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Bibliometric and Scientometric Review of Architectural Flood Resilience for Housing

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Abstract The desire for sustainable architectural flood resilience for housing that will lower the number of defects caused by floods prompted an investigation into the stakeholders in the domain. In recent years, the threat of flooding has pulled the attention of both researchers and practitioners. The purpose of the study is: to determine the most important authors, collaboration connections, and countries in academic works in this field, to identify the present mainstream research, and to suggest future research directions. The research's scope reveals a tendency that goes from small to huge, or from the level of individuals and friends to businesses and organisations, then to the level of countries. A systematic literature review (SLR) was done. From Scopus, 155 related bibliographic records were retrieved. Through exclusion and inclusion criteria, bibliometric analysis has been performed, and scientometric analysis has also been applied to strengthen the SLR findings using science mapping visualisation tools. The study provides an easily accessible point of reference for practitioners, policymakers, and research and development (R&D) bodies in the realm of practices. The most important authors, collaboration connections, and countries around the world are known as a result of the study. The study increases public awareness of the present trend in the domain and creates room for future research in less explored areas. The data reported in this review are primarily drawn from developed countries because there is a dearth of research on the field in Africa and other developing countries.

Keywords Flood, Resilience, Housing, Bibliometric Analysis, Scientometric Analysis

1. Introduction

Insight [1], opines that floods are a fundamental consequence of the water balance, and are particularly associated with heavy rainfall. As one might imagine, several factors influence inundation phenomena. Aside from other essential physical characteristics of a drainage basin, such as scale, geography, bedrock, geological features, plants, and land utilization, flood intensities are influenced by surface runoff, depths, duration, and distribution patterns. Flooding is indeed one of the globe's greatest catastrophic dangers, affecting human livelihoods, socioeconomic systems, and environmental quality [2]. Aderogba [3] asserts that concrete surfaces were allowed for road building, business and residential buildings, healthcare facilities and nursing homes, educational institutions, research organizations, marketplaces and retail outlets, service stations, and many other uses, all of which have boosted flood flows from rainfall and wastewaters, inadvertently adding to the waters in water bodies, watercourses, and drainage channels in our cities. Notably, flooding due to human vulnerabilities was the outcome of social interaction with the environment from practices such as facility design and location, natural resource extraction, and demographic density [4]. Again, a flood could be

linked to rapid urban expansion and flood plains encroachments. Four different floods devastated cities in the United Kingdom in 2012, causing a total loss of $2.9 billion and affecting thousands of people [5].

Hundreds of thousands of people died as a result of the flooding events, mostly in Asia (most notably in China, Thailand, and Bangladesh), and billions of people were harmed, primarily through homelessness, disease spread, severe ailments, deaths (mostly from drowning), and psychological conditions such as depressive symptoms, panic attacks, and post-traumatic stress disorder [6]. The amount of documented flood incidents has been steadily increasing during the last two decades. The number of individuals killed or seriously harmed by flood disasters has increased dramatically around the world [7].

Resilience is the potential of a system and its components to foresee, absorb, accommodate, and recover from stress. It ensures the preservation of the effects of a hazardous occurrence in a timely and efficient manner restoration or enhancement of its key structural and functional elements [8]. The concept of resilience refers to the idea that we should learn to live with floods and manage flood risk rather than trying to prevent them as a community [9-11]. Resilience can be defined regarding technological features such as novel architectural components, materials, or strategies that take into account material interactions [12-13] or socioeconomic issues, such as climate change scenarios combined with long-term land-use modelling and flood risk assessments to provide maps and time series of predicted yearly damages [14-16]. There are several flood resilience evaluation measures due to the large range of challenges addressed by the term resilience [17]. Most flood resilience frameworks focus on the relationship between flooding probability and direct impact (engineering resilience) and factors that contribute to resilience, such as economic resources, assets and skills, information and knowledge, support and supportive networks, and access to public services (socioecological resilience) [18].

International organisations such as the World Health Organization (WHO) and UN-Habitat have proposed numerous definitions of ‘healthy housing' or ‘adequate shelter' to date, all of which emphasise that ‘housing' does not only imply the presence of a physical structure but also includes necessary services and facilities in the surroundings [19]. One of the most serious deprivations faced by the impoverished around the world is substandard housing. Over 860 million people are projected to live in substandard buildings in developing nations, and this number is constantly increasing due to rising urbanisation rates [20,21]. Lack of access to running water, power, heating, ventilation, and security of tenure are all linked to poor housing. Because more than half of humankind lives in cities, which is expected to rise to 68 per cent by 2050, promoting sustainable cities is critical. Rapid urbanisation is putting immense strain on the environment in emerging countries, including land and freshwater supplies, housing, infrastructure, and fundamental public utilities [22]. This goes a long way to affect adversely the productivity of the substandard house dwellers.

