

Better Safe Than Sorry: A Systematic Literature Review on Flood Preparedness Among Indigenous Peoples

Sediakan Payung Sebelum Hujan: Kajian Literatur Bersistematik Mengenai Kesiapsiagaan Menghadapi Banjir Dalam Kalangan Orang Asli

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ABSTRACT

Climate change has increased the likelihood of severe flooding, which particularly affects indigenous communities living in remote areas. Research on the preparedness of indigenous peoples to floods is crucial for the development of strategies based on traditional knowledge to increase resilience and mitigate the effects of severe floods. However, there is a lack of comprehensive studies on flood preparedness in these communities. Previous research has tended to focus on traditional literature reviews, overlooking critical elements such as identification, screening and eligibility processes. To address this research gap, a systematic literature review was conducted using the Reporting Standards for Systematic Evidence Syntheses (ROSES) protocol to examine flood preparedness among Indigenous peoples. The articles analysed in this study were sourced and screened from Scopus and Web of Science, with additional references from Google Scholar and ScienceDirect. The literature search was conducted in five main steps, including adherence to the review protocol, formulation of research questions, and systematic search strategies based on identification, screening, and eligibility. Ten main themes were identified in the thematic analysis: technology adoption, government policy and collaboration, social capital, structural measures, ecosystem-based adaptation, food security, income stability and diversity, self-proactive actions, house-building strategy and adjustments, and traditional knowledge of flood forecasting indicators. These main themes were further subdivided into 22 sub-themes. This study makes an important contribution to the existing body of knowledge and provides practical insights for stakeholders.

Keywords: Disaster; disaster risk reduction; flood preparedness; Indigenous people; systematic literature review

ABSTRAK

Perubahan iklim telah meningkatkan kebarangkalian berlakunya banjir yang teruk dan menjejaskan terutamanya komuniti orang asli yang tinggal di kawasan pedalaman. Kajian mengenai kesiapsiagaan orang asli bagi menghadapi banjir adalah penting untuk membangunkan strategi yang berteraskan pengetahuan tradisional, meningkatkan daya tahan dan seterusnya dapat mengurangkan kesan banjir yang teruk. Walau bagaimanapun, terdapat kekurangan kajian yang menyeluruh berkaitan kesiapsiagaan menghadapi banjir dalam kalangan orang asli. Kajian-kajian terdahulu lebih terarah kepada ulasan literatur yang bersifat tradisional dan mengabaikan elemen-elemen kritikal seperti proses pengenalanpastian, saringan dan kelayakan. Bagi menangani jurang kajian tersebut, kajian literatur bersistematik ini dijalankan dengan menggunakan protokol semakan ROSES (Piawaian Pelaporan untuk Sintesis Bukti Sistematis) bagi mengkaji kesiapsiagaan menghadapi banjir dalam kalangan orang asli. Artikel-artikel yang dianalisa di dalam kajian ini diambil dan disaring daripada sumber Scopus dan Web of Science dan disulami dengan beberapa sumber tambahan daripada Google Scholar dan ScienceDirect. Semakan literatur dalam kajian ini mengambil kira lima langkah utama seperti pematuan kepada protokol semakan, penggubalan soalan kajian dan strategi carian sistematik berdasarkan pengenalanpastian, saringan dan kelayakan. Sepuluh tema utama telah dikenal pasti dalam analisis tematik yang dijalankan dalam kajian ini: penggunaan teknologi, dasar dan kerjasama kerajaan, modal sosial, langkah struktur, penyesuaian berasaskan ekosistem, keselamatan makanan, kestabilan dan kepelbagaian pendapatan, tindakan proaktif sendiri, strategi pembinaan rumah dan pelarasan, dan pengetahuan tradisional tentang penunjuk ramalan banjir. Tema-tema utama ini dipecahkan pula kepada 22 sub-tema. Kajian ini memberi sumbangan penting kepada spektrum pengetahuan sedia ada dan juga sumbangan praktikal kepada pihak-pihak berkepentingan.

Kata kunci: Bencana; pengurangan risiko bencana; kesiapsiagaan banjir; orang asli; kajian literatur sistematik

INTRODUCTION

Climate change has heightened the probability of severe floods in remote communities. One of the most devastating natural disasters in the world, floods have recently become an issue that affects people all over the world. The attention turns to Indigenous communities worldwide, highlighting that they encounter various risks, including a heightened vulnerability to flooding (Danladi et al., 2018). The United Nations Office for Disaster Risk Reduction (UNDRR) reports that 476 million Indigenous people across more than 90 countries inhabit territories covering about 20% of the Earth, making them globally vulnerable to natural hazards. Climate change and extreme weather events are severely affecting the livelihoods of an estimated 370 million Indigenous people (United Nations Office for Disaster Risk Reduction, n.d.). There is no doubt that indigenous communities are facing the most serious consequences of climate change and the myriad complications arising from this phenomenon that jeopardise the indigenous way of life (Zimmerman et al., 2024). Given the inherent inevitability of floods, it is imperative for individuals to consistently maintain a state of preparedness to effectively offset the adverse consequences associated with such occurrences. Disaster preparedness comprises a variety of activities or strategies designed to reduce the impacts of damage such as loss of life or property in the event of a perilous incident. Research on Indigenous disaster risk reduction (DRR) has shown that traditional practices help communities deal with the effects of disasters like floods (Chowdhoree, 2019; Obi et al., 2021).

Based on the above discussion, it is believed that climate change has significantly increased the likelihood of severe flooding, which particularly affects remote Indigenous communities, who are among the most vulnerable groups to these natural disasters. If nothing is done for these communities, they will continue to face increasing threats to their lives, livelihoods and cultural heritage, leading to potentially irreversible damage to their way of life and further marginalisation in the face of global environmental change. Although flood preparedness has been extensively studied in urban (e.g., Elum and Lawal, 2022; Monteil et al., 2022) and general populations (e.g., Ridzuan et al., 2025; Intaramuean et al., 2025), there is a significant lack of research focusing specifically on Indigenous peoples, particularly regarding how they prepare for floods. While some studies have addressed flood preparedness in rural or vulnerable communities (e.g., Rahman et al., 2024; Ao et al., 2020), limited attention has been given to the unique socio-cultural, environmental, and economic challenges faced by Indigenous peoples in preparing for and responding to floods. Moreover, existing literature often overlooks Indigenous knowledge systems, traditional practices, and community-based strategies that could play a crucial role in enhancing flood resilience.

Munthali et al. (2024) emphasized that flood preparedness is vital for reducing the impact of natural hazards, and research specific to Indigenous peoples is necessary to develop tailored strategies that integrate traditional knowledge and improve community resilience. Despite a growing body of empirical research on flood preparedness (e.g., Along et al., 2024; Hussain and Khan, 2023; Arotoma-Rojas et al., 2022; Cudjoe and Alorvor, 2021), there remains a lack of a comprehensive systematic review that synthesizes these studies, identifies patterns, and evaluates the effectiveness of current strategies. Many existing reviews follow traditional methodologies and fail to employ systematic processes, such as identification, screening, and eligibility assessments, which could lead to biases and a lack of transparency (Shaffril et al., 2021).

