggesting that future systems would benefit from real-time control strategies. Additionally, though developed nations primarily use LIDs for pollution control, developing tropical cities can gain immediate advantages by prioritising them for flood protection and heat island mitigation.

Materials and Methods

Bibliometric analysis and science mapping

The bibliometric approach relies on quantitative analytical tools to measure and evaluate publication data, for example, citation analysis to bibliometric data (units of publication and citations (Donthu et al., 2021). Bibliometric analysis systematically examines scientific literature to map out patterns, trends, and research impact within a discipline. The process typically involves gathering data from relevant databases, cleaning and refining the dataset, and using bibliometric techniques to extract actionable insights. Bibliometric analysis is an increasingly popular and thorough technique for examining and assessing large amounts of scientific data, which is increasingly used in research. This entry thoroughly introduces bibliometric methodology, emphasising its numerous methodologies (Passas, 2024). The contribution of this study based on the method of incorporating bibliometric analysis for flood retention pond in relation to land use changes using GIS (citation analysis; to provide the structural link and relationship between the most influential cited publications (co-citation analysis); and to evaluate emerging trends for future studies (co-occurrence of keywords analysis). Science mapping is the development and application of computational techniques for the visualisation, analysis, and modelling of a broad range of scientific and technological activities (Chen et al., 2014). Science maps, also known as scientographs, bibliometric network visualisations, and knowledge domain maps, are visual representations of the structure and dynamics of scholarly knowledge (Petrovich, 2021). Science mapping aims to build bibliometric maps that describe how specific disciplines, scientific domains, or research fields are structurally organised conceptually, intellectually, and socially. Various techniques and software tools have been proposed for conducting science mapping analysis (Cobo et al., 2011). This article aims to review, analyse, and considering available bibliometric techniques and different analytical approaches.

Citation analysis, co-citation analysis and co-occurrence of keywords

A reference represents the outbound credit a document gives to a source, whereas a citation is the inbound credit a document receives. Broadly, a citation signifies a connection between the ideas or content of the citing work and those of the source document. Citation analysis is the area of bibliometrics that studies these relationships (Smith, 1981). Citation analysis, along with graph mining, is a common bibliometric method that has been successfully used to enhance scientific information retrieval (Liu et al., 2013). This approach determines the most impactful publications, authors, and journals, while revealing patterns of knowledge diffusion and intellectual continuity within the scientific literature. It evaluates total citations per article, average citation rates, and citation trends over time to assess research impact. Further, it analyses

citation practices across countries and institutions to identify research leadership and mechanisms of knowledge exchange. Co-citation analysis offers a distinctive approach to mapping the cognitive structure of scientific disciplines by tracking how frequently pairs of papers are cited together. When multiple authors repeatedly co-cite the same pairs, distinct research clusters emerge around shared themes. By integrating techniques like single-link clustering and multidimensional scaling, this methodology creates visual maps of both specialised fields and the broader scientific landscape (Kademani, 2011). One feature of co-citation analysis is the possibility of fractionally assigning papers in the research front to multiple clusters (Boyack and Klavans, 2010). In this study, co-citation analysis is used to map the intellectual structure of the field by identifying clusters of frequently co-cited publications, thereby illustrating how research themes in retention pond, land use change, and GIS. Keyword extraction is an important technique for document retrieval, beb page retrieval, document clustering, summarisation, text mining, and so on. By extracting appropriate keywords, we can easily choose which document to read to learn the relationship among documents (Matsuo and Ishizuka, 2004). This method reveals dominant research themes, emerging topics, and shifts in research emphasis over time. This study utilises keyword co-occurrence analysis, combining both author-provided and indexed keywords to map core themes and uncover conceptual clusters surrounding retention ponds, land-use change, and GIS.

Data collection and search string

Bibliometric metadata extracted from Scopus was exported into a comma-separated values (CSV) file (Narong and Hallinger, 2023; Zamzuri, 2021). Scopus was selected for its reliability, enabling a holistic and systematic assessment of research trends, collaborations, and knowledge development related to flood retention ponds. Its structured indexing, citation tracking, and advanced analytical features support robust bibliometric analysis, making it a dependable source for identifying influential studies, key themes, and emerging research directions within this field. Figure 1 shows the methodology of this research. The screening dataset is based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, enabling systematic filtering of large datasets, as needed when working with extensive Scopus databases, as shown in *Figure 1*. The search string used in the Scopus document search. All document types, including journal articles, conference proceedings, books, book chapters, letters, and notes, with no restrictions imposed. Only English-language publications were considered. This process yielded 111 publications published between 1983 and 2026. The retrieved records were then screened in multiple stages. Subsequently, the final dataset was exported in CSV format and analysed using VOSviewer and Bibliometric RStudio.

