

# FLOOD RISK COMMUNICATION

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Murilo Noli da Fonseca <sup>a\*</sup> - Luciene Pimentel da Silva <sup>b</sup> - Carlos Mello Garcias <sup>c</sup>

(a) PhD Student in Urban Management. Pontifical Catholic University of Paraná, Curitiba (PR), Brazil.

**ORCID:** <http://orcid.org/0000-0002-0718-3087>. **LATTES:** <http://lattes.cnpq.br/8044427709165005>.

(b) PhD in Civil Engineering. Professor at the Pontifical Catholic University of Paraná, Curitiba (PR), Brazil.

**ORCID:** <http://orcid.org/0000-0002-6533-9430>. **LATTES:** <http://lattes.cnpq.br/5649390252824515>.

(c) PhD in Civil Engineering. Professor at the Pontifical Catholic University of Paraná, Curitiba (PR), Brazil.

**ORCID:** <http://orcid.org/0000-0001-7982-5803>. **LATTES:** <http://lattes.cnpq.br/6180344401571354>.

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## (\*) CORRESPONDING AUTHOR

**Address:** PUCPR. Prado Velho, Cep: 80215901, Curitiba (PR). Brazil. Tel: (+55 41) 32711598

**E-mail:** [murilonoli@gmail.com](mailto:murilonoli@gmail.com)

## Abstract

The aim of the present study is to present an overview of, and research trends to investigate, flood risk communication between 2010 and 2020. Thus, bibliometric analysis was used as research technique. The main results comprised 34 identified articles that were mainly published from 2014, onwards. Most authors were from European, North American and Asian countries. It was possible observing lack of authors from developing countries in Africa and Latin America, which are areas acknowledged as vulnerable to, and affected by, disproportionate impacts caused by natural disasters. Studies conducted so far have presented elucidative findings about the effects of effective risk communication presence or absence on society.

**Keywords:** Risk Information. Resilience. Bibliometrics. Collaboration Networks

## Resumo / Resumen

### COMUNICAÇÃO DE RISCO DE INUNDAÇÃO

O presente trabalho busca apresentar um panorama e as tendências na pesquisa em comunicação de risco de inundação entre 2010 e 2020. Para tanto, empregou-se a análise bibliométrica como técnica de pesquisa. Como principais resultados, tem-se a identificação de 34 artigos, os quais foram publicados principalmente a partir de 2014. A maior parcela dos autores é oriunda de países europeus, norte-americanos e asiáticos. Pode-se verificar também uma ausência de autores de países em desenvolvimento na África e na América Latina, áreas reconhecidas como vulneráveis e que sofrem impactos desproporcionais de desastres. Os trabalhos realizados até o momento têm apresentado resultados elucidativos no que diz respeito aos efeitos da existência ou ausência de uma comunicação efetiva de risco na sociedade.

**Palavras-chave:** Informação de Risco. Resiliência. Bibliometria. Redes de Colaboração

### COMUNICACIÓN DEL RIESGO DE INUNDACIÓN

El presente trabajo busca presentar una visión general y las tendencias en la investigación en la comunicación del riesgo de inundación entre 2010 y 2020. Para ello, se utilizó el análisis bibliométrico como técnica de investigación. Como principales resultados, tenemos la identificación de 34 artículos, que fueron publicados principalmente a partir de 2014. La mayor parte de los autores proviene de países europeos, norteamericanos y asiáticos. También puede haber una ausencia de autores de países en desarrollo de África y América Latina, áreas reconocidas como vulnerables y que sufren impactos desproporcionados de los desastres. Los estudios realizados hasta el momento han presentado resultados elucidantes respecto a los efectos de la existencia o ausencia de una comunicación efectiva del riesgo en la sociedad.

**Palabras-clave:** Información de Riesgo. Resiliencia. Bibliometría. Redes de Colaboración

## INTRODUCTION

The high frequency and magnitude of floods have increased in recent years; moreover, they have had several impacts, both on the national territory and on society (TELLMAN et al., 2021). In total, 3,254 flood events were recorded worldwide from 2000 to 2019, mainly in Asia (EM-DAT, 2021); this record was higher than the 1,389 flood events recorded from 1980 to 1999. These events affected 1.65 billion people, caused 122,000 deaths and produced 563 billion dollars in damage from 2000 to 2019 (EM-DAT, 2021). The population living in risk areas has increased by 34.1% - from 58 million to 86 million – from 2000 to 2018 (TELLMAN et al., 2021). Approximately 5.4 million people were forced to leave their homes in 2018 due to flood events (IDMC, 2019). Several studies have shown that damage caused by flood events can increase by approximately 20 times by the end of the 21st century, in comparison to 2013 (WINSEMIUS et al., 2016). Therefore, the impact of flood events on urban areas is expected to significantly increase due to climate change (IPCC, 2019; BERTOLA et al., 2020), to population density (LUKE et al. 2018), as well as to urbanization expansion processes (KERIM; ZEYNEP, 2021) yet to take place, mainly in the African and Asian continents (TELLMAN et al., 2021). This reality emphasizes the need of providing accurate and understandable information to be used by people, mainly by ‘at-risk’ individuals. Individuals should be warned about the imminence of flood events, for example. However, in order to be effective, messages must clarify who should, and should not, be protected, as well as when to start and complete proper actions, based on using terms that can be understood by different population groups (PARKER; TAPSEL; MCCARTHY, 2007). However, making information available - per se - does not necessarily make individuals adopt preventive and preparedness measures. It is necessary developing effective and efficient communication strategies to provide information to the target audience, based on adopting appropriate modes and messages.

Nevertheless, a large body of evidence has shown that communication does not necessarily lead to preparedness (SAMADDAR; MURASE; OKADA, 2014). Efforts to improve and provide information about flood risks are not compatible to preparedness levels observed in the Asian population (CHAN; MAN; LAM, 2019). Europe presents low information penetration and preparedness levels, which are followed by high level of distrust in communication and management institutions (O’SULLIVAN et al., 2012). Lack of communication has led to increased local vulnerability in Red River watershed, Canada (STEWART; RASHID, 2011).

Thus, bibliometric analysis application is a method of quantitative and statistical nature used to enable broad and comprehensive understanding on this field. It enables assessing a set of publications to both strengthen and improve scholars’ contributions to this field by mapping knowledge field and trends, as well as by assessing research quality and identifying its gaps. Bibliometric analyses about disasters triggered by natural and man-made events have been published over the years. However, only two studies focused on investigating flood risk communication are available in the literature (KELLENS; TERPSTRA; DE MAEYER, 2013; FONSECA; GARCAS, 2020).