Some systematic literature reviews have been conducted previously (Kusumastuti et al., 2021); however, these articles focused on disaster preparedness in general and do not capture the flood preparedness strategies specific to Indigenous peoples. Mishra et al. (2010) have urged researchers to conduct separate studies for each type of natural disaster rather than treating "natural

disasters" as a single category, as different types of disasters have distinct characteristics and impacts. Hence, understanding how Indigenous peoples around the world prepare for floods is crucial in formulating policies and strategies to mitigate the impacts of floods on these communities. This highlights the need for a systematic literature review that examines the extent, methods, and effectiveness of flood preparedness strategies specific to Indigenous peoples, ensuring a more rigorous and unbiased synthesis of the available evidence. In light of this knowledge gap, the present study intends to address it by conducting an SLR with a specific focus on indigenous peoples' flood preparedness globally. The researchers focused on the study's research question: "How do indigenous populations worldwide prepare for flooding?" Hence, this study primarily explores the preparatory measures employed by indigenous communities to mitigate flood risks and reduce human and property losses.

RESEARCH METHOD

REVIEW PROTOCOL

In the present study, the Reporting Standards for Systematic Evidence Syntheses (ROSES) review protocol developed by Haddaway et al. (2018) was used to ensure the transparency and robustness of the methodology for the systematic literature review. The process of reviewing this paper begins with the formulation of a research question. This study utilised the PICo method in formulating the research question whereby the "P" represents Population or Problem, "I" for Interest, and "Co" stands for Context. The next step was to formulate a strategy for the document search, which was then carried out in a methodical three-stage process consisting of identification, screening and eligibility. A quality assessment was then carried out using the modified standards of Hong et al. (2018). The quality of each article was assessed before it was included in the review. Finally, the selected articles went through several stages of data extraction and data analysis. All these processes are illustrated in FIGURE 1. The research question of the study served as a roadmap for data extraction, and thematic synthesis, a kind of qualitative data analysis, was employed for data analysis.

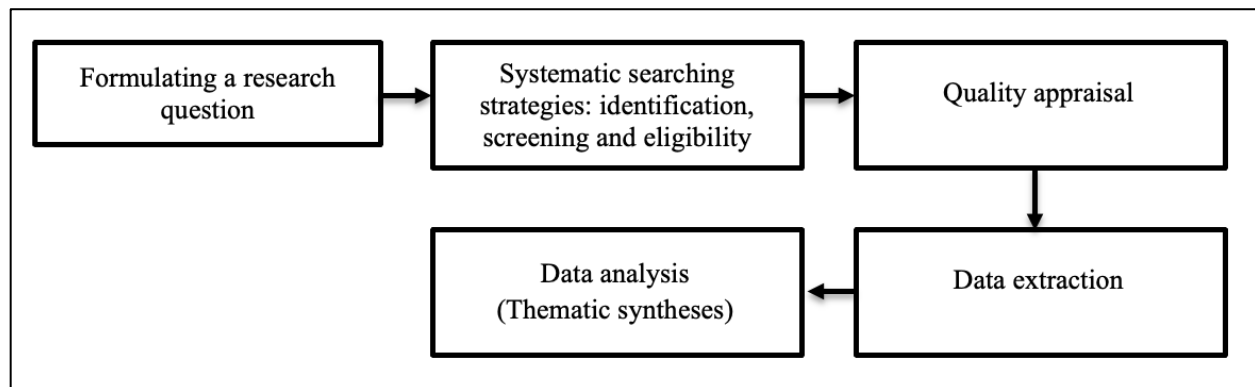


FIGURE 1. Review Protocol-ROSES

FORMULATION OF A RESEARCH QUESTION

Lockwood et al. (2015) developed a PICO method as a guide for developing a research question for a study that requires researchers to identify the problem or population, interest, and context. By applying the PICO method, this study identified the three main aspects of the research question: Population (indigenous peoples), Interest (flood threats) and Context (flood preparedness). The research question of this study was therefore: “How do indigenous peoples around the world prepare for floods?”

SYSTEMATIC SEARCHING STRATEGIES

As suggested by Shaffril et al. (2018), three systematic processes of identification, screening and selection were applied in this study to find the relevant articles and comprehensively locate and synthesize the articles to be reviewed by the researchers. By following this process, transparent and robust findings can be obtained to ensure the accuracy and reliability of the literature review to provide valuable insights for the research field.

IDENTIFICATION

Three main keywords were derived from the research questions: indigenous peoples, flood, and flood preparedness. The researchers enriched these keywords by utilizing an online thesaurus. Additionally, keywords from previous studies and those automatically generated by Scopus were also considered. The full search string, including Boolean operators, phrase searching, truncation, wildcard, and field code functions, was employed using Scopus and Web of Science (refer to TABLE 1). Furthermore, the researchers employed the handpicking technique, utilizing other databases such as Google Scholar, and ScienceDirect, to ensure a thorough exploration of available literature. Initially, this study obtained 207 journal articles related to flood preparedness among Indigenous people based on keywords and the full search string. All these articles underwent the second phase, which is screening.

TABLE 1. Search string used in the selected database

Database	Search String
Scopus	TITLE-ABS-KEY (("flood*") AND ("prepar*" OR "read*" OR "plan*" OR "adapt*" OR "vigil*" OR "alert*" OR "precaution" OR "strateg*" OR "safeguard" OR "safety measure*")) AND ("indigenous people*" OR "indigenous communit*" OR "Indigenous group*" OR "abroginal* people*" OR "abroginal* communit*" OR "native* people*" OR "primitive* people*" OR "primitive* group*" OR "primitive* communit*"))
Web of Science	TS = (("flood*") AND ("prepar*" OR "read*" OR "plan*" OR "adapt*" OR "vigil*" OR "alert*" OR "precaution" OR "strateg*" OR "safeguard" OR "safety measure*")) AND ("indigenous people*" OR "indigenous communit*" OR "Indigenous group*" OR "abroginal* people*" OR "abroginal* communit*" OR "native* people*" OR "primitive* people*" OR "primitive* group*" OR "primitive* communit*"))

SCREENING

Screening was the second procedure carried out where articles were either included or excluded from the study based on a specific set of criteria. Conforming to the ‘research field maturity’ concept suggested by Kraus et al. (2020), this study reviews articles published between 2013 and 2024. The researchers decided to review empirical research papers since they offer primary data and only English-written articles were considered. The subject area of the study is social science. During the screening process, a total of 153 articles were excluded to be reviewed since they were not in line with the inclusion requirement. Hence, only 54 articles remained for the subsequent stage.