Research demonstrates that there are knowledge gaps that have not been adequately filled in earlier research [23]. It is essential to perform a thorough evaluation of the pertinent literature to identify the knowledge gaps clearly and completely in architectural flood resilience for housing. The review study on flood resilience for housing has significant implications for practitioners as well as academics.

The review of the literature is an important and fundamental yet time-consuming method for gathering literature for independent research [24]. Frehe et al., [25] assert that a few files, such as the h-index, provide a method for evaluating and differentiating authors' writings from researchers. It is a widely accepted approach to separate the significant literature from the unimportant literature using different h-file variations, such as the one for institutions, or entirely new variations, such as the g-list, which is also based on the h-index. Reviews of just qualitative literature could have been influenced by personal prejudice, making them less reliable [26]. Limited-scope literature evaluations could only present partial depictions of the status quo, and as a result, some important areas of research and practice may have been missed [27].

The objectives of this study which incorporates scientometric analysis include:

(1) To determine the most important authors, collaboration connections, and countries in academic works in this field.
(2) To identify the present mainstream research subjects inside flood resilience for housing.
(3) To suggest future research directions in flood resilience for housing.

To determine any gaps in current knowledge on flood resilience for housing, a thorough and methodical study on the subject is essential. In response, a study was started to thoroughly search and assess the body of knowledge on architectural flood resilience for housing. The process of searching the literature for this review study and the tools employed to review it are described in the following section. A part devoted to in-depth discussions of the material studied follows the presentation of the sequence of scientific, quantitative analyses performed on the searched literature. The discussions' conclusions revealed the key knowledge gaps that needed further attention. Below is a description of the literature review's workflow, as seen in Fig. 1.