Therefore, the aim of the present study is to answer the following question: how have studies about flood risk communication been conducted between 2010 and 2020? Therefore, the current study has identified, quantified and assessed the keywords and terms most often used in this field, as well as the countries, institutions and journals involved in producing knowledge about flood risk communication, available in the two main scientific databases, namely: Web of Science (WoS) and Scopus.

## THEORETICAL BACKGROUND

Flood risk communication focuses on information and experience exchange among different social actors. It aims at identifying ‘at-risk’ areas and at reaching the largest number of individuals living in such a condition, mainly in vulnerable groups. It is done to help improving knowledge about the phenomenon and developing appropriate flood prevention, protection and preparedness strategies (DE BOER; WOUTER BOTZEN; TERPSTRA, 2014; MAIDL; BUCHECKER, 2015). Moreover, effective flood risk communication must also identify and handle any type of false information, misinformation, among other challenges linked to the communication process.

However, there is no direct association between transmitting information about risks and people who make decisions or who take actions to manage them, since receiving, interpreting and understanding transmitted messages depends on both receivers and their conscience. Its effectiveness is linked to internal factors affecting individuals' ability to access and use information, as well as to external factors associated with individuals at risk and their ability to communicate in society. Income is another element capable of influencing information transmission. Low-income individuals living in Makurdi, Nigeria, are less likely to receive information than high-income households (LAMOND et al., 2019). Schooling can also influence this process. Information may not be accessible to, or available in a format that can be understood and used by, low-schooling individuals (BHATTACHARYA-MIS; LAMOND, 2015).

Communication failures are also associated with communication dynamics, such as information sources, as well as with time and features of messages, senders, the public, the communication context and the mode/channel in which it is inserted. Terms and conditions used in transmitted messages can influence communication effectiveness; therefore, a given message may be ignored because it was misinterpreted, because of differences in priorities, distrust and inadequate physical or mental ability to respond, as well as because one may not be aware of the risks (HANDMER, 2000).

## METHOD

The current study was based on bibliometric analysis, which is a quantitative technique that provides a macro view of the academic literature. The bibliometric method can be used to assess the performance, research patterns and influence of authors, journals, countries and institutes that publish studies on a given topic, as well as to map terms and citations, and to identify and quantify cooperation patterns among them. The number of journals publishing studies about a specific topic, for example, can indicate the range of topics and the multidisciplinary nature of a given research field. Results can also be taken into consideration to support policy makers and funding agencies in the process to allocate research funding (UGOLINI et al., 2015).

## DATA SURVEY AND ANALYSIS

Information collection took place on June 30, 2021, based on using the application of keywords in scientific study databases as parameter. Therefore, chronological restriction comprising the time interval from January 01, 2010 to December 31, 2020 was applied. Web of Science and Scopus were the herein selected databases; they are considered the main databases, nowadays (MORIOKA; CARVALHO, 2016). The first stage of the searching protocol comprised terms' consultation and definition. The search process was carried out based on using keywords in Portuguese, Spanish and English languages: "comunicação" (comunicación and communication) and "risco de inundação" (riesgo de inundación and flood risk). Subsequently, Boolean operator "AND" was used for "title, abstract and keyword". Truncation of words to derived and plural forms was another adopted resource. The asterisks (\*) were used in place of a character or letter when any number of characters or letters, or no character, might be in its place, such as: flood\* for flood, floods, or flooding.

Overall, five patterns were applied to the article selection process: (1) only the "article" modality was used; (2) studies published between 2010 and 2020; (3) primarily empirical studies focused on analyzing flood risk communication - consequently, articles that only mentioned flood risk communication or that suggested ways to improve it through other analysis types were disregarded; (4) studies carried out with citizens; and (5) studies that measured, or gave specific attention to, flood risk communication (FIGURE 1).

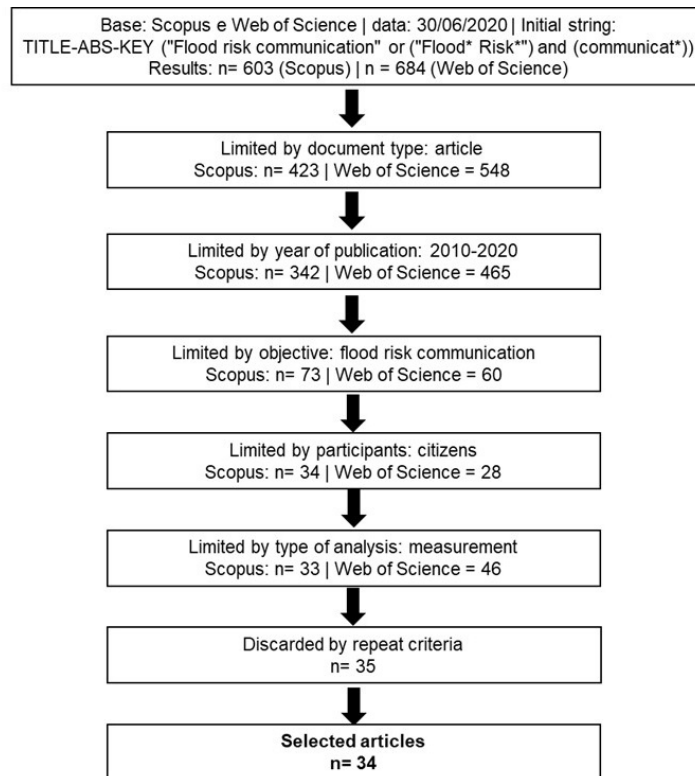


Figure 1 - Bibliometric analysis search protocol in Scopus and WoS databases.

Collected information comprised author's name, study title, year, institution, country, journal, impact factor, citation and keywords. They were quantitatively analyzed in "Bibliometrix" open-source tool to contextualize scientific production, journals, authors, affiliation and the most contributing country (ARIA; CUCCURULLO, 2017). Then, they were presented in the form of graphs to make result analysis easier. The second stage consisted in scientific mapping, which encompassed keyword networks. This process was performed in VOSviewer free software, which enabled visualizing the connection between terms and related authors, as well as dividing them into clusters. Each cluster was represented by a given color and aggregated all similar items. The size of the circles shows the number of times a given item emerged; the proximity between them represents their relationship degree: the closer they are to each other, the more related.

## RESULTS

### ARTICLES' DISTRIBUTION AND EVOLUTION OVERTIME

Results have indicated increasing number of articles from 2011, onwards. It was the year when the first set of studies found in our search, which totaled 34 articles in the entire investigated period (annual growth rate of 11.5%), were published. One of the first articles focused on assessing risk communication based on evacuation exercises, mainly based on alert issuance, on walking speed and on time taken by individuals to get to shelters (YAMADA et al., 2011). Another study – also published in 2011 – focused on identifying gaps in communication and on addressing strategies developed to improve information sharing (STEWART; RASHID, 2011). Briefly, 76% of articles were published in 2020, 2018, 2016 and 2019, in that exact order (FIGURE 2), and it has evidenced a trend towards growing interest in this topic.