ELIGIBILITY, QUALITY APPRAISAL AND DATA EXTRACTION

In this phase, the authors manually checked the remaining 54 articles to identify whether they were suited to the inclusion criteria. As illustrated in FIGURE 1, of the initial pool of articles, 17 were excluded during the title and abstract screening due to lack of relevance, and an additional 14 were removed as they did not specifically address flood preparedness among Indigenous populations. Therefore, the total number of articles selected for quality appraisal was 23. Then, two experts were appointed to appraise the quality of the remaining articles ($n = 23$). Following the recommendation of Petticrew and Roberts (2008), both experts classified 20 articles as high quality and 3 articles as moderate. Consequently, all 23 articles passed the quality appraisal process and were ready for review. While several qualitative synthesis methods could have been applied, the present study opted for the thematic synthesis approach suggested by Flemming et al. (2019). After a thorough review of the 23 articles, the researchers identified ten themes. The flow diagram of the searching process is illustrated in FIGURE 2.

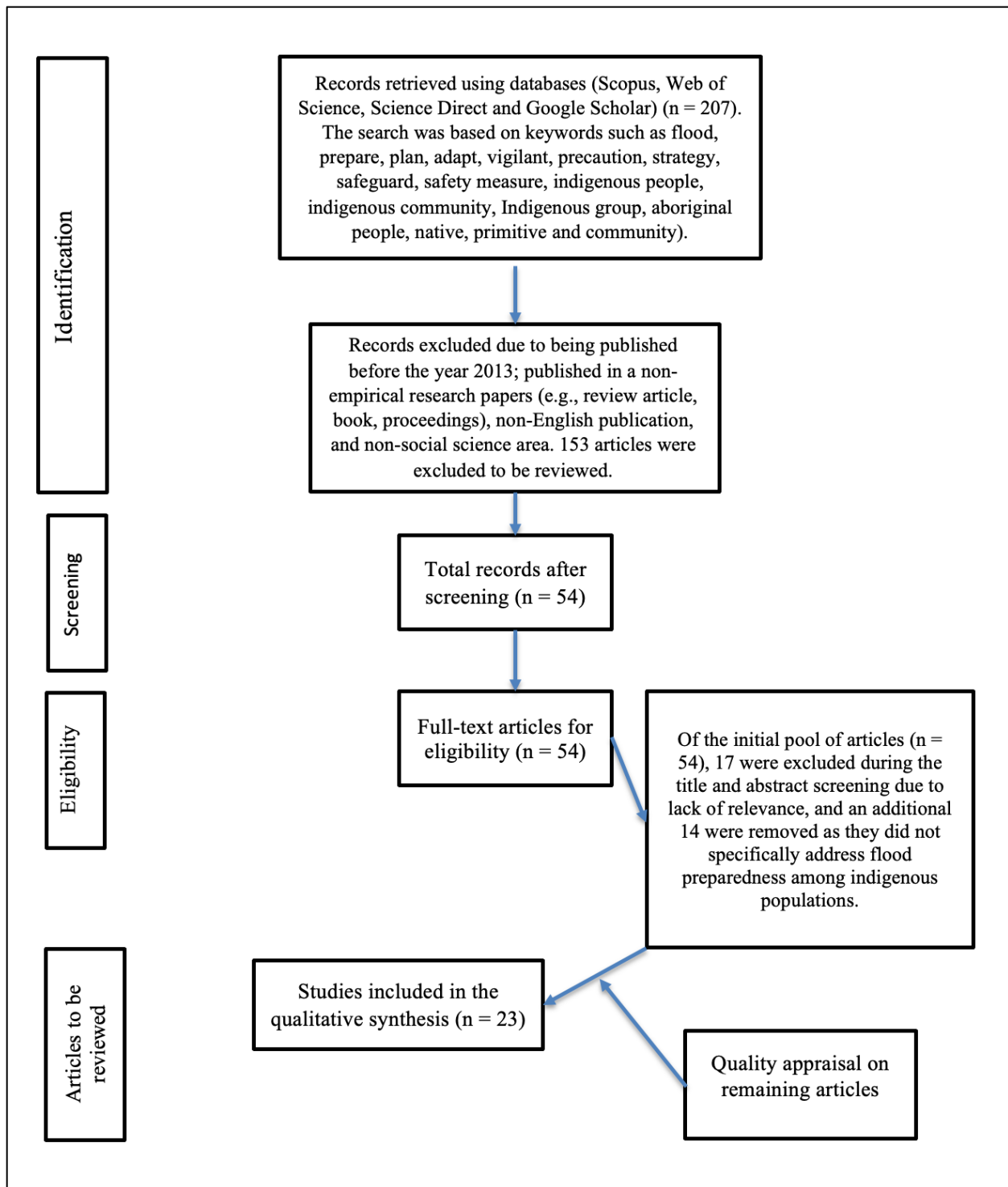


FIGURE 2. Flow diagram of the searching process

RESULTS AND DISCUSSION

This study reviewed a total of 23 journal articles that underwent a strict process of screening, eligibility, and quality appraisal. Of the 23 articles, 2 focused on studies in Malaysia, 2 in Indonesia, 2 in Canada, 2 in Nepal, 2 in Bangladesh, 2 in Malawi, 2 in Nigeria, 1 in India, 1 in Ghana, 1 in Mexico, 1 in Zimbabwe, 1 in Uganda, 1 in Namibia, 1 in Vietnam, 1 in Russia, and 1 in Pakistan. In terms of research design, 14 articles were qualitative studies, while the remaining 9 were mixed-method studies (see FIGURE 3). Regarding the year of publication, 1 article was published in 2024, 2 in 2023, 3 in 2022, 5 in 2021, 2 in 2020, 3 in 2019, 4 in 2016, 1 in 2015, 1 in 2014, and 1 in 2013. All selected journals were of good quality, as they were indexed by both the Scopus and Web of Science databases.

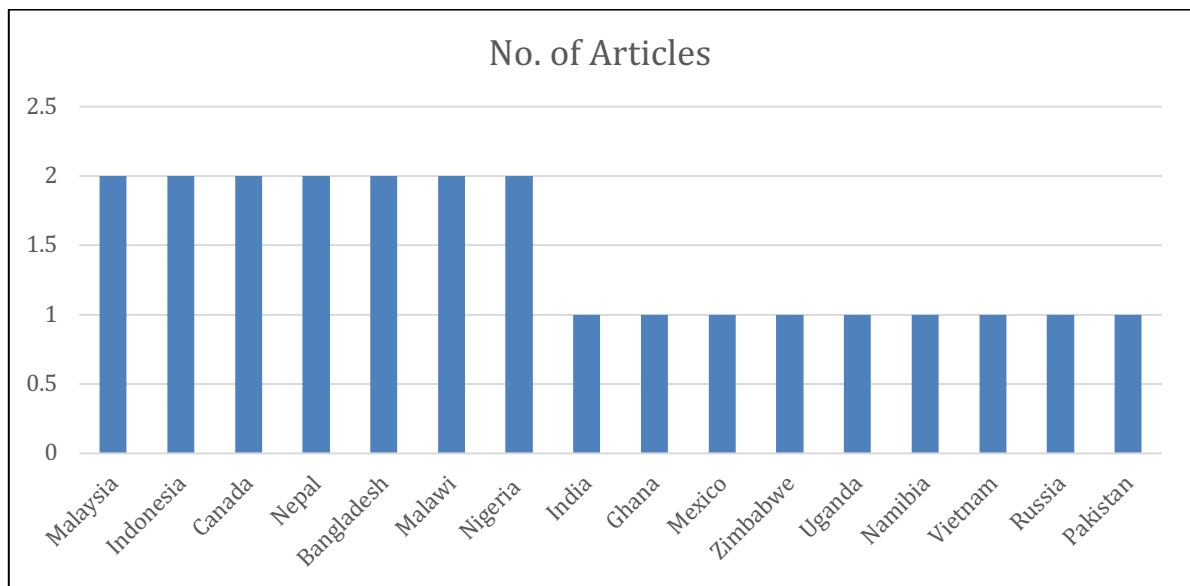


FIGURE 3. Countries and the number of articles in which the selected studies were conducted