TITLE-ABS-KEY (("retention pond" OR "detention pond") AND (flood planning OR geospatial OR gis))

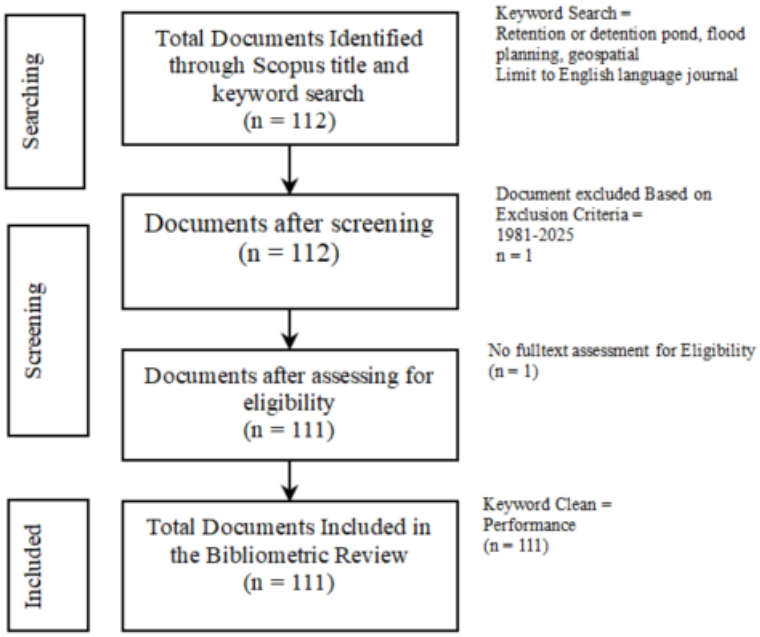

Figure 1. *PRISMA flow diagram.*

Results and Discussion

Data were gathered from the Scopus database, subsequently examined using statistical tools, including Microsoft Excel and VOSviewer, and displayed in tables, charts, graphs, and figures, among other formats. This section discusses the result using bibliometrics analysis and VOSviewer. First, we present the descriptive analysis and publication trends. Then: top ten journal publications, most productive and influential universities, and most productive and influential countries. Second, we present network visualisations: co-citation, co-authorship, and citation networks.

Descriptive analysis and publication trends

Table 1 provides information on articles retrieved from Scopus published from 1981 to 2026. It was found that 111 papers were published in 45 years. The descriptive analysis based on the data obtained is shown in Figure 1. From the 111 publications, the highest citation was 255. The earliest publications were in 1981. The topic received and upsurged in interest until the recent one. The highest number of articles was published in 2025, with 18 publications. It is expected that more studies will be conducted to analyse flood retention ponds in relation to land-use changes using GIS. Furthermore, the emergence of several key streams in the field interests' scholars and practitioners. The annual scientific production seems to fluctuate over time, with the highest citation year being 1981. The progression of papers published related to flood retention ponds from 1959 to 2026 is shown in *Figure 2*. A clear upward trend over time is observed, indicating an increasing role of scientific research in food retention ponds related to land-use changes, as assessed using GIS. The study period can be divided into three stages: the first, from 1983 to 1986; the second, from 1987 to 2001; and the third, from 2002 to 2026. In the early years, annual scientific output was minimal, averaging fewer than 2 publications per year. In the second stage, there were years with no papers published: 1987, 1989, 1991, 1995, 1997, and 2001. At the third stage, it fluctuated

from 2002 to 2026. This trend indicates that this topic is not receiving much attention, and more studies in this field need to be highlighted.