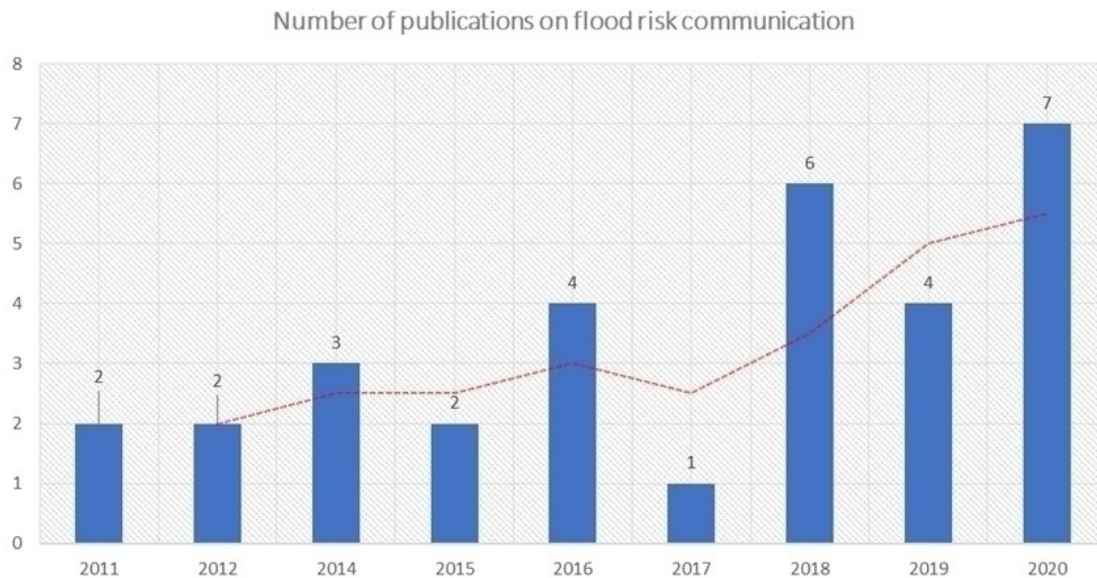


Figure 2 - Number of publications on “flood risk communication”

All 34 analyzed articles were published in 21 different journals. In total, eight journals published at least two articles and accounted for 54.8% of the total number of analyzed studies (TABLE 1). “Natural Hazards and Earth System Sciences” was the journal making the greatest contribution to research on flood risk communication; it accounted for 11.9% of the analyzed studies. In addition, approximately two-thirds of the most productive journals were based in European countries; 22%, in the United States; and 3.7% (each), in Africa and Asia.

| Journal                                          | %    | Citation | Country        | IF    | SJR   |
|--------------------------------------------------|------|----------|----------------|-------|-------|
| Natural Hazards and Earth System Sciences        | 11,9 | 123      | Germany        | 1.685 | 1.122 |
| International Journal of Disaster Risk Reduction | 9,5  | 43       | United Kingdom | 4.320 | 1.161 |
| Journal of Flood Risk Management                 | 7,1  | 14       | Denmark        | 3.884 | 1.049 |
| Risk Analysis                                    | 7,1  | 39       | United Kingdom | 3.137 | 0.972 |
| Disasters                                        | 4,7  | 15       | United Kingdom | 1.937 | 0.744 |
| PLoS ONE                                         | 4,7  | 6        | USA            | 3.240 | 0.99  |
| Natural Hazards                                  | 4,7  | 21       | Netherlands    | 2.254 | 0.76  |
| WasserWirtschaft                                 | 4,7  | 17       | Germany        | 0.112 | 0.134 |

Table 1 - Journals with the highest number of publications. IF: Impact Factor; SJR: SCImago Journal Rank.

From the temporal perspective, “Journal of Advanced Transportation” and “Disasters” were the first journals holding articles published on this topic, in 2011. Except for 2018 and 2020, there was little diversification of journals with studies published between 2011 and 2017, and 2019 (FIGURE 3). In this case, “Natural Hazards and Earth System Sciences” stood out for constant publications over the years, whereas “Journal of Flood Risk Management” stood out for publications in 2018 and 2020. Recently, there has been emergence of publications in PLoS ONE.

Journals’ impact factor oscillates between 0.112 and 9.384. Approximately 50% of them range from 0.112 to 1.937, whereas 35% range from 2.254 to 3.884. This factor identifies the mean frequency of citations to a given journal in a given year, and it enables assessing the influence of the most prominent journals. “Bulletin of the American Meteorological Society” (9.384), “Environmental Science

and Policy” (5.581), “International Journal of Disaster Risk Reduction” (4.320) and “Journal of Flood Risk Management” (3.384) are the journals holding the highest impact factor. The five journals accounting for the largest number of publications have impact factor ranging from 0.112 (“Wasserwirtschaft”) to 4.320 (“International Journal of Disaster Risk Reduction”).

## AUTHORS

The current research identified 152 authors associated with the analyzed productions, both main and co-authors. The following authors accounted for the largest number of studies on flood risk communication: Bonaiuto M and De Dominicis S (2 articles and 113 citations, each; Italy), De Boer J (2 articles; The Netherlands), Terpstra T (2 articles, 46 citations; The Netherlands) and Man N and Muktar BG (2 articles and 5 citations, each; Nigeria and Malaysia, respectively) (FIGURE 3). These authors accounted for 12 of the 34 analyzed publications (35.2%). One of the reasons why the last authors have fewer citations lies on the fact that their studies were only published in 2018, whereas the first ones has their studies published in 2012 and 2014.