TABLE 2 presents the research design and names of journals for the selected studies. It lists 23 studies along with their respective authors and publication years. The research approaches are categorized as either Qualitative (QL) or Mixed Method (MM). Each study is linked to a specific journal, reflecting the diversity of sources in which the research was published.

TABLE 2. Research design and names of journals for the selected studies

No.	Authors and Years	Research Approach	Name of Journals
1	Thapa et al. (2019)	MM	Water
2	Chaudhary et al. (2021)	MM	Climate and Development
3	Sadeka et al. (2020)	QL	Social Indicators Research
4	Filippova (2020)	QL	Polar Science
5	Das (2016)	MM	Journal of Global South Studies
6	Along et al. (2024)	QL	International Journal of Disaster
7	Islam (2016)	MM	Resilience in the Built
8	Hussain and Khan (2023)	MM	Environment
9	Arotoma-Rojas et al. (2022)	QL	International Journal of Scientific and Engineering Research
10	Mavhura et al. (2013)	QL	Environment, Development and Sustainability

11	Khalafzai et al. (2021)	QL	Sustainability
12	Bwambale et al. (2022)	QL	International Journal of Disaster Risk Reduction
13	Echendu (2023)	QL	International Journal of Disaster Risk Reduction
14	Obi et al. (2021)	MM	International Journal of Disaster Risk Reduction
15	Hooli (2016)	QL	Natural Hazards Research
16	Cudjoe and Alorvor (2021)	MM	International Journal of Disaster Risk Reduction
17	Marfai et al. (2015)	QL	Regional environmental change
18	Phu and De (2016)	MM	Hydrology
19	Devkota et al. (2014)	MM	Natural Hazards
20	Ngongondo et al. (2021)	QL	Cyclones in Southern Africa
21	Syahputra (2019)	QL	International Journal of Global Warming
22	Chowdhoree and Das (2022)	QL	International Journal of Disaster Resilience in the Built Environment
23	Šakić Trogrlić et al. (2019)	QL	Collection and Curation

Note: QL = Qualitative study, MM = Mixed Method

FIGURE 4 illustrates the number of publications per year, detailing the annual publication trends in a given field. The data covers 12 years, starting from 2013 and ending in 2024. The TABLE highlights an overall increasing trend in publications over the years, with notable fluctuations. The peak in 2021 suggests heightened research activity, while the decline in the later years may indicate a reduced focus or a different trend in research interest.

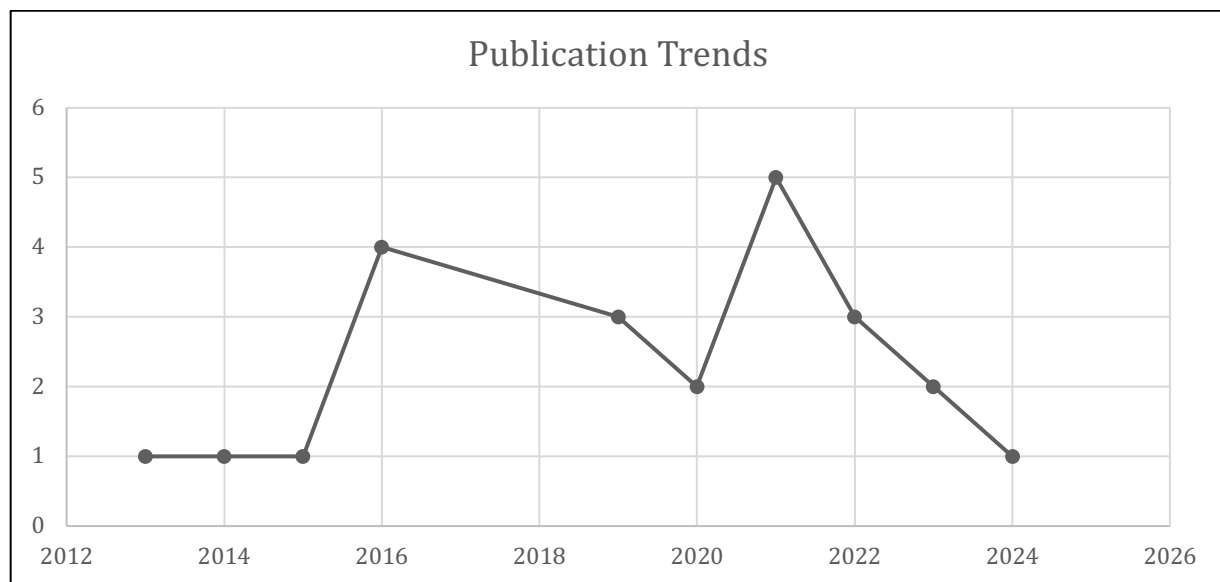


FIGURE 4. Publication trends

FIGURE 5 depicts the percentage distribution of research publications across four continents. Asia leads with 48% of the total publications, indicating a significant concentration of research activity in this region. Africa follows with 35%, demonstrating a strong contribution to the overall body of work. North America accounts for 13%, showing a moderate share, while Europe contributes the smallest percentage at 4%. These figures highlight the varying levels of research output across different continents, with Asia being the dominant region in terms of publication volume.