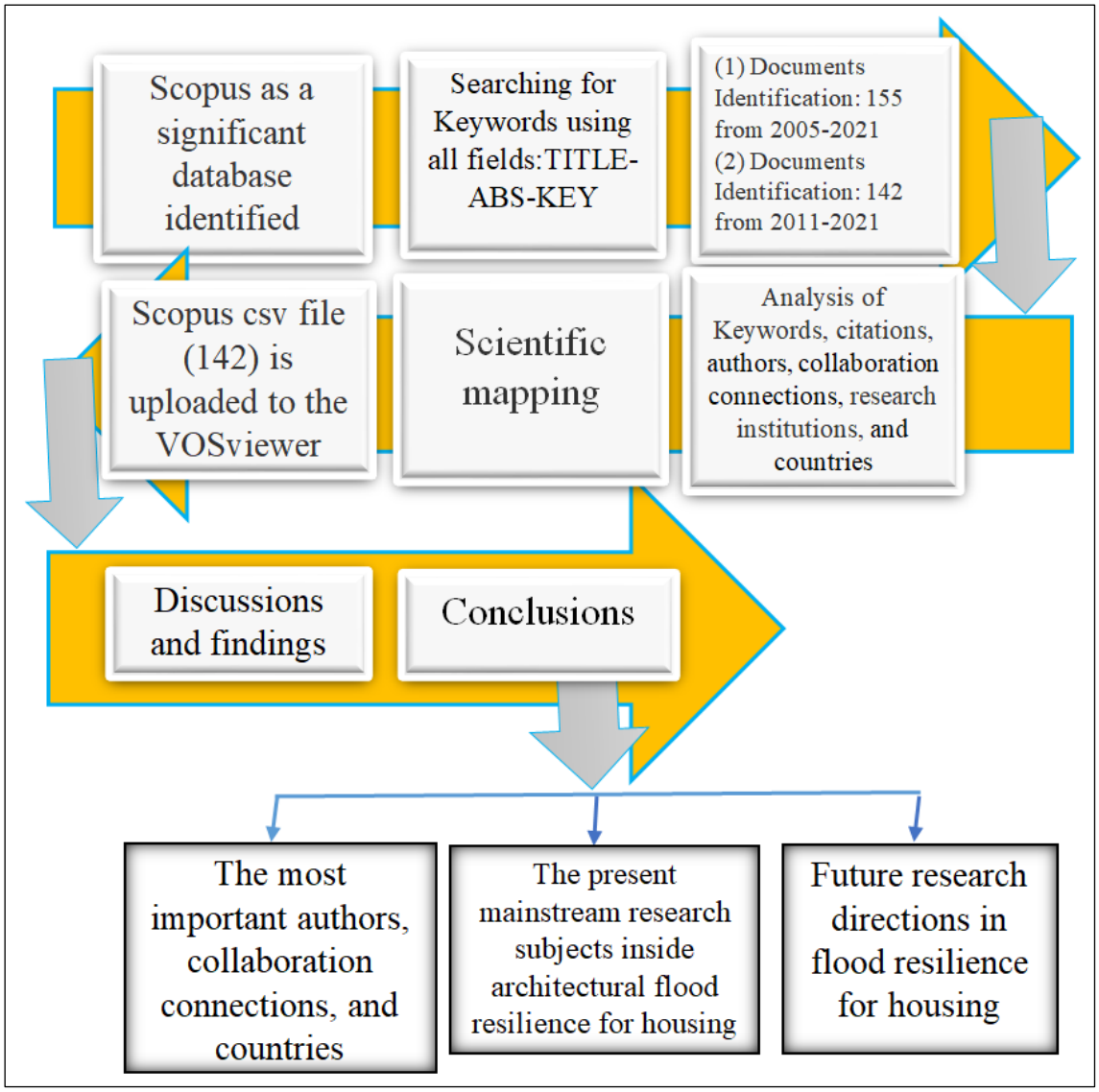

Figure 1. Literature review workflow for flood resilience for housing

Undoubtedly, the accepted currency for scientific activity is research articles [28]. By recording observational results and providing a venue for discussion, reasoning, and the constant evolution of scientific knowledge, they contribute to the open entire record of science [29]. It is impossible to imagine interpreting investigation into knowledge or practice without the indication of research in publications, even though it is not the end goal of logical study. No accurate evaluation of the impact of translational research can ignore the importance of publications as intermediate output in this regard [30]. Expert evaluation and research metrics are increasingly combined to provide answers to critical questions. For instance, specialists in academia, government, and corporation employ them to foresee logical advancements, determine where to contribute, and gauge the assessment of prior endeavours [31, 32]. One of the important reference measurements that demonstrates the average cite effect of each publication in a set of numbers is the average number of citations per paper [33].

Science method, science policy, and scientific communication are all subjected to scientometric analysis. Measures of the effect of authors, papers, journals, institutions, and comprehension of citations associated with them are its primary, though not exclusive, focus. It also examines the visualisation and mapping of scientific domains as well as the evaluation of indicators for the application of management and policy in the future. Recently, scientometrics has been used as a method to assess and quantify the performance of research [34]. This is a type of data mining, and as data is used in so many different fields of study and human endeavour, it is crucial to have the ability to mine data effectively. Paper & Development [35] argued that applied researchers are falling behind in the field of scientometrics because there is a lack of scientometric methodologies among them.

Datasets must also be combined to be useful because the origin and quality of large amounts of information are frequently faulty. Big data are usually too large to be kept on just one computer system or managed by conventional database frameworks, measurement bundles, or conventional graphical programming [36]. claims that big data is a collection of information from traditional and digital sources inside and outside of specific organisations that may be used for analysis and research.

2. Methodology

The study used a review that was based on scientometrics [37-39] and a detailed analysis of the current study areas in flood resilience for housing. The adoption of the scientometric review is logically justified by the fact that numerous review-based research in the construction industry have revealed that we may be relying on judgments that may be subjective and hence unreliable. Using scientometric analysis, a conclusion that is objective and less subjective can be obtained [26, 31]. The prospect of retrieving more current papers is increased by Scopus's substantially quicker indexing process [40]. The approach chosen for this study is appropriate since it demonstrates and examines the evolution of research across time. It makes use of a quantitative approach that maps, visualises, and links the evolution of research by relying on extensive bibliographic data to evaluate the development of a study topic using qualitative indexes. The primary data source for this study was "Scopus." The parameters and outcomes of the search for data collection are shown in Table 1.

Table 1. The parameters and outcomes of the search for data collecting

S/N	Search settings	Search results
1	Database	Scopus Core Collection
2	Search Method	Topic: “flood” “resilience” & “housing”
3	Document Types	Articles and conferences
4	Range	2005-2021 (17 years)
5	Search time	14-6-2022
6	Publications	155

Knowing the most trustworthy databases to use as a resource for information is crucial given the abundance of research articles that the scientific community publishes. Aghaei et al., [41] argued that Scopus and Web of Science are the two most comprehensive, effective, and impartial databases for literature searches, with Scopus having the database with the larger coverage and more recent publications. These two databases rate journals according to their visibility and citation counts, which reveal the journal's significance, standing, and influence. Due to the difficulty in identifying and removing publications that appeared in many databases, as well as the sheer volume of data required, this study was not able to combine any literature databases; instead, it relied exclusively on the Scopus database [42].

Scientometrics and Bibliometrics are two majors, closely linked logical disciplines that estimate and analyse logical distributions in a given field. A modern branch of logic known as "bibliometrics" allows for the factual breakdown of academic writing and the representation of production processes in a certain discipline. The quantitative analysis of bibliographic data for distributions described as "bibliometrics" includes measurements such as the absolute number of publications, reference counts, mean standardised reference score (MNCS), h-file, and fractions of interdisciplinarity and specialisation. Because any significant amount of research activity inevitably results in production, bibliometric analysis is a quick, easy, and effective means of assessing the quantity and quality of research output. Furthermore, experts generally agree that bibliometric analysis gives objective, accurate, quantitative measures of research effect for scientific outputs [43,51]. Typically, a bibliometric or scientometric analysis method is used in a science mapping study [44]. Although bibliometric analysis focuses on the literature as a whole, the scientometric analysis provides a more comprehensive approach that includes bibliometric tools, methodologies, and data to analyse the literature and its outputs to identify the domain's potentially informative trends and patterns [26].