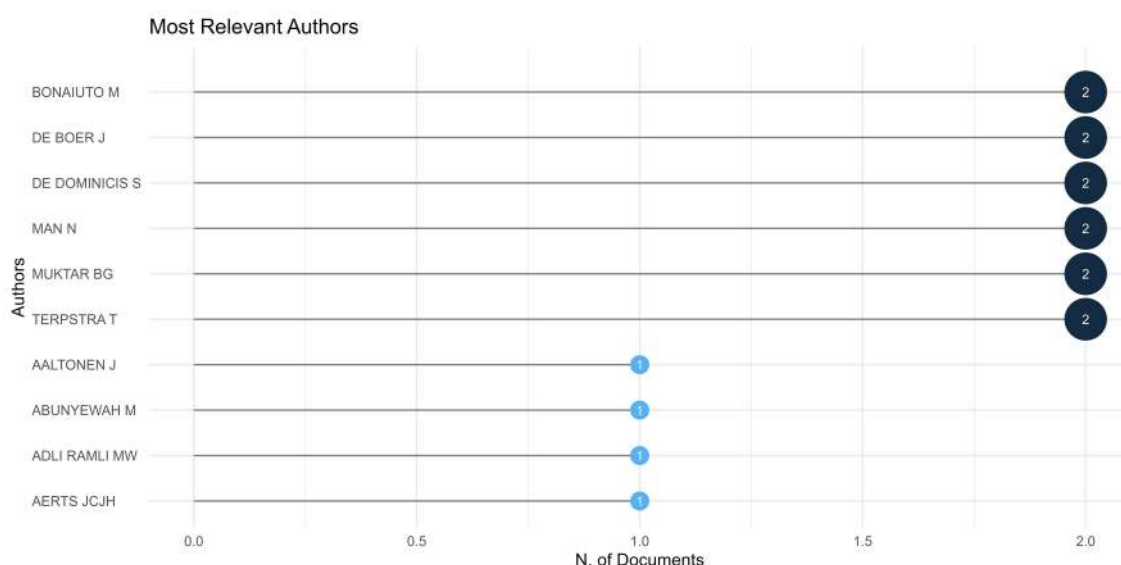


Figure 3 - Authors with the highest number of publications between 2011 and 2020

The largest share of articles (approximately 59.5%) has two to four authors, with emphasis on studies carried out by four authors (26.2%). These studies were mainly carried out by scholars from the research country itself, and it led to low international collaboration (29.4%). In addition, it is worth emphasizing the emergence of authors from Malaysia, United Kingdom, The Netherlands, Germany, Austria and Vietnam, whose studies were mainly published in 2020; they are the main researchers investigating this topic, nowadays.

## COUNTRIES

With respect to authors’ geographical distribution, flood risk communication was investigated as research topic in 17 countries, whose researchers participated as both main and co-authors. US researchers accounted for 16.3% of analyzed articles; they were followed by researchers from The Netherlands (14%), United Kingdom and Germany (11.6%, each), Italy, Malaysia and Japan (7%, each) and Canada (4.7%). There was concentration of publications by European (60.5%), North American (18.6%) and Asian (16.2%) authors. It was also possible seeing the emergence of authors from Germany, Malaysia and Japan (FIGURE 4).

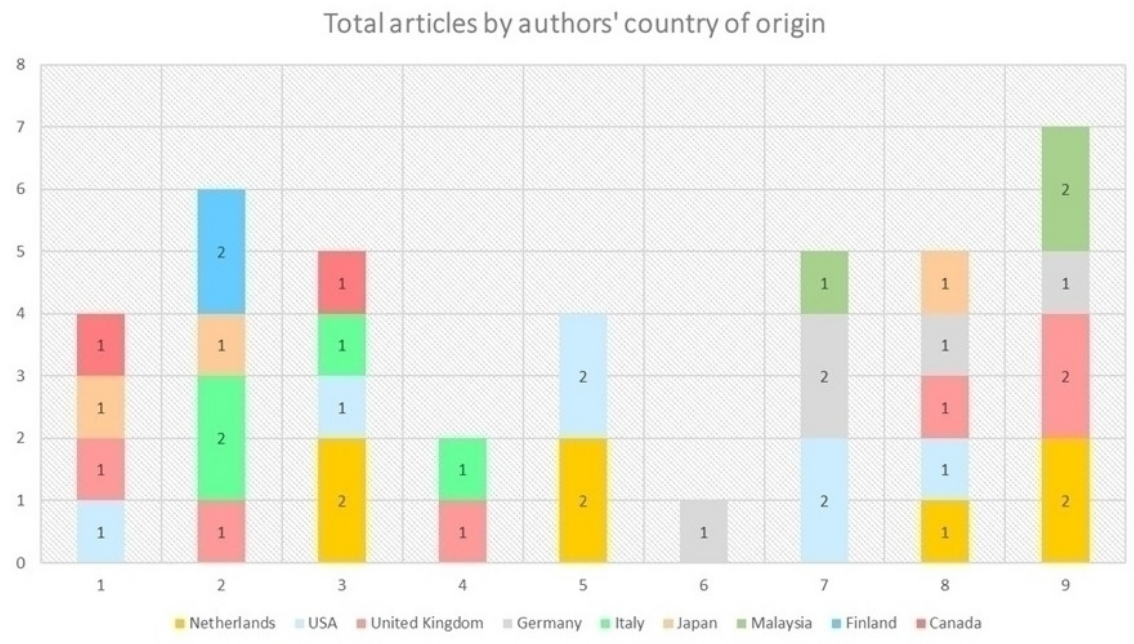


Figure 4 - Total articles by author's country of origin between 2011 and 2020

Thus, there was low production by authors from Oceania and Africa (2.3% of articles, each) and lack of authors from Latin America. This finding reflects on the number of most cited countries: The Netherlands ranked first (166 citations), and they were followed by the United States (92), United Kingdom (80), Ireland (79), Canada (63), Germany (47), Italy (34), Japan (29) and Malaysia (21).

## INSTITUTIONS

The most prolific institutions were the ones located in the most productive countries. However, it was possible seeing the participation of different institutions in each publication: 65 institutions were identified in 17 countries. Most of them were universities (68.2%), which were followed by state (21.2%) and private (10.6%) institutions. Still, the most productive institutions were located in the United States (Montana State University, University of California and University of Maryland), Malaysia (Universiti Teknologi Malaysia and Universiti Pura Malaysia), Nigeria (Federal University Dutse), The Netherlands (IHE Delft Institute for Water Education and VU University) and Germany (University of Potsdam).

## CITATIONS

The analyzed articles were cited 798 times between 2010 and 2020. Most of them were cited 20 times, at most (61.9%); they were followed by articles cited from 41 to 60 times (14.3%), from 21 to 40 times (11.9%), from 61 to 80 times (7.1%) and non-cited articles (4.7%). From the temporal perspective, articles published in 2016 and 2014 are the most cited ones (16% and 13.9%, respectively). From the spatial perspective, US authors accounted for the largest number of citations (125); they were followed by authors from The Netherlands (123) and UK (115).

## ARTICLES' CLASSIFICATION

Overall, the analyzed articles can be categorized into three different groups: (1) the ones focused on investigating how population groups understand risk communication based on alert issuances (KREIBICH et al., 2017); (2) the ones concerning the risk, i.e., users' preferences, as well as the main

barriers and benefits observed in strategies developed by both public power and community (HAER; BOTZEN; AERTS, 2016; DE DOMINICIS et al., 2014; YAMADA et al., 2011; DE BOER; WOUTER BOTZEN; TERPSTRA, 2014); and (3) studies focused on conducting experiments with sample groups to help better understanding the effects of certain risk communication strategies on different populations (O'SULLIVAN et al., 2012; LIESKE; WADE; RONESS, 2014; FELDMAN et al., 2016; MAIDL; BUCHECKER, 2015; ROLLASON et al., 2018; STEWART; RASHID, 2011). Group (2) accounted for the largest number of articles (50%); it was followed by Group (3) (41.6%) and Group (1) (8.4%) groups.