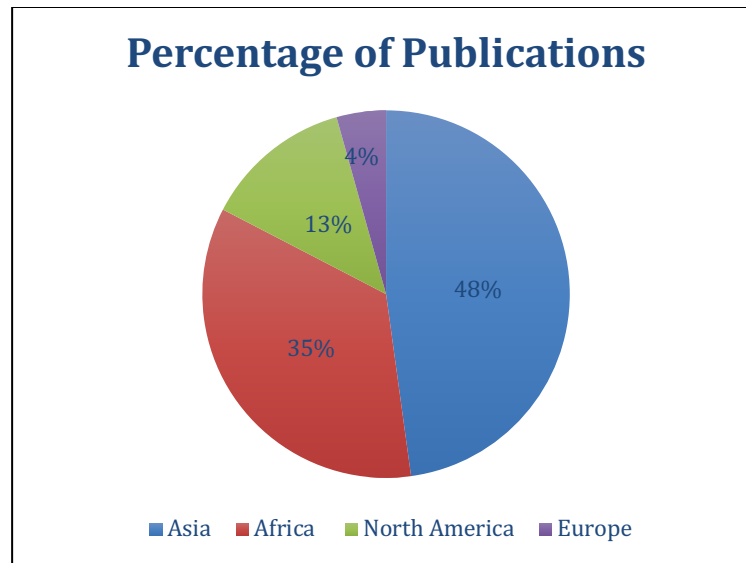


FIGURE 5. Percentage of publications by continent

THE DEVELOPED THEMES

In this study, the themes were developed using thematic analysis. Thematic analysis is the process of reviewing previous studies, identifying recurring themes or patterns in the data, and then grouping them into categories for better understanding (Braun & Clarke, 2006). Flemming et al. (2018) asserted that thematic analysis is the most suitable method for synthesizing mixed research designs. The thematic analysis of 23 selected articles revealed seven main themes: (1) Technology adoption, (2) Government policy and collaboration; (3) Social capital, (4) Structural measures, (5) Ecosystem-based adaptation, (6) Food security, (7) Income stability and diversity, (8) Self-proactive actions; (9) House building strategy and adjustments; (10) Traditional knowledge of flood forecasting indicators. Based on the results, 10 themes and 22 sub-themes provided answers to the research question of this SLR: "How do indigenous peoples around the world prepare for floods?". All ten themes and 22 sub-themes can be summarised in TABLE 3.

TECHNOLOGY ADOPTION

Technology plays a crucial role in assisting indigenous populations in confronting flood challenges. Through the integration of innovative technologies such as early warning systems, community radio, pumping machines, and large containers for storing crops, Indigenous communities fortify their resilience against the detrimental impacts of floods (Thapa et al., 2019; Chaudhary et al., 2021; Bwambale et al., 2022; Cudjoe and Alorvor, 2021). Tapsell et al. (2021) emphasized the importance of developing comprehensive risk maps as efficient and effective flood mitigation measures. Imam et al. (2017) highlighted that technology not only serves as a means of flood preparedness but also addresses governance and mobility challenges arising from floods. The integration of technology in Indigenous communities' flood preparedness strategies represents a promising pathway to enhancing resilience against natural disasters. However, the integration of technology into Indigenous communities is not without its challenges. One potential limitation is the accessibility and affordability of these technologies. Many Indigenous populations live in remote, economically disadvantaged regions where access to advanced technology or the financial

resources to implement it may be limited. The adoption of technology poses challenges due to the lack of financial resources and technology transfer among many indigenous communities (Sarkar and Modak, 2023), impeding its long-term adoption (Florin and Wandersman, 1990). Therefore, it is important to consider the feasibility of introducing such technologies and the potential need for external support or partnerships with governmental or non-governmental organizations to facilitate their adoption.

GOVERNMENT POLICY AND COLLABORATION

Government assistance and collaboration with other stakeholders, especially NGOs, have aided indigenous people in preparing for floods (Chaudhary et al., 2021; Sadeka et al., 2020; Šakić Trogrlić et al., 2019). In Malaysia, several government agencies provide necessary support and services to Orang Asli families before and during floods (Sadeka et al., 2020). In Pakistan, the government and NGOs offer financial assistance to Indigenous peoples for constructing floodwalls, ensuring the protection of houses and lands from flood disasters (Hussain and Khan, 2024). Das (2016) revealed that the government distributed various crucial machinery, including tractors, along with agricultural necessities such as seeds, fertilizers, and pesticides. In Russia, the government plans relocation programs and funds public infrastructure and facilities (Filippova, 2020).

The findings point to the consistent involvement of governments in flood preparedness and disaster risk reduction, demonstrating their recognition of the vulnerability of Indigenous populations. It shows that these countries embrace and uphold the aspiration of the Sendai Framework for Disaster Risk Reduction (SFDRR) in highlighting the roles of government to work and coordinate with civil society, communities and indigenous peoples in disaster risk management at the local level (Peters, 2024). However, the reliance on government and NGO support could be problematic if these agencies fail to consider the local knowledge and cultural practices of Indigenous communities. There is also the risk that aid is not consistently distributed, especially in areas with political instability or limited infrastructure. Furthermore, relocation, particularly when it is part of disaster response strategies for Indigenous communities, offers both positive and negative consequences. Relocation provides an opportunity for communities to move away from flood-prone areas, which could increase their chances of living in a safer and more resilient environment. While relocation provides the opportunity to earn a sustainable income, it disrupts children's education and reduces social networks (Aryal et al., 2014). This disruption may have long-term consequences for children's educational development, potentially leading to lower academic performance or disengagement from formal education systems.

SOCIAL CAPITAL

In Malaysia, a strong sense of community and close relationships among families, relatives, and neighbours foster mutual trust and facilitate effective communication, cooperation, and support networks during the flood preparedness process (Sadeka et al., 2020). In Pakistan, Indigenous people help each other by raising funds to purchase floodwall materials, and household representatives voluntarily participate in the construction of floodwalls (Hussain and Khan, 2024). In Uganda, community members have developed saving and internal lending schemes in preparation for future floods (Bwambale et al., 2022). Social cohesion embedded among indigenous peoples in Nigeria (Echendu, 2024) and Nepal (Devkota et al., 2014) can also help community members prepare for future floods. Aldrich and Meyer (2015) contend that increasing

social capital can enhance disaster resilience and preparedness. Social networks and mutual aid embedded within communities are crucial factors that help Indigenous people prepare for and cope with floods (Madzwamuse and Fabricius, 2013). The reasons for the strong role of social capital in these cases lie in the shared cultural values of cooperation, mutual assistance, and collective responsibility. Communities with strong social ties are better equipped to handle the stress of floods because they have built-in support systems. These systems not only provide material help but also help maintain mental and emotional well-being during times of crisis.