Flood, resilience, and housing were the keywords utilised to retrieve relevant documents and data from the Scopus database's all fields: title, abstract, and keywords sections (TITLE-ABS-KEY) of publications. All flood, resilience, and housing-related documents thereafter appeared and were downloaded. Each downloaded document's abstract was read to make sure the studies related to flood, resilience, and housing research. The Scientometric analysis used scientific mapping, which provides a thorough description, assesses policy goals and handles large amounts of bibliographic data. Additionally, science mapping emphasises the systematic and efficient features of scientific research and illustrates the relationships among various domains, authors, disciplines, and publications [37].

There are numerous science mapping tools, and each one has distinct advantages and functions. Consequently, it is vital to employ the right tools for the right kinds of studies to completely study any domain [45]. The strengths and limitations of several science mapping tools, such as VOSviewer, Gephi, CiteSpace, Sci2, and HistCite, were examined in this study [46], were assessed, resulting in the choice of VOSviewer. VOSviewer is open-source software designed for the creation and evaluation of bibliometric maps. VOSviewer considers the graphical representation of bibliometric maps, which is different from most software used for bibliometric mapping. VOSviewer's value as a data mining tool is especially beneficial for displaying large bibliometric maps in an easy-to-understand manner [47]. VOSviewer is adaptable

in that it may be used to create, visualise, and explore maps regardless of the type of network data [46].

Science mapping was used to analyse clusters and interrelationships between keywords, scientists, articles, and organisations. The information about scholars and keywords that was retrieved provides a comprehensive picture of the most recent advancements in the scholarly study in a certain field. It prevents academics in the global scholarly network or those interested in the academic field from being isolated [37].

The study used a sequential method for gathering data from Scopus, choosing a tool, data mining, processing and analysing the data, visualising and presenting the results, interpreting the data, discussing the results, identifying gaps, setting limitations, and drawing a conclusion.

It should be emphasised that this study does not cover articles written in languages other than English, and the publications used were from journals and conference papers.

3. Type of Documents

As of June 14th, 2022, a search of the Scopus database for literature produced a total of 155 articles. Journal publications and conference papers make up 66.9 per cent and 17.8 per cent, respectively, and account for a combined 84.7 per cent of the document database on flood resilience for housing, as shown in Fig. 2. The data acquired from the Scopus database was evaluated by the Scopus analyser. Most of the data included in the study come from journal and conference publications, which, as shown in Fig. 2, account for 84.7% of the total data gathered.