Table 1. *Descriptive statistics from 1981 to 2026.*

Category	Number
Articles	111
Timespan	1981-2026
Authors	378
Average citations per article	14.14
Single author documents	13
Co-author per document	3.64
International co-authorship %	17.12
Total journal	134
Author's keywords	358
References	8172

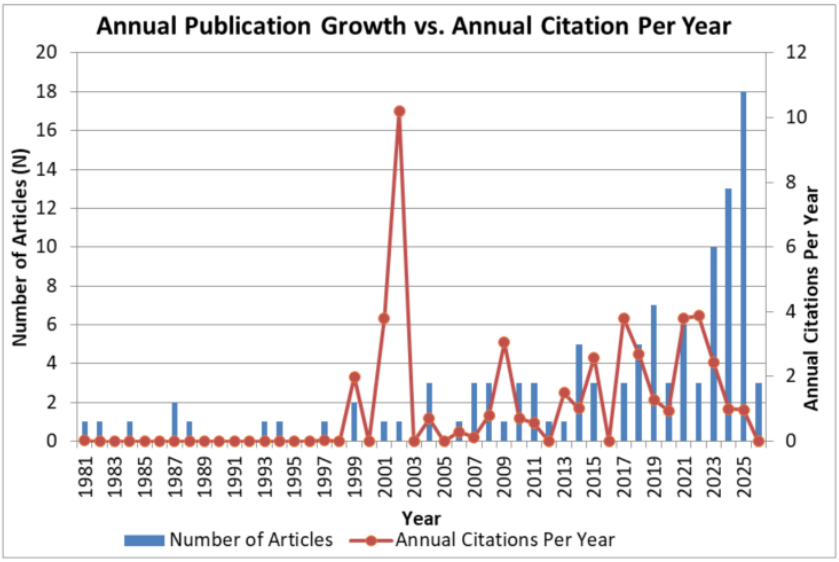

Figure 2. *Number of annual scientific production from 1981 to 2026.*

This dual-axis chart illustrates the 45-year trajectory of a specific scientific field's annual publication growth and citation rates from 1981 to 2026. The data are divided into two metrics: the total number of articles published each year, represented by the blue vertical bars on the left axis, and the annual citation volume, tracked by the red line on the right axis. For the first nearly two decades, spanning 1981 to 1998, the field remained largely dormant or highly niche, with annual publication output hovering between zero and two articles, while citations flatlined. This quiet period was broken by a massive anomaly between 1999 and 2002; despite article production remaining very low, a sharp, dramatic spike in citations occurred, peaking in 2002 at over 10 citations per year. This behaviour strongly suggests the publication of a highly influential, seminal paper during this window that catalysed a wave of academic interest. Between 2003 and 2022, the number of published papers slowly increased, reaching a high of 7 in 2019. During these same years, the number of citations fluctuated in waves, peaking every few years. The biggest change happened between 2023 and 2025, when the number of new papers suddenly exploded. Production jumped from 10 articles in 2023 to a record high of 18 articles in 2025. However, even though many more papers were

being written, the number of citations dropped almost to zero. This happens because of "citation lag," a normal delay in research in which it takes a few years for other scientists to read, use, and cite newly published work in their own papers.

Journal distribution and research domains

The bibliometric analysis results related to each research area are presented in *Table 2*. The subject category was based on journal types in the Scopus database. The ranking results reveal that the most highly published papers in this field are IOP Conference Series: Earth AI (5.4%), Natural Hazards (3.6%), and E3S Web of Conferences (2.7%). For *Table 3*, the highest-ranking reveal that the most relevant affiliations are the Indian Institute of Technology (2.7%), Bina Nusantara University (2.1%), and Monash University (1.5%).

***Table 2**. Top 10 journals by publication volume.*

Rank	Journal Title	Articles	Percentage
1	IOP Conference Series: Earth AI	6	5.4
2	Natural Hazards	4	3.6
3	E3S Web of Conferences	3	2.7
4	Proceedings – International A	3	2.7
5	Sustainability (Switzerland)	3	2.7
6	Water (Switzerland)	3	2.7
7	Applied Sciences (Switzerland)	2	1.8
8	Blue Green Systems	2	1.8
9	Ecological Indicator	2	1.8
10	Engineering, Technology and Applied Science Research	2	1.8

***Table 3**. Top 10 most relevant affiliations.*

Rank	Affiliation	Articles	Percentage
1	Indian Institute of Technology	10	2.7
2	Bina Nusantara University	7	2.1
3	Monash University	7	1.5
4	University of Innsbruck	6	1.2
5	Lamar University	5	1.2
6	Texas A and M University	5	1.2
7	The University of Texas at Austin	5	1.2
8	University Malaysia Pahang Al-Sultan Abdullah	5	0.9
9	Universiti Putra Malaysia	5	0.9
10	University of Oxford	3	0.9

Geographic distribution and research leadership

Table 4 presents the Top 12 Countries by Research Output in the field of flood retention ponds and land use changes using GIS, ranked based on the number of institutional affiliations contributing to published studies. The United States ranks first with 97 affiliations, representing 21.80% of the total research output. This reflects strong research capacity in hydrology, urban planning, and geospatial analysis, as well as extensive GIS application for flood management and land-use planning. Indonesia ranks second with 76 affiliations (17.08%). China ranks third with 28 affiliations (6.29%). Further analysis (*Figure 3*) aims to identify and investigate the country's scientific production on flood retention ponds in relation to land-use changes using GIS.