## COUNTRY NETWORKS

Mapping the origin of authors who mostly published in collaboration is another element to help better understanding a given scientific field. This analysis took into consideration countries with at least one joint publication. Based on the results, six collaboration clusters were formed: the red cluster comprised Austria, Belgium, The Netherlands, Czech Republic and Vietnam; the green one, which accounted for most publications, comprised Finland, Ireland, Italy and Scotland; the blue cluster comprised Australia, Germany and Japan; the moss green one encompassed UK, Malaysia and Nigeria; the purple one was formed by the United States and Canada; and the light blue cluster was formed by Switzerland (FIGURE 5).

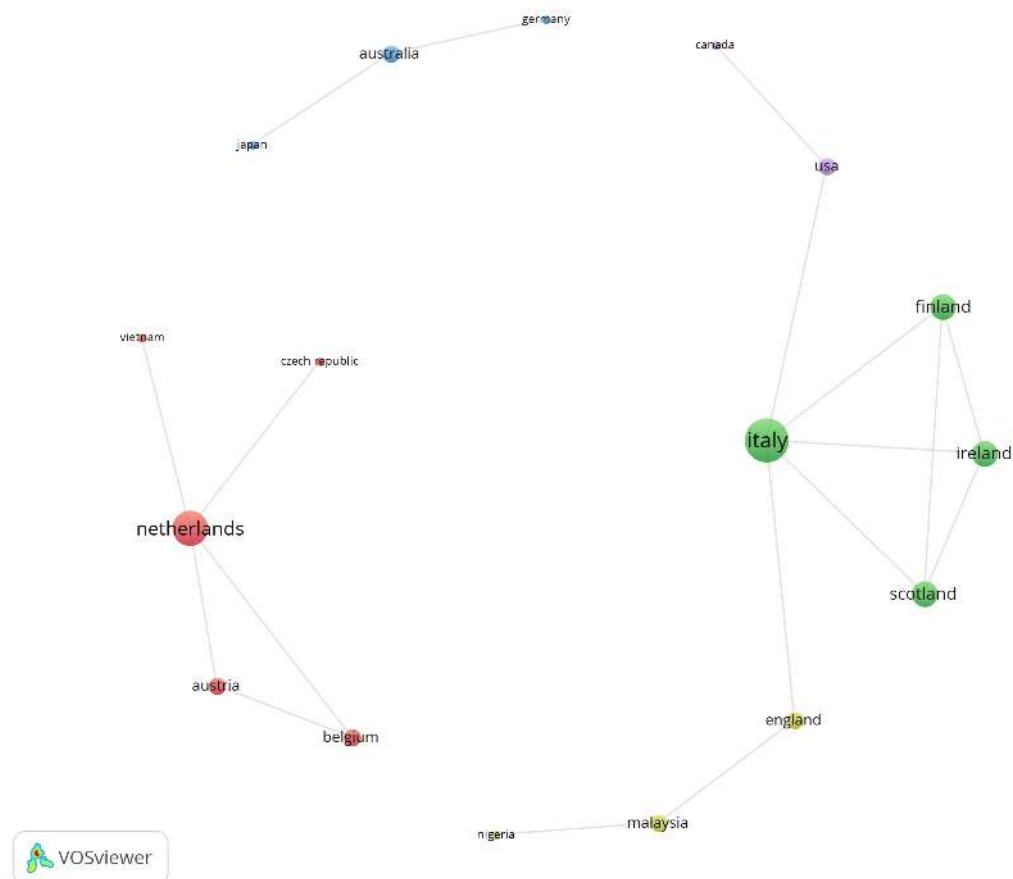


Figure 5 - Collaboration networks between countries

Based on the current findings, advantages of international collaborations are not limited to

network expansion, and to knowledge exchanging and sharing; they also comprise an effective ranking strategy. The United States, the United Kingdom, Japan, Austria, Belgium and Taiwan, for example, stood out among countries mostly publishing studies on this topic; however, they presented low international collaboration. Accordingly, 80% of studies were only published by German authors, and it suggested internal collaboration. Still, it is worth emphasizing the trend of authors from Asian (Malaysia, Vietnam), African (Nigeria) and Oceania (Australia) countries to conduct studies on this topic.

## KEYWORDS' NETWORK

Keyword association diagram was built based on using meshes that have been used at least twice. In total, 48 keywords were counted (FIGURE 6). Overall, the most frequent keywords comprised risk communication (13), risk perception (7), flood risk (5), flood risk management (4), floods (4), flood risk communication (3), Protection Motivation Theory (3) and adaptation (3). The network generated in the software was formed by five main clusters. The red cluster comprised meshes such as “risk communication” - which accounted for the largest number of occurrences and links -, “risk perception”, “warnings”, “social media” and “information”. It is also worth emphasizing the green cluster, which comprised “participation”, “maps”, “GIS”, “availability” and “resilience”.

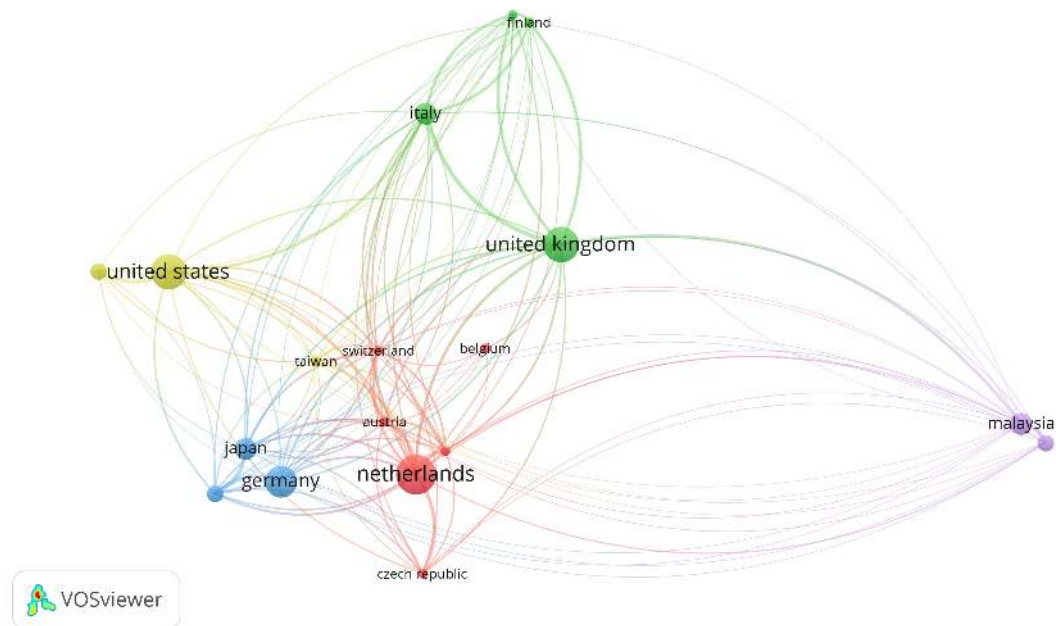


Figure 6 - Keywords diagram

Furthermore, it is important highlighting the main research trends observed in recent years, with emphasis on the main research lines established nowadays and in the coming years. The analyzed studies have move from a risk communication perspective centered on the information deficit model - with priority participation of local authorities and professionals - to a participatory communication that mainly includes the most vulnerable groups, at all its stages. The main keywords used in the first aspect focused on climate change, evacuation routes, alerts, probability, planning and information spreading (FIGURE 7).