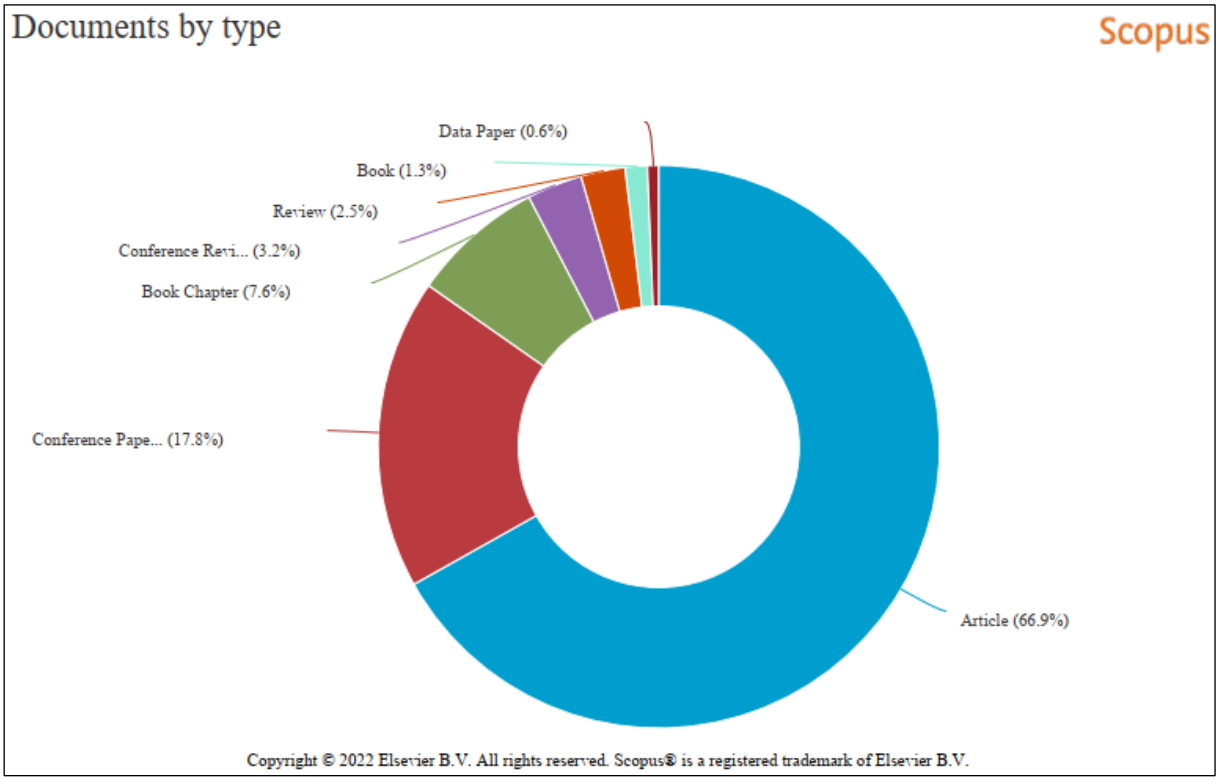

Figure 2. Type of documents retrieved

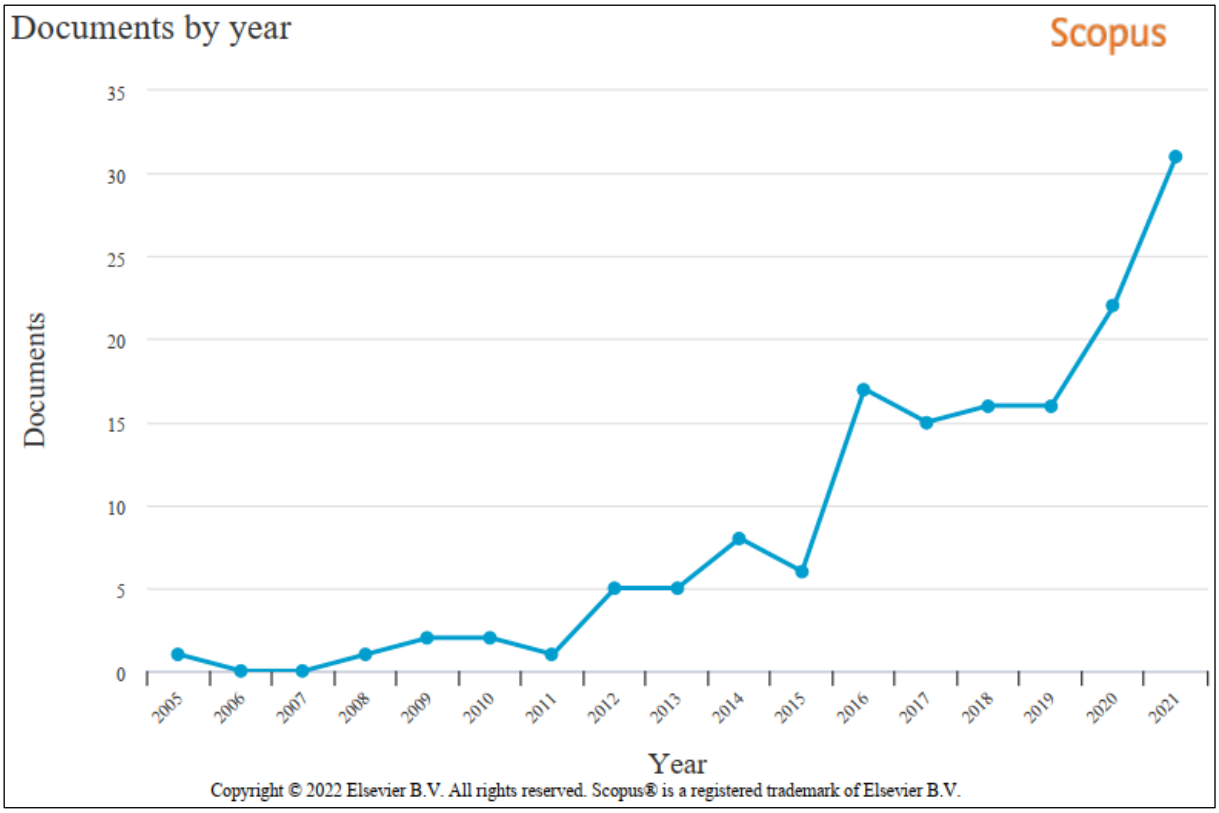

Figure 3. Literature sample based on year of publication

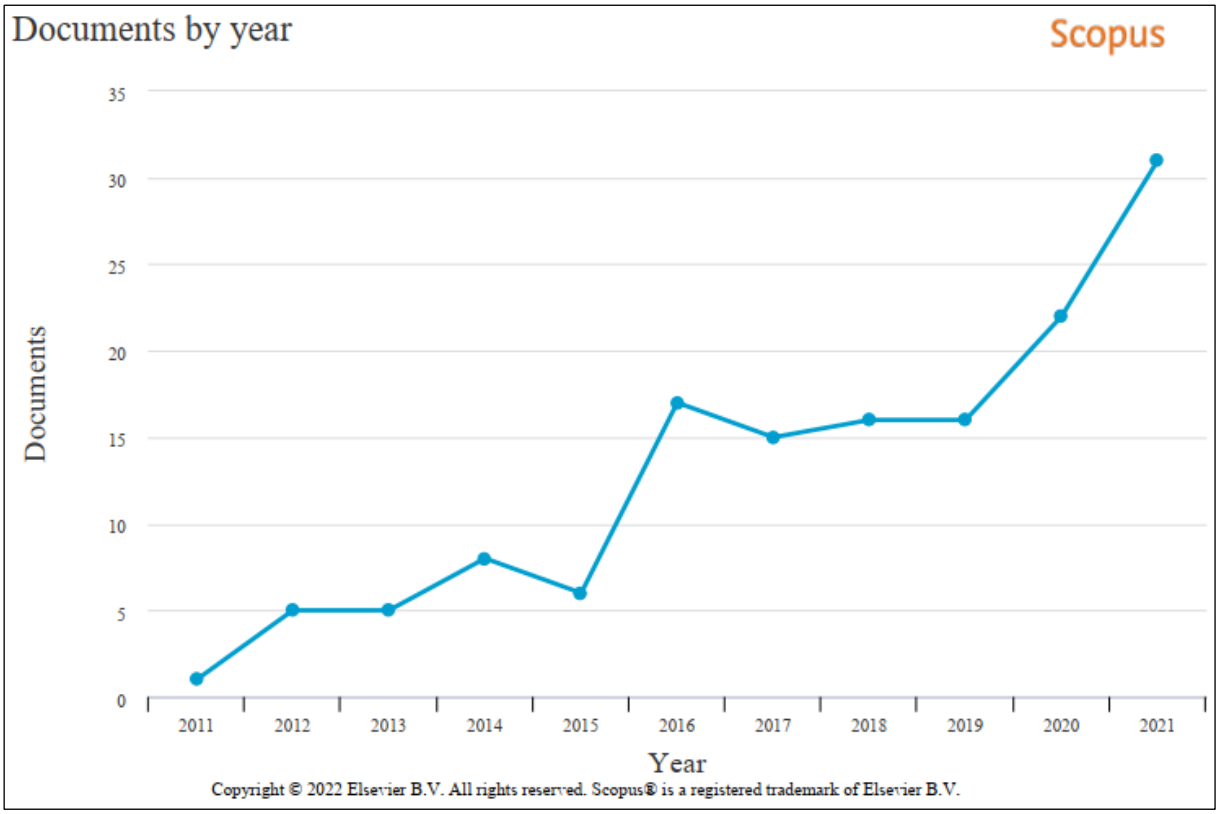

Figure 4. Literature sample based on peak year of publication

4. Literature Sample

The publication years for the whole literature collection, as shown in Fig. 3, range from 2005 to 2021. Table 1 presents the parameters and findings of the data collection search. While Fig. 4 illustrates the period of increased publication in flood resilience for housing. The first article was identified in 2005, then after two years without any articles, there was one in 2008. 2009 and 2010 both saw 2 articles, with 2011 seeing a drop to just 1 article. 2012 and 2013 recorded 5 articles each. Hence, the research in the field of study began to peak in 2012. From then the growth in publications increased annually until 2021 when 31 articles were recorded. The trend anticipates more research articles in the upcoming years because of this tendency, which demonstrates that academics are becoming more interested in flood resilience for housing.

5. Research Keywords

The main ideas in articles are reflected in the keywords, which also link the body of research grouped under a specific theme [48]. To visualise keyword co-occurrence in the research area for this study, VOSviewer software was utilised, and the results show how the themes are related [49]. The knowledge between their relationships and the intellectual arrangement of study subjects are represented by a network of keywords [46]. By the suggestions of [26,50] "Author