Indonesia has the highest scientific production, with 69 articles, followed by the USA with 61 articles, China with 29 articles, and Malaysia with 23 articles.

Table 4. *Top 12 countries by research output.*

Rank	Country	Affiliations	Percentage
1	Indonesia	69	62
2	USA	61	55
3	China	29	26
4	Malaysia	23	21
5	India	20	18
6	Greece	17	15
7	Brazil	15	14
8	UK	15	14
9	Canada	12	11
10	Khazastan	8	7
11	Thailand	8	7
12	Iran	7	6

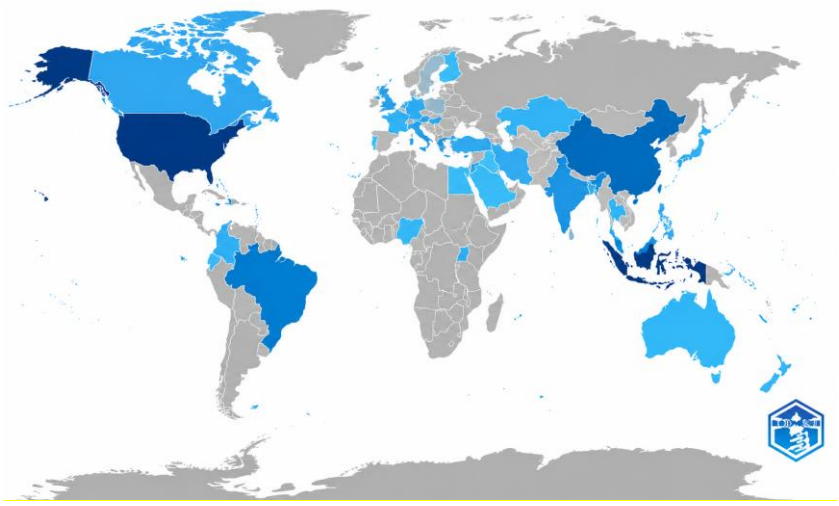

Figure 3. *Country scientific production on this topic.*

Result of co-citation analysis

Figure 4 presents the results of a cluster analysis of the most common keywords used by authors in the literature over the past 43 years. This study can also help identify emerging topics in the future. In this type of map, colours represent different clusters, and clusters are based on relationships. In the map, each keyword represented by a circle. Co-occurrence analysis of all keywords was applied to conceptualise the development and growth of a flood retention pond in relation to land-use changes using GIS. This analysis is performed by selecting the analysis type (co-occurrence) and the unit of analysis (author keywords). To arrive at a meaningful analysis, a minimum threshold of two occurrences for a particular keyword was required and applied. This result yielded 938 keywords for 111 papers, spanning studies from 1981 to 2026. The results are reported in *Figure 4* and show that the most frequently used words are retention pond, climate change, flood and pond. Overall, the keywords that appeared with the highest frequency in the selected articles were flood control (48 times), floods (35 times), lakes (22 times), climate change (21 times), runoff (21 times), urban

planning (19 times) and flooding (16 times). Keywords such as flood control, floods, climate change, urban planning, and runoff are the most heavily connected nodes, indicating they are the core focus of this research dataset. Thick lines and close physical proximity mean those two concepts are studied together very frequently.