These individuals' participation has driven the main trends towards knowledge, experience and behavior patterns, with emphasis on the development of appropriate risk communication strategies for different population groups, such as men, women and elderly individuals. Other elements focused on the realistic interactive visualization of information about risks, based on geographic information systems

(GIS), as well as about the use of social media, in order to enable people to be more prepared to deal with the herein investigated phenomenon.

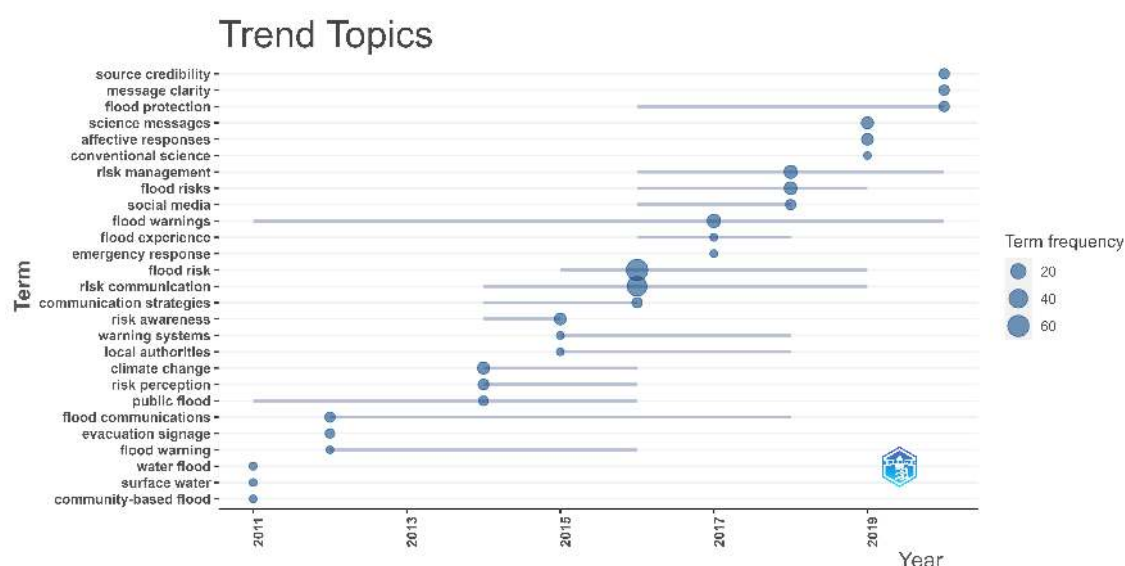


Figure 7 - Keyword trend.

## DISCUSSION

The implementation of risk communication strategies, based on the risk perception of several social actors, mainly of the vulnerable ones, is a vital step in flood risk-management processes, since it enables establishing protection and risk reduction measures, initiatives to improve individuals' preparedness and appropriate response to warnings and alerts. This process can contribute to community's resilience since the impacts from the investigated phenomenon often persist in space and time. Studies have shown that the incidence of flood events can increase morbidity (MILOJEVIC et al. 2017) and infectious disease outspread (WAITE et al. 2017), as well as lead to long-term mental health issues such as depression, anxiety and post-traumatic stress disorder (MUNRO et al. 2017).

Thus, results in the current study have indicated that flood risk communication is a recent research field, but one that attracts researchers from different socioeconomic contexts and knowledge fields, mainly from Europe and North America. However, there is almost lack of research conducted in developing countries, although they are the ones facing major-impact floods (KAKINUMA et al., 2020) and presenting the most favorable conditions for significant disasters (TELLMAN et al., 2021). Flood events are the most common type of disaster observed in Latin America. According to estimates, these events affected 41 million people and caused more than US\$26 billion in damages, from 2000 to 2019 (OCHA, 2020). Approximately 3 million people in Colombia were displaced due to floods in 2010, alone (IDMC, 2019). According to estimates, these events have affected approximately 70 million people in Brazil, from 2000 to 2019 (OCHA, 2020).

In addition, it is necessary conducting studies about flood risk communication since, according to climate change forecasts, developing countries may be more susceptible to high-intensity and high-magnitude floods (HIRABAYASHI et al., 2013; IPCC, 2019). China, for example, will experience increase from 9 million affected people and €25 billion in damages to 40 million affected people and €110 billion in damages, on a yearly basis, with 4°C warming (ALFIERI et al., 2017). Furthermore, predictions show increased risk of these events in coastal areas due to rising sea levels (NICHOLS et al., 2021), mainly in the tropics. Studies have also indicated that these countries may be at risk of facing population displacement caused by floods, due to low-income levels (KAKINUMA et al., 2020) and high social inequality (TANOUE; HIRABAYASHI; IKEUCHI, 2016).

Therefore, it is necessary overcoming the information deficit model prevailing in risk management processes so that flood risk-communication strategies can lead to efficient and effective results (ABUNYEWAH et al., 2019). This model assumes that laypeople lack sufficient knowledge on this topic and that the information provided to them will be equally interpreted by all individuals. However, this model has been criticized for its positivist knowledge translation based on a vertical communication process (GOOSEN et al., 2014). Furthermore, by centralizing and professionalizing information production, communities lose the ability to properly understand their risk situation (BUBECK et al. 2012).

Understanding communities' features is one way to overcome the herein addressed issue, since communities are formed by individuals from different social and demographic profiles, a fact that requires adapted risk communication strategies to include these individuals in all risk management stages. Therefore, participation enables rethinking how information can be transmitted to people at risk, by placing them at the very core of the process to generate, spread and receive information about flood risk. Participation also reconfigures traditional roles played by experts and laypeople, as well as takes into consideration the circulation of different knowledge forms, based on the idea that people must work together as equals in order to co-produce shared knowledge and results.