Keywords" was adopted in VOSViewer for keyword filtering. The literature sample provided these keywords. Since the main objective of this research among others was to identify the research gap in flood resilience for housing. Therefore, using keywords is crucial to achieving these objectives. The number of occurrences of the keywords was set to be at least 7, and 33 meet the threshold. The 33 major keywords in the field include; Adaptation, Adaptive Management, Climate Change, Community Resiliences, Decision Making, Disaster, Disaster Management, Disasters, Ecosystem Resilience, Flood, Flood Control, Flooding, Floods, Hazard Management, Hazards, Housing, Housing Infrastructure, Human, Humans, Hurricanes, Land Use, Natural Disaster, Natural Disasters, Resilience, Risk Assessment, Risk Management, Runoff, Sea Level, Storms, Sustainable Development, Urban Area, Urban Planning, and Vulnerability. Table 2 shows the keywords with the most occurrences in the research articles used for this study. Floods, Housing, Resilience, Flooding, and Climate change appeared most in the search making the top five most used keywords. Fig. 5 shows the visualization of the most occurring keywords and their connectivity to each other according to their link strength. Total link strength indicates the interrelatedness between the given journal and other peer sources. The visualization shows that Floods, Housing, and Resilience are the most prominent keywords in the study relative to other keywords and the size of their labels is bigger. Additionally, the total link strength of the two items increases with the thickness of the lines between them [46].