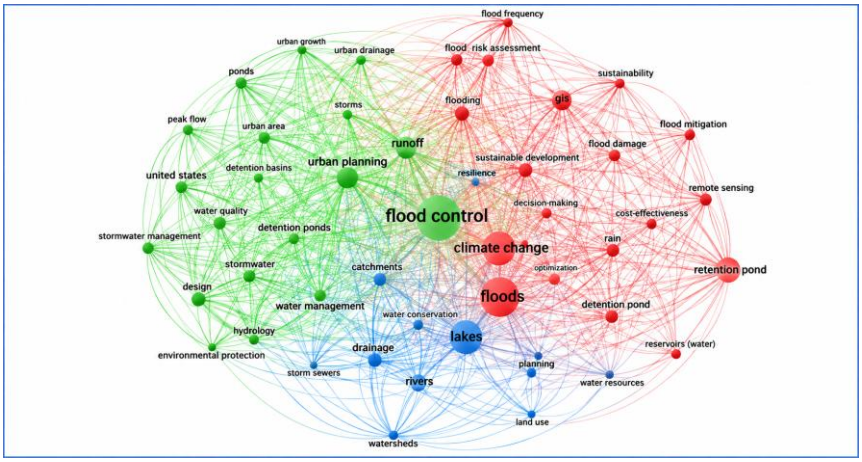

Figure 4. *Co-occurrence analysis using VOSviewer.*

The green cluster focuses on how cities and engineered environments handle water. Keywords such as urban planning, runoff, stormwater management, detention basins, ponds, urban areas, water quality, and hydrology. These keywords fall under the theme of engineering and planning solutions to manage rainfall and surface water in urban settings to prevent local flooding. The red cluster focuses on the macro-environmental drivers, risk analysis, and mapping of flood events. The keywords involved include floods, climate change, GIS (Geographic Information Systems), remote sensing, risk assessment, sustainable development, and flood mitigation. These keywords fall under the theme of using spatial technology and modelling to predict, assess, and mitigate the overarching risks of flooding, which are heavily tied to climate change. This theme is revise to urban stormwater management and flood mitigation. The blue cluster represents the natural hydrology and water resource elements interacting with these floods. Keywords such as lakes, rivers, drainage, watersheds, water resources, and land use. These keywords fall under the theme of natural river basins, water bodies, and how natural landscapes route water during heavy rain events. Thus, this study revises the theme to macro-environmental flood risk analysis and mapping. The map beautifully bridges the gap between environmental science (red cluster: climate change and risk), civil engineering or urban design (green cluster: managing stormwater and urban runoff), and natural hydrology (blue cluster: rivers and watersheds). Flood control sits at the centre as the primary linking mechanism, tying all three disciplines together. For this one, this study revise the theme to river basin hydrology and natural landscape routing (*Figure 5*).

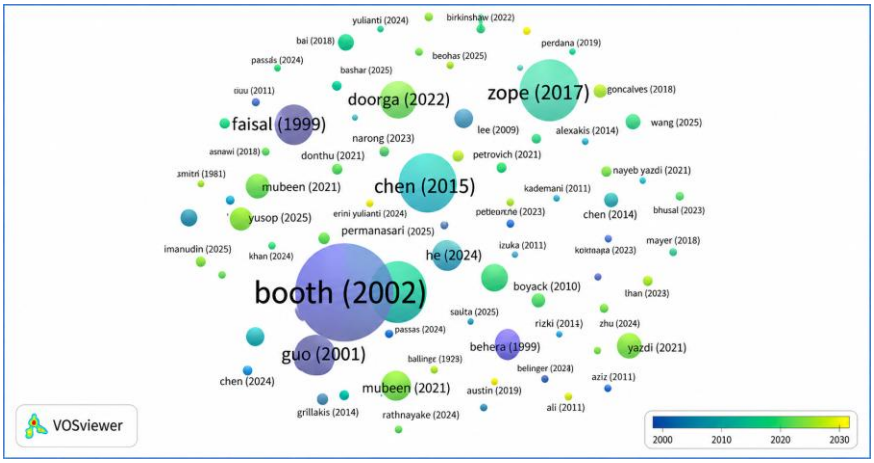

Figure 5. *Citations.*

The larger the circle, the more frequently that paper has been cited. For example, the largest circle on the map, indicating it is the most highly cited or foundational paper in this research cluster. Other prominent papers include Chen (2015). Papers that are clustered tightly together share strong citation links, meaning they are frequently cited together and likely cover the same sub-topic. Papers on the outer edges are less connected to the central theme or represent niche/emerging offshoots. *Figure 6* shows the trend topic of this subject. Looking at papers from 2000 to 2026, it can be divided into three main focuses. Firstly, economic and tactical strategies, as the keywords cost-effectiveness and decision-making have emerged as the latest focus areas. This indicates that the field has shifted from purely understanding hydrological mechanics to evaluating the economic viability and policy implementation of water systems. Secondly, risk and vulnerability mitigation, as indicated by keywords such as flood damage and flood frequency, is seeing a sharp increase in focus. Research is heavily prioritising the calculation and mitigation of actual damage over simple forecasting. Thirdly, climate-driven frameworks: climate change is a major pillar of recent literature, with a high frequency (21 publications) and a third-quartile (Q3) that extends into 2024. In 2019-2022, these topics serve as the foundational bedrock connecting classic water management with modern smart-city applications: geospatial technology; keywords such as GIS and Remote sensing continue to dominate as essential technological tools for monitoring environmental shifts and urban flooding. Another area is modern urban adaptation, with keywords such as urban planning and Sustainable development, highlighting how modern flood control is woven directly into sustainable urban architecture. Topics like detention ponds, hydrology, and basic water conservation have much earlier median years. While they remain fundamentally important, they are no longer the primary drivers of new trend frontiers, having been largely integrated into the newer climate change and urban planning models.