Accordingly, the most recent studies, mainly the ones published in 2016, have developed participatory approaches to a wide variety of population groups (elderly, retired individuals, children, youngsters, adults, male and female individuals) and communication stages, such as community preparation (VAN KERKVOORDE et al., 2018), proper map plotting (PERCIVAL; GATERELL; HUTCHINSON, 2020) and risk management procedures (STEWART; RASHID, 2011). Another way to turn people into active agents lies on alert issuing by reliable local people (PARKER; PRIEST; MCCARTHY, 2011). Such actions can be enhanced by information technology (IT), which enables communities to participate in management processes and to provide feedback on the local reality. This process was implemented in Egypt, Mali and Belgium to classify flood intensity and to adjust community alert thresholds (COOLS; INNOCENTI; O'BRIEN, 2016).

Therefore, flood risk communication should be seen as preventive activity that allows the development of adequate strategies to generate, spread and receive accurate and reliable information about risks, from a well-known and reliable source, through properly determined channels. This process enables improving knowledge about risk, changing attitudes and/or behaviors, promoting trust in issuing agents and providing conditions for the effective involvement of interested parties (WACHINGER et al., 2012).

## CONCLUSION

The current study provided clearer perceptions about the evolution and main trends of flood risk communication, based on bibliometric methods. It is essential discussing risk communication to help better understanding how risk information identification, assessment and disclosing processes take place. Based on this circumstance, it is possible understanding the risk situation one is exposed to and, subsequently, adopting prevention, mitigation and preparation strategies to face the incoming phenomenon, in order to better deal with its consequences and to make both the city and its citizens increasingly resilient.

The bibliometric technique herein applied to map published studies about the investigated topic was considered valid. Flood risk communication has been increasingly used in climate change adaptation studies and in the risk reduction discourse. Bibliometrics enabled seeing that flood risk communication is an emerging and growing research topic. There are several journals, disciplines, institutions and countries involved in flood risk-communication research, nowadays. However, clear disparity between developed and developing countries was observed.

These patterns have the potential to substantiate future research, although an in-depth analysis of their content and gaps should be conducted. Authorship analysis pointed towards the role played by researchers in identifying gaps, in mentoring other researchers and in collaborating to help developing the herein addressed research field. Further analysis on this topic, including the process to map future methodological needs, can help developing this field through partnerships set with different sectors and

interested parties, even with those that are not currently involved in flood risk communication. Therefore, research collaboration and networking focused on increasing national preparedness, as well as on improving natural disaster management processes, are of paramount importance for ‘at-risk’ communities.

However, scientific studies based on bibliometric analysis have some limitations. Search conducted in WoS database only retrieves articles and journals based on using selected keywords. Since these keywords are written in English language, there may be language bias. Database bias may lead to underestimation of publications about flood risk communication. Consequently, this process can lead to limited scientific knowledge, to exclusion of knowledge deriving from other sources, as well as to lack of an important corpus of gray literature (World Bank, Organizations associated with the UN) on this topic. Data were retrieved on a specific date; therefore, citations and number of publications may vary. Therefore, it is recommended including additional databases, as well as conducting an in-depth thematic/content analysis, to capture the greater essence of the literature on this topic.

## REFERENCES

- ABUNYEWAH, M; GAJENDRAN, T; MAUND, K; OKYERE, S A. Linking information provision to behavioural intentions Moderating and mediating effects of message clarity and source credibility. *International Journal of Disaster Resilience In The Built Environment*, vol. 11, no. 1, p. 100–118, 2019.
- ALFIERI, L.; BISSELINK, B.; DOTTORI, F.; NAUMANN, G.; DE ROO, A.; SALAMON, P.; WYSER, K.; FEYEN, L. Global projections of river flood risk in a warmer world. *Earth’s Future*, vol. 5, no. 2, p. 171–182, 1 Feb. 2017.
- ARIA, M.; CUCCURULLO, C. bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics* , vol.11, n.4, p.959-975. 2017
- BERTOLA, M.; VIGLIONE, A.; LUN, D.; HALL, J.; BLÖSCHL, G. Flood Trends in Europe: Are Changes in Small and Big Floods Different? *Hydrology and Earth System Sciences*. Vol.24, p.1805-182210, 2020.
- BHATTACHARYA-MIS, N.; LAMOND, J. Mapping community knowledge of vulnerability of value: A case study in the UK. *International Journal of Safety and Security Engineering*, vol. 5, n.3, p. 266–279, 2015.
- CHAN, E, Y, Y; MAN, A Y T; LAM, H C Y. Scientific evidence on natural disasters and health emergency and disaster risk management in Asian rural-based area. *British Medical Bulletin*, vol. 129, n.1, p. 91–105, 2019.
- DE BOER, J.; BOTZEN, W.J.W.; TERPSTRA, T. Improving flood risk communication by focusing on prevention-focused motivation. *Risk Analysis*, vol. 34, n.2, p. 309–322, 2014.
- DE DOMINICIS, S; CRANO, W D; CANCELLIERI, U G; MOSCO, B; BONNES, M; HOHMAN, Z; BONAIUTO, M. Vested interest and environmental risk communication: improving willingness to cope with impending disasters. *Journal of Applied Social Psychology*, vol. 44, no. 5, p. 364–374, 2014.
- EM-DAT. The International Disaster Database. 2021. Disponível em: Acesso em 04/10/2021
- FELDMAN, D.; CONTRERAS, S.; KARLIN, B.; BASOLO, V.; MATTHEW, R.; SANDERS, B.; HOUSTON, D.; CHEUNG, W.; GOODRICH, K.; REYES, A.; SERRANO, K.; SCHUBERT, J.; LUKE, A. Communicating flood risk: Looking back and forward at traditional and social media outlets. *International Journal of Disaster Risk Reduction*, vol. 15, p. 43–51, 2016.
- FONSECA, M. N.; GARCAS, C.M. Comunicação de risco de inundação: instrumento fundamental da gestão de riscos de desastres. *DRd – Desenvolvimento Regional em debate*, vol.10, p.1139-1159, 2020
- GOOSEN, H.; DE GROOT-REICHWEIN, M.A.M.; MASSELINK, L.; KOEKOEK, A.; SWART, R.; BESSEMBINDER, J.; WITTE, J.M.P.; STUYT, L. Climate adaptation services for the Netherlands: an operational approach to support spatial adaptation planning. *Regional environmental change*, vol.14,

p.1035-1048, 2014

HAER, T.; BOTZEN, W.J.W.; AERTS, J.C.J.H. The effectiveness of flood risk communication strategies and the influence of social networks-Insights from an agent-based model. *Environmental Science and Policy*, vol. 60, p.44–52, 2016.

HIRABAYASHI, Y.; MAHENDRAN, R.; KOIRALA, S.; KONOSHIMA, L.; YAMAZAKI, D.; WATANABE, S.; KIM, H.; KANAE, S. Global flood risk under climate change. *Nature Climate Change*, vol. 3, no. 9, p. 816–821, 2013.