It is clear from Table 2 and Fig. 5 that the keywords that have lesser occurrences need more research and are considered the gap in the study. They include Adaptation, which has 7 occurrences, with total link strength of 41. Housing Infrastructure, which has 7 occurrences, with total link strength of 38. Land Use, which has 7 occurrences, with total link strength of 38. Runoff, which has 7 occurrences, with total link strength of 36. Sea Level, which has 7 occurrences, with total link strength of 45. Others are Community Resiliences, which has 8 occurrences, with total link strength of 42. Ecosystem Resilience, which has 8 occurrences, with total link strength of 50. Hazard Management, which has 8 occurrences, with total link strength of 46. Hurricanes have 8 occurrences, with total link strength of 48. On the other hand, keywords with more occurrences have been more researched and hence need less attention even though the study field do not have huge numbers of publication compared with other long-time existing fields like concrete, blocks, steel, and furniture. The top 7 in this category include Floods, which has 58 occurrences, with total link strength of 310. Housing, which has 54 occurrences, with total link strength of 278. Resilience, which has 46 occurrences, with total link strength of 198. Flooding, which has 41 occurrences, with total link strength of 218.Vulnerability, which has 37 occurrences, with total link strength of 181. Climate Change, which has 35 occurrences, with total link strength of 179. Disasters, which have 27 occurrences, with total link strength of 168. Fig. 6 shows a detailed visualization of the most occurring keywords(floods), and their connectivity to each other according to their link strength. Fig. 7 shows a detailed visualization of the second most occurring keywords (Housing), and their connectivity to each other according to their link strength. While Fig. 8 shows the visualization of the third most occurring keywords (Resilience), and their connectivity to each other according to their link strength.

6. Source of Publication

Five sources of publication were identified spanning 2013 to 2021 in Fig. 9. International Journal of Disaster Resilience in the Built Environment, which has four publications: a publication each in 2013, 2014, 2019, and 2021. Water Switzerland has a publication in 2016, and 2 in 2020. Procedia Engineering has four publications: a publication in 2016, and 3 in 2018. Top conference Series Earth and Environmental Science, which has four publications: a publication each in 2017 and 2018, and 2 in 2021. Global Environmental Change has four publications: a publication in 2019, and 3 in 2020.

Table 2. Keywords with the most occurrences

S/N	Keywords	Occurrences	Total Link Strength
1	Adaptation	7	41
2	Adaptive Management	12	60
3	Climate Change	35	179
4	Community Resilience	8	42
5	Decision Making	15	100
6	Disaster	12	75
7	Disaster Management	19	97
8	Disasters	27	168
9	Ecosystem Resilience	8	50
10	Flood	19	74
11	Flood Control	22	107
12	Flooding	41	218
13	Floods	58	310
14	Hazard Management	8	46
15	Hazards	13	91
16	Housing	54	278
17	Housing Infrastructure	7	38
18	Human	10	73
19	Humans	9	60
20	Hurricanes	8	48
21	Land Use	7	38
22	Natural Disaster	11	74
23	Natural Disasters	9	56
24	Resilience	46	198
25	Risk Assessment	21	118
26	Risk Management	10	63
27	Runoff	7	36
28	Sea Level	7	45
29	Storms	13	71
30	Sustainable Development	13	51
31	Urban Area	9	47
32	Urban Planning	11	51
33	Vulnerability	37	181