TABLE 3. Findings

Authors / Themes	Countries	Technology adoption		Government policy and collaboration		Social Capital			Structural Measures		Ecosystem-Based Adaptation		Food Security	
		GIS	RMT	Tr	Res	Collabs	SC	CN	ES	MMT	VFMS	CBNRM	EFS&PT	AFP4FR
Thapa et al. (2019).	Canada	√												
Chaudhary et al. (2021)	Nepal		√	√		√								
Sadeka et al., (2020).	Malaysia				√		√							
Filippova (2020).	Russia				√									
Das (2016)	India				√									
Along et al. (2024)	Malaysia				√									
Islam (2016).	Bangladesh			√		√			√	√			√	
Hussain & Khan (2023)	Pakistan				√			√	√		√	√		
Arotoma-Rojas et al., 2022	Mexico										√	√		
Mavhura et al. (2013).	Zimbabwe										√	√	√	
Khalafzai et al. (2021).	Canada													
Bwambale et al. (2022)	Uganda		√				√	√						√
Echendu (2023).	Nigeria						√		√	√	√	√		
Obi et al. (2021).	Nigeria									√				√
Hooli (2016)	Namibia								√		√	√		
Cudjoe & Alorvor (2021)	Ghana		√							√				
Aris et al. (2015)	Indonesia								√					
Phu & De (2016).	Vietnam													√
Devkota et al. (2014)	Nepal					√	√							
Ngongondo et al., 2021)	Malawi													
Syahputra (2019).	Indonesia													
Chowdhoree & Das (2022)	Bangladesh													

Šakić Trogrlić et al. (2019).	Malawi			√		√			√		√
Thapa et al. (2019)	Canada										
Chaudhary et al. (2021)	Nepal	√							√		√
Sadeka et al. (2020)	Malaysia			√		√					
Filippova (2020)	Russia						√				
Das (2016)	India						√				
Along et al. (2024)	Malaysia						√		√		√
Islam (2016)	Bangladesh							√			
Hussain & Khan (2023)	Pakistan	√	√	√							
Arotoma-Rojas et al., 2022	Mexico	√									
Mavhura et al. (2013)	Zimbabwe		√				√		√		√
Khalafzai et al. (2021)	Canada					√			√		√
Bwambale et al. (2022)	Uganda	√	√	√						√	
Echendu (2023).	Nigeria										
Obi et al. (2021).	Nigeria	√				√	√		√	√	√
Hooli (2016)	Namibia			√		√			√		
Cudjoe & Alorvor (2021)	Ghana	√		√			√		√	√	
Aris et al. (2015)	Indonesia						√			√	
Phu & De (2016).	Vietnam			√		√					
Devkota et al. (2014)	Nepal								√		√
Ngongondo et al., 2021)	Malawi										√
Syahputra (2019).	Indonesia								√		√
Chowdhoree & Das (2022)	Bangladesh						√				
Šakić Trogrlić et al. (2019).	Malawi	√	√	√					√	√	√

Note: Abio = Abiotic Indicators for Flood Forecasting, AFP4FR = Adaptive Farming Practices for Flood Resilience, Bio = Biotic Indicators for Flood Forecasting, CBNRM = Community-Based Natural Resource Management, CD = Crop Diversification, CM&SA = Construction Materials and Structural Adaptations, CN = Community network, Collabs = Collaboration between government, NGOs, and community members, EFS&PT = Emergency Food Storage and Preservation Techniques, ERSS = Emergency Relocation and Shelter Strategies, ES = Engineering Solutions, GIS= Geographic Information Systems, LD = Livelihood Diversification, MMT = Mitigation and Management Techniques, PRME = Preparedness and Resource Management for Emergencies, Res = Resources, RM4FP = Renovations and Modifications for Flood Prevention, RMT = Resource Management Technologies, SC = Social cohesion, SS&HET = Site Selection and House Elevation Techniques, TP = Trees plantation, Tr = Training, VFMS = Vegetative Flood Mitigation Strategies

STRUCTURAL MEASURES

Past studies found that the indigenous peoples have embarked on structural measures for flood defence purposes (Hooli, 2016; Obi et al., 2021; Islam, 2016; Hussain and Khan, 2024; Echendu, 2024; Marfai et al., 2015). The construction of floodwalls along the rivers (Hooli, 2016; Hussain and Khan, 2024), embankments (dikes, levees and ridges) (Islam, 2016; Echendu, 2024; Marfai et al., 2015), the construction of bridges from bricks (Hooli, 2016) were among the flood preparedness efforts of Indigenous peoples. The Indigenous peoples were also found digging gutters and drains around their houses (Obi et al., 2021; Cudjoe and Alorvor, 2021; Šakić Trogrlić et al., 2019; Echendu, 2024), and piling sandbags as barriers or walls to redirect floodwaters away from vulnerable areas (Obi et al., 2021; Cudjoe and Alorvor, 2021; Islam 2016). According to Ridzuan et al. (2022), both structural and non-structural measures are commonly employed to safeguard areas at risk of flooding. One significant reason behind the adoption of such measures is the Indigenous peoples' intimate relationship with the land and their deep understanding of local environmental dynamics. Communities that live in flood-prone areas tend to have a heightened awareness of the risks and have historically developed various ways to protect themselves. The construction of infrastructure will expedite the rescue process during emergencies (Bastakoti et al., 2014). However, these structural interventions often require ongoing maintenance and resources, which may not always be available, particularly in Indigenous communities with limited access to funding or external support. Without adequate investment and long-term planning, these measures might eventually fail to provide adequate protection.

ECOSYSTEM-BASED ADAPTATION

Indigenous peoples, especially in Pakistan, Mexico, Zimbabwe, Nigeria, and Namibia, have utilized a nature-based approach to flood preparedness (Mavhura et al., 2013; Hooli, 2016; Hussain and Khan, 2024; Echendu, 2024; Arotoma-Rojas et al., 2022). In Pakistan and Namibia, indigenous people have grown a variety of trees with broad and deep roots that help to stabilize the soil (Hooli, 2016; Hussain and Khan, 2024). The indigenous populations have cultivated several forest plants, including yacushimbillo or guava trees, coach grass, Indian bamboo, and mangroves, as a means to mitigate soil erosion and flooding (Mavhura et al., 2013; Echendu, 2024; Arotoma-Rojas et al., 2022). The findings reveal the innovative and sustainable nature-based approaches that Indigenous peoples across various regions have employed to mitigate the effects of floods. Indigenous communities have utilized tree planting and the cultivation of forest plants to strengthen flood resilience. The use of nature-based solutions by Indigenous peoples is aligned with broader global movements toward more sustainable, eco-friendly, and climate-resilient approaches to disaster management. By restoring natural landscapes and ecosystems, Indigenous communities are contributing to global efforts to combat climate change and promote resilience. Planting trees can mitigate flooding due to their extensive root systems, which fortify and bind the soil, stabilize river banks, and consequently diminish erosion and the risk of floods (Moore, 2022). By obstructing and deflecting water with their roots and trunks, trees not only slow down floodwaters but also alter the direction of flow (Spiekermann et al., 2021).

FOOD SECURITY

Floods can destroy crops, leading to immediate food shortages and long-term impacts on food security. Indigenous people in Uganda, Nigeria, and Vietnam have opted to change their farming practices to prevent food insecurity due to flood disasters (Obi et al., 2021; Bwambale et al., 2022; Phu et al., 2016). In Uganda, indigenous people have altered their livelihoods from crop farming to tree farming. In Zimbabwe, they utilize polythene bags to stockpile dry food, grain, and seeds, which are then kept in a special hut called *dura* (Mavhura et al., 2013). In Bangladesh, indigenous people stockpile food, store pure drinking water, reserve cooking oil, and store food for their livestock before floods occur (Islam, 2016). In Malawi, Indigenous people keep food on a raised platform inside the house called 'khungu', 'nsanja', and 'tandala', while also placing food reserves in houses in the uplands (Šakić Trogrlić et al., 2019). The findings suggest that Indigenous communities in different countries have developed various adaptive strategies to combat food insecurity caused by flood disasters. The adaptations highlight both short-term and long-term responses to ensure food security during and after flood events. Food insecurity in Indigenous communities is not just a result of the challenges caused by the pandemic but has deeper, long-standing causes. As a result, many Indigenous communities rely on food sources from outside their communities, rather than being self-sufficient (Rowe et al., 2024; Sampson et al., 2021). Rakib et al. (2019) highlighted the necessity of storing food in suitable places, as the contamination of food and drinking water during floods can increase the likelihood of human diseases such as diarrhoea and starvation.