HANDMER, J. Are Flood Warnings Futile? Risk communication in emergencies. *The Australasian Journal of Disaster and Trauma Studies*, vol.2, 200

HÖPPNER, C., BRÜNDL, M., BUCHECKER, M. Risk Communication and Natural Hazards. CapHaz project. Birmensdorf, Switzerland, 2010.

IDMC. Internal Displacement Monitoring Center. Global report of internal displacement. 2019.

KAKINUMA, K.; PUMA, M.J.; HIRABAYASHI, Y.; TANOUE, M.; BAPTISTA, E.A.; KANAE, S. Flood-induced population displacements in the world. *Environmental Research Letters*, vol. 15, no. 12, p.124029, 2020.

KELLENS, W.; TERPSTRA, T.; DE MAEYER, P. Perception and Communication of Flood Risks: A Systematic Review of Empirical Research. *Risk Analysis*, vol. 33, no. 1, p. 24–49, 2013.

KERIM, K.; ZEYNEP, I. Assessment of Urban Flood Risk Factors Using Monte Carlo Analytical Hierarchy Process. *Natural Hazards Review*, vol. 22, no. 4, p. 4021048, 1 Nov. 2021.

KREIBICH, H.; MÜLLER, M.; SCHRÖTER, K.; THIEKEN, A.H. New insights into flood warning reception and emergency response by affected parties. *Natural Hazards and Earth System Sciences*, vol. 17, n.12, p. 2075–2092, 2017.

LAMOND, J.; ADEKOLA, O.; ADELEKAN, I.; EZE, B.; UJOH, F. Information for Adaptation and Response to Flooding, Multi-Stakeholder Perspectives in Nigeria. *Climate*, vol. 7, no. 4, p. 46, 2019.

LIESKE, D.J.; WADE, T.; RONESS, L.A. Climate change awareness and strategies for communicating the risk of coastal flooding: A Canadian Maritime case example. *Estuarine, Coastal and Shelf Science*, vol. 140, p. 83–94, 2014.

MAIDL, E.; BUCHECKER, M. Raising risk preparedness by flood risk communication. *Natural Hazards and Earth System Sciences*, vol. 15, no. 7, p. 1577–1595, 2015.

MILOJEVIC, A.; NIEDZWIEDZ, C.L.; PEARCE, J.; MILNER, J.; MACKENZIE, I.A.; DOHERTY, R.M.; WILKINSON, P. Socioeconomic and urban-rural differentials in exposure to air pollution and mortality burden in England. *Environmental Health*. Vol.16, n.1, 2017

MORIOKA, S.N.; CARVALHO, M.M. Sustentabilidade e gestão de projetos: um estudo bibliométrico. *Production*, v. 26, n. 3, p. 656-674, 2016

MUNRO, A.; KOVATS, R.S.; RUBIN, G.J.; WAITE, T.D.; BONE, A. Effect of evacuation and displacement on the association between flooding and mental health outcomes: a cross-sectional analysis of UK survey data. *Lancet Planet Health*. Vol.1. n.4, p.134-141, 2017

NICHOLLS, R.J.; LINCKE, D.; HINKEL, J.; BROWN, S.; VAFEIDIS, A.T.; MEYSSIGNAC, B.; HANSON, S.; MERKENS, J-L.; FANG, J. A global analysis of subsidence, relative sea-level change and coastal flood exposure. *Nature Climate Change*, vol. 11, no. 4, p. 338–342, 2021.

O’SULLIVAN, J. J.; BRADFORD, R. A.; BONAIUTO, M.; DE DOMINICIS, S.; ROTKO, P.; AALTONEN, J.; WAYLEN, K.; LANGAN, S. J. Enhancing flood resilience through improved risk communications. *Natural Hazards and Earth System Science*, vol. 12, no. 7, p. 2271–2282, 2012.

OBERACKER, C.; RIMBÖCK, A.; MÜLLER, U. Flood risk communication. *WasserWirtschaft*, vol. 108, no. 12, p. 25–29, 2018.

OCHA. Natural disasters in latin america and the caribbean 2000-2019. 2020.

PARKER, D.J., TUNSTALL, S.M., MCCARTHY, S. New insights into the benefits of flood warnings: Results from a household survey in England and Wales. *Environmental Hazards*, vol.7, n.3, p.193-210, 2007.

ROLLASON, E.; BRACKEN, L. J.; HARDY, R. J.; LARGE, A. R.G. Rethinking flood risk communication. *Natural Hazards*, vol. 92, no. 3, p. 1665–1686, 2018.

SAMADDAR, S; MURASE, M; OKADA, N. Information for Disaster Preparedness: A Social Network Approach to Rainwater Harvesting Technology Dissemination. *International Journal of Disaster Risk Science*, vol. 5, no. 2, p. 95–109, 2014.

STEWART, R.M.; RASHID, H. Community strategies to improve flood risk communication in the Red River Basin, Manitoba, Canada. *Disasters*, vol. 35, no. 3, p. 554–576, 2011.

TANOUE, M.; HIRABAYASHI, Y.; IKEUCHI, H. Global-scale river flood vulnerability in the last 50 years. *Scientific Reports*, vol.6, n.1, p. 36021, 2016.

TELLMAN, B; SULLIVAN, J A; KUHN, C; KETTNER, A J; DOYLE, C S; BRAKENRIDGE, G R; ERICKSON, T A; SLAYBACK, D A. Satellite imaging reveals increased proportion of population exposed to floods. *Nature*, vol. 596, no. 7870, p. 80–86, 2021.

UGOLINI, D; BONASSI, S; CRISTAUDO, A; LEONCINI, G; RATTO, G B. Temporal trend, geographic distribution, and publication quality in asbestos research. *Environmental Science and Pollution Research*, vol. 22, n.9, p. 6957–6967, 2015.

WAITE, T.D.; CHAINTARLI, K.; BECK, C.R. et al. The English national cohort study of flooding and health: cross-sectional analysis of mental health outcomes at year one. *BMC Public Health*, vol.17, p.129, 2017.

WINSEMIUS, H.C.; AERTS, J.C.J.H.; VAN BEEK, L.P.H.; BIERKENS, M.F.P.; BOUWMAN, A.; JONGMAN, B.; KWADIJK, J.C.J.; LIGTVOET, W.; LUCAS, P.L.. Global drivers of future river flood risk. *Nature Climate Change*, vol. 6, n. 4, p.381–385, 2016.

YAMADA, F; KAKIMOTO, R; YAMAMOTO, M; FUJIMI, T; TANAKA, N. Implementation of community flood risk communication in Kumamoto, Japan. *Journal of Advanced Transportation*, vol. 45, n. 2, p. 117–128, 2011.