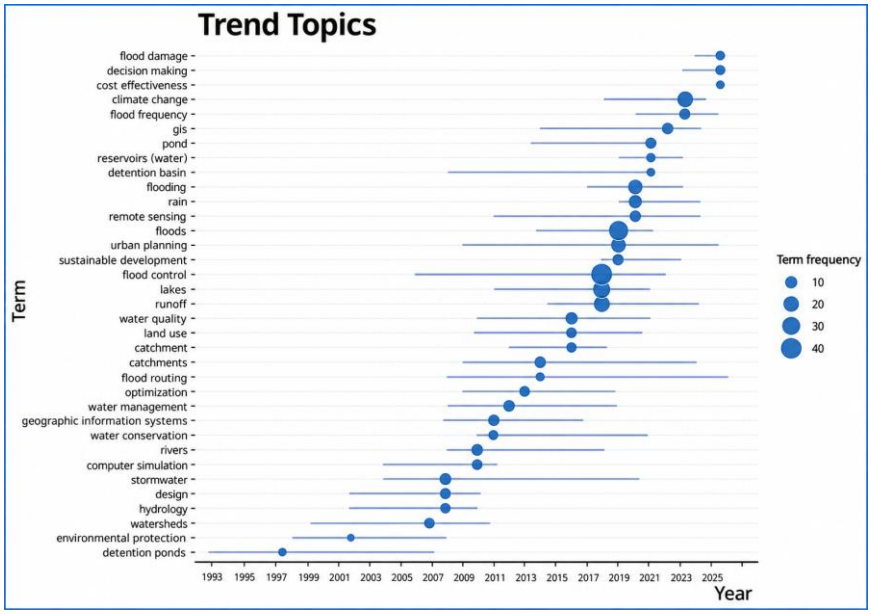

Figure 6. *Trend topics.*

Conclusion

This study focuses on retention or detention pond analysis in flood planning using geospatial analysis to gain clearer insights into trends and historical developments through bibliometric methods. This bibliometric analysis of 111 publications from the Scopus database maps research at the intersection of floods, retention ponds, and land-use changes using GIS assessments from 1981 to 2026. The field has grown substantially. Over 70% of all publications appeared between 2020 and 2025 alone, reflecting the increasing recognition of retention pond studies related to flood hazards as a global challenge and growing confidence in geospatial technologies. The Top 12 Countries by Research Output shows that Indonesia ranks first, with 97 affiliations, accounting for 21.80% of the total research output. USA ranks second with 76 affiliations (17.08%). China ranks third with 28 affiliations (6.29%). The keywords that appeared most frequently in the selected articles were flood control (48 times), floods (35 times), lakes (22 times), climate change (21 times), runoff (21 times), urban planning (19 times), and flooding (16 times). The results of the keyword analysis suggest future research directions, including economic and tactical strategies, risk and vulnerability mitigation, and climate-driven frameworks. This bibliometric analysis provides a comprehensive overview of the intellectual structure and thematic evolution of the flood management research landscape. The citation network reveals an academic domain with deeply rooted foundations, most notably anchored, which has evolved into a vibrant, modern research frontier marked by a recent influx of publications. Concurrently, the keyword co-occurrence network uncovers a highly integrated, tri-disciplinary framework. The field successfully bridges macro-scale climate risk and spatial modelling (the Red Cluster), meso-scale urban infrastructure and stormwater engineering (the Green Cluster), and micro-scale natural hydrological systems (the Blue Cluster). At the epicentre of this network, "flood control" and "climate change" serve as vital conceptual anchors, tying these disciplines together and highlighting a global research shift toward resilient, climate-adaptive water management strategies. The themes found in this research that were evaluated using bibliometric analyses are urban

stormwater management and flood mitigation, ii) macro-environmental flood risk, analysis, and mapping and iii) river basin hydrology and natural landscape routing.

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Conflict of interest

The authors confirm that there is no conflict of interest involve with any parties in this research study.

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