INCOME STABILITY AND DIVERSITY

Indigenous people often diversify their crops as a flood preparedness measure to sustain their income (Cudjoe and Alorvor, 2021; Hussain and Khan, 2024). In Pakistan, they also engage in non-farm employment activities (Hussain and Khan, 2024). In Ghana, farmers have shifted to large-scale cultivation of shallots and peppers as alternative crops (Cudjoe and Alorvor, 2021). Other indigenous groups prioritize the location of their farming land, with some in Malawi farming in both uplands and lowlands or renting farming plots in the uplands (Šakić Trogrlić et al., 2019). In Mexico, Indigenous people identify the most at-risk places in the community to avoid planting in those areas (Arotoma-Rojas et al., 2022). Additionally, indigenous farmers reschedule their farming timing to protect their crops from being inundated by floodwaters (Obi et al., 2021; Chaudhary et al., 2021; Bwambale et al., 2022; Šakić Trogrlić et al., 2019). In Zimbabwe and Uganda, they sell their assets and flood-prone land to those who can afford to engage in tree farming and/or pastoralism (Mavhura et al., 2013). The findings reveal that Indigenous communities around the world use a variety of strategies to stabilize and diversify their income in the face of flood risks. These adaptive measures focus on income resilience, ensuring that Indigenous peoples can maintain their livelihoods even when floods disrupt agricultural activities. The strategies outlined in the findings highlight how Indigenous groups employ a combination of agricultural diversification, non-farm employment, land management practices, and even rescheduling farming activities as a proactive response to flood disasters. The destruction of crops by floods makes it imperative for community members to diversify their income. The various skills possessed by indigenous people offer opportunities to utilize all resources and skills to diversify their income as a strategy to prepare for floods (Zhang et al., 2019).

SELF-PROACTIVE ACTIONS

The indigenous peoples proactively minimize the detrimental effects of floods by moving to safer locations such as community halls (Sadeka et al., 2020), schools, and churches situated in higher elevation areas (Bwambale et al., 2022; Šakić Trogrlić et al., 2019). Additionally, they transfer both people and animals to the elevated ground (Das, 2016; Phu et al., 2016; Cudjoe and Alorvor, 2021; Hussain and Khan, 2024) until the floodwaters recede. Indigenous people in Malaysia, Namibia, and Canada safeguard important documents such as Identification Cards and bags by storing them on upper floors or in safer locations inaccessible to floodwaters, while also preparing emergency survival items (Hooli, 2016; Sadeka et al., 2020; Khalafzai et al., 2021). They also arranged for emergency transportation, such as boats and canoes (Obi et al., 2021; Sadeka et al., 2020; Islam, 2016). In Nigeria, indigenous communities keep canoes (Ugbojo, a small canoe, and Ugboamala, a large canoe) close to their homes to evacuate household members and property in case of sudden flooding (Obi et al., 2021). In Bangladesh and Vietnam, indigenous peoples equip themselves with swimming skills acquired from family members, neighbours, and relatives (Islam, 2016; Phu et al., 2016). The findings highlight the proactive measures taken by Indigenous peoples to mitigate the impacts of floods, demonstrating their resilience and adaptability in the face of flood risks. These actions include moving to safer locations, safeguarding important documents and property, preparing emergency survival items, and organizing transportation methods such as boats and canoes for evacuation. Additionally, some Indigenous communities equip themselves with swimming skills to navigate floodwaters, further enhancing their preparedness and survival capacity. Indigenous communities recognize the importance of anticipating these risks and taking early, preventative actions to minimize harm. Individuals are urged to take proactive action to prepare themselves for flood risks to increase their safety (Grothmann and Reusswig, 2006) and reduce the economic damages of floods considerably (Fink et al., 1996).

HOUSE BUILDING STRATEGY AND ADJUSTMENTS

The location of a house is one of the criteria considered by indigenous people before construction (Mavhura et al., 2013; Filippova, 2020; Along et al., 2024). In Zimbabwe, Indigenous people build their houses on earthen platforms to prevent floodwater from reaching the plinth level during low-magnitude floods (Mavhura et al., 2013). In Ghana, they elevate the foundation of their houses before construction begins (Cudjoe and Alorvor, 2021). In Bangladesh, indigenous people practice raising homesteads above agricultural land to protect houses from flooding, as well as excavating ponds for both building materials and water management, which are strategies for adapting living spaces to flood risks (Chowdhoree and Das, 2022). Many Indigenous groups prefer stilt houses for their elevated position above ground level, offering protection against flooding (Das 2016; Along et al. 2024), while others opt for floating houses (Mavhura et al., 2013; Obi et al., 2021). In Indonesia, terraced housing is built by indigenous people to minimize flood risk (Marfai et al., 2015). Additionally, they adjust or renovate their houses to prevent flooding (Mavhura et al., 2013; Obi et al., 2021; Cudjoe and Alorvor, 2021; Along et al., 2024; Šakić Trogrlić et al., 2019; Marfai et al., 2015; Khalafzai et al., 2021). Indigenous people are also mindful of the materials used in house construction and take measures to protect their homes from flooding (Mavhura et al., 2013; Hooli, 2016; Šakić Trogrlić et al., 2019). According to Along et al. (2024), Indigenous people typically have fewer belongings and smaller houses, making stilt houses appropriate for sufficient space and security against floodwaters, aligning with their lifestyle and housing needs.

TRADITIONAL KNOWLEDGE OF FLOOD FORECASTING INDICATORS

Indigenous people around the world use nature's surroundings as reliable indicators of upcoming weather changes and flood events (Obi et al., 2021; Chaudhary et al., 2021; Bwambale et al., 2022; Devkota et al., 2014; Šakić Trogrlić et al., 2019; Ngongondo et al., 2021; Syahputra, 2019). Various riparian biotic and abiotic elements are considered to consistently indicate changes in weather and the possibility of floods. The first indicator is riparian biotic, which refers to living organisms (Bwambale et al., 2022). Indigenous people in Nepal, Indonesia, Malawi, and Uganda use this indicator to forecast changes in weather and incoming flood events (Bwambale et al., 2022; Devkota et al., 2014; Šakić Trogrlić et al., 2019; Syahputra, 2019). In Nepal and Indonesia, indigenous people observe the movement of ants to forecast rainfall (Devkota et al., 2014; Syahputra, 2019). Other Indigenous people use living animals as indicators to forecast changes in weather and incoming flood events (Chaudhary et al., 2021; Bwambale et al., 2022; Šakić Trogrlić, 2019).

The second indicator is riparian abiotic, which refers to non-living factors such as soil, water, and geological features found in riparian zones (Bwambale et al., 2022). Indicators such as the movement of clouds and the intensity of thunderstorms in the sky (Devkota et al., 2014), the colour of the sky and clouds (Ngongondo et al., 2021; Syahputra, 2019), the direction and speed of winds (Obi et al., 2021; Chaudhary et al., 2021; Ngongondo et al., 2021), the presence of debris like dead leaves, grasses, polythene bags, sand, and silt particles (Obi et al., 2021), as well as rainfall in the upper catchment area and the sensation of heat (Devkota et al., 2014), all indicate an impending flood, prompting people to move to higher ground. Santha et al. (2014) confirmed that traditional knowledge systems are inherent elements of people's capacity to foresee natural hazards, invariably mitigating disaster risk. Although indigenous people must predict weather and floods, this knowledge may disappear in the modern era as people prefer modern technology for forecasting floods (Iticha and Husen, 2019; Markkula et al., 2019).

CONTRIBUTIONS OF THE STUDY

This study presents a novel contribution by addressing a significant gap in flood preparedness research specifically focused on Indigenous peoples, an area that remains largely underexplored compared to studies on urban and general populations. It makes a meaningful contribution to the body of knowledge by filling a gap in existing systematic literature reviews on flood preparedness, with a specific focus on Indigenous peoples. While previous reviews, such as Kusumastuti et al. (2021), have explored disaster preparedness in general, they do not capture the unique flood preparedness strategies employed by Indigenous communities. By examining flood preparedness within the context of Indigenous peoples, this research offers insights into the socio-cultural, environmental, and economic factors that influence their preparedness practices. Furthermore, in line with the call by Mishra et al. (2010), this study emphasizes the importance of treating flood preparedness as a distinct category within disaster research, recognizing that floods have specific characteristics and challenges that differ from other natural disasters. This focused approach enhances the understanding of Indigenous flood resilience, thereby enriching the broader field of disaster preparedness.

This review introduces a novel perspective by developing evidence-based, culturally appropriate strategies that integrate traditional Indigenous knowledge with modern flood resilience methods, offering more sustainable and context-specific solutions. Furthermore, the study's use of

rigorous systematic literature review methodologies ensures transparency and minimizes bias, providing a reliable synthesis of evidence that can guide future research, policy-making, and practical interventions. The study's practical contributions are also significant, offering new insights into how Indigenous knowledge can be systematically integrated into flood preparedness programs. It provides actionable guidance for policymakers and emergency management organizations, enabling them to design tailored interventions. Additionally, the study will help improve resilience programs by identifying existing gaps and suggesting ways to incorporate Indigenous practices, strengthen community networks, and empower Indigenous communities in disaster risk reduction. Finally, the research lays the groundwork for future studies by establishing a framework for integrating Indigenous perspectives into flood preparedness and resilience strategies, ensuring that these approaches are both culturally relevant and sustainable. This innovative approach not only fills a crucial gap in the existing literature but also offers actionable insights for improving flood resilience in Indigenous communities.

CONCLUSIONS

The primary goal of this study was to conduct a systematic literature review on Indigenous peoples' flood preparedness, aiming to provide substantial theoretical and practical contributions to several stakeholders such as academics, policymakers, and the Indigenous community. By shedding light on the cultural insights, customary methods, and beliefs passed down through generations in Indigenous communities to manage flooding, it enhances our theoretical grasp of indigenous knowledge systems concerning flood preparedness. According to Tran et al. (2021), indigenous people's perspectives on flood preparedness can lay the groundwork for more effective, collaborative, and culturally appropriate flood preparedness efforts. By synthesizing existing literature, this study contributes to resilience and adaptation theories by exploring how indigenous communities adapt to and recover from flood events. It can identify resilience-building strategies and adaptive capacities inherent within indigenous cultures. Theoretical insights from the SLR can inform policy and governance frameworks aimed at enhancing flood preparedness among Indigenous peoples. Furthermore, the findings of the study guide future research on flood preparedness by revealing which topics and methods should be prioritised.

This study emphasises the importance of ecosystem-based approaches to flood preparedness among indigenous peoples and advocates the preservation of traditional land management practices. The study concludes that Indigenous peoples' flood preparedness can be categorised into 10 themes and 22 sub-themes. The results indicate that indigenous communities can use modern technologies such as early warning systems in addition to traditional practices to prepare for floods. Their preparedness is often influenced by government policies, collaboration with local authorities and support programmes that recognise and integrate traditional knowledge. The strength of community networks and social ties within indigenous groups plays a critical role in collective flood preparedness and response. Indigenous communities can also take structural measures, such as elevated houses or dams adapted to local conditions, to mitigate the effects of flooding. In addition, many indigenous groups apply ecosystem-based strategies, such as the conservation of wetlands or forests, which can naturally reduce flood risk.

Ensuring food security by preserving traditional agricultural practices or storage methods is crucial for preparing for and recovering from floods. Diversifying sources of income helps Indigenous communities to prepare for the economic impacts of flooding. Indigenous peoples

often take proactive measures, such as community drills, building emergency shelters or stockpiling essential supplies, based on their knowledge and experience. Traditional house-building techniques, such as building houses on stilts or using flood-resistant materials, are tailored to withstand flooding. In addition, Indigenous communities often rely on traditional ecological knowledge, such as observing animal behaviour or natural signs, to predict flooding and prepare accordingly. Together, these themes provide a comprehensive understanding of the different ways in which indigenous peoples prepare for floods and illustrate the mix of traditional knowledge and modern practices. In this analysis, the theme concerning technological aid appeared less prominent compared to other themes. There has been a scarcity of research conducted to assess and investigate these preparatory aspects. Hence, researchers and other scholars must explore how technology can support and enhance the flood preparedness of indigenous communities. Discovering such insights could provide a fresh perspective for governments and private sectors to integrate technology in rural areas, thereby mitigating the effects of floods and narrowing the gap in technological resources between urban and rural areas.

While this systematic review employed a thorough search and aimed to include more articles investigating the strategies Indigenous peoples around the world use to prepare for floods, the number of studies from each country varied significantly. The distribution of research publications shows that Asia leads with 48%, followed by Africa at 35%, North America at 13%, and Europe at 4%. Future studies should focus on under-researched continents to gain a more global understanding of flood preparedness. Additionally, most of the articles reviewed are entirely qualitative (14), with nine studies utilizing a mixed methods approach, and none employing a purely quantitative design. Future research should consider incorporating more quantitative methods. A quantitative approach allows for the collection of statistical data, enabling researchers to generalize findings to larger populations and identify measurable trends. This method can be particularly useful in detecting patterns and relationships that may not be evident in qualitative studies, such as the influence of specific variables on flood preparedness among different Indigenous communities.

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