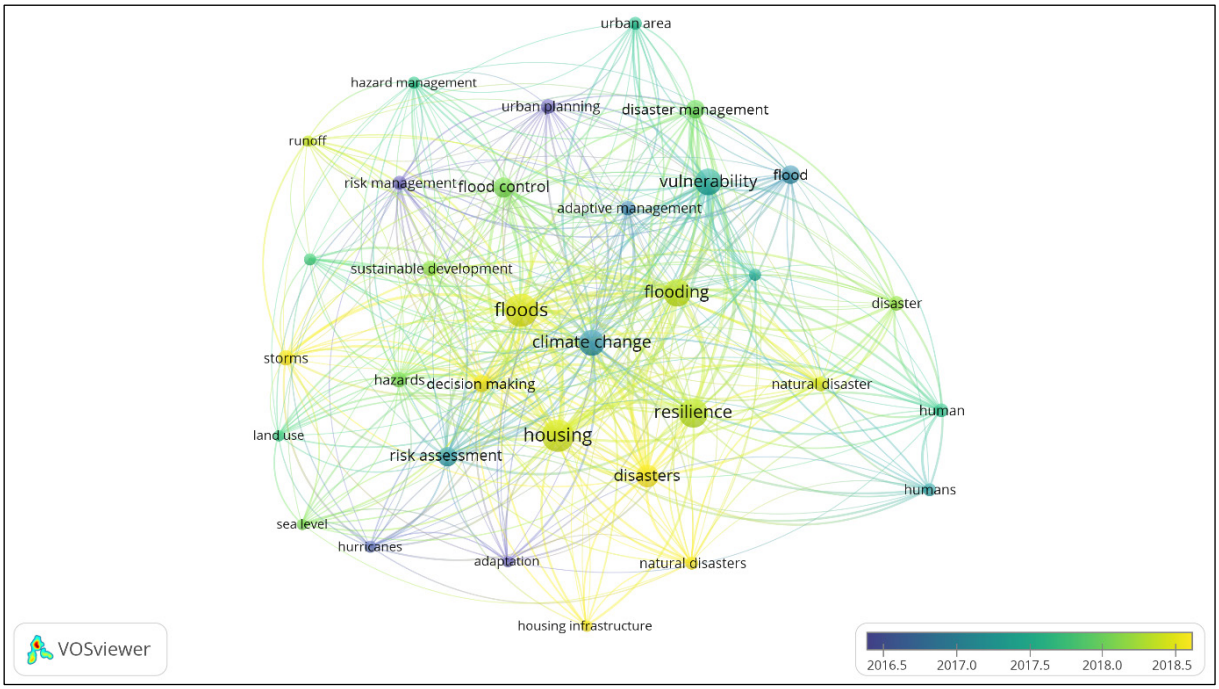

Figure 5. shows the visualization of the most occurring keywords (variables)

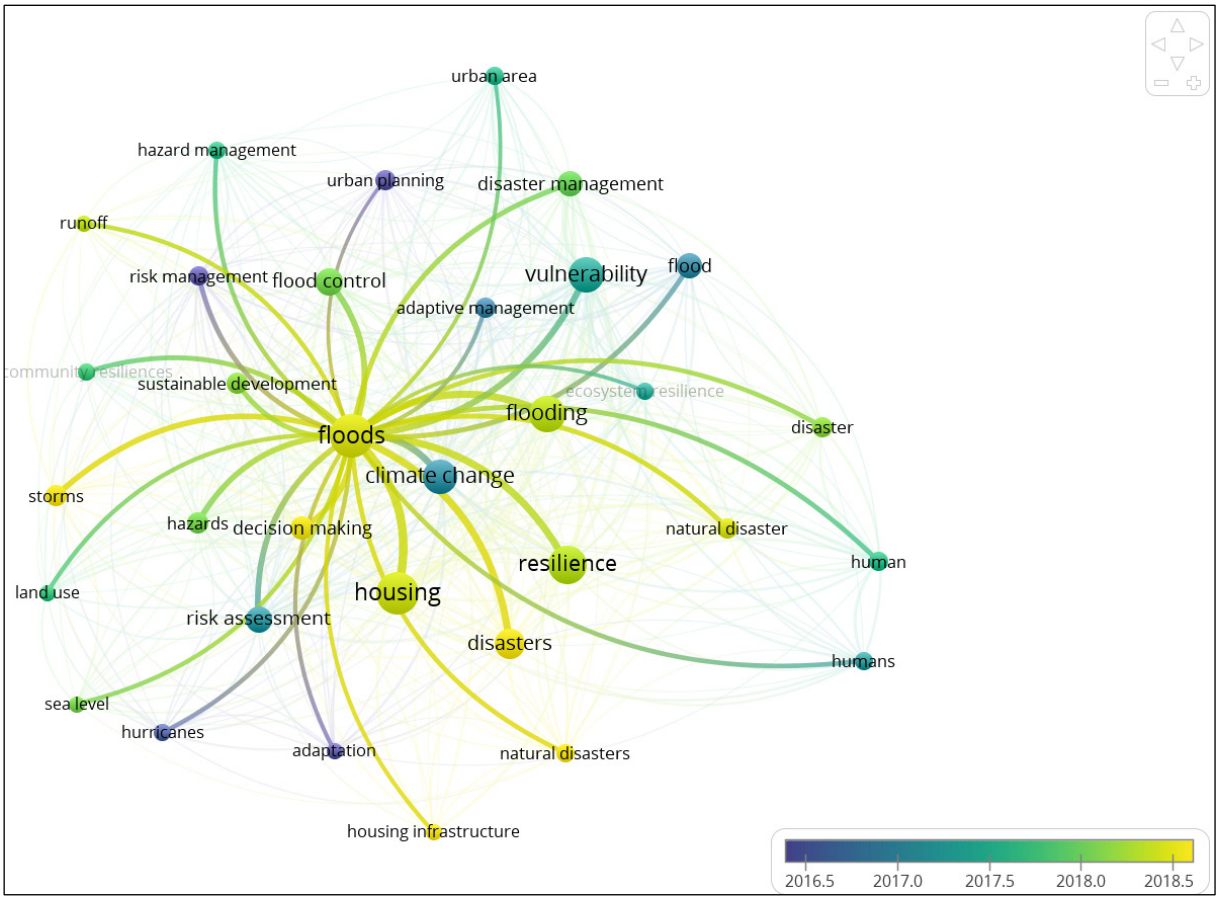

Figure 6. shows a detailed visualization of the most occurring keywords; variables (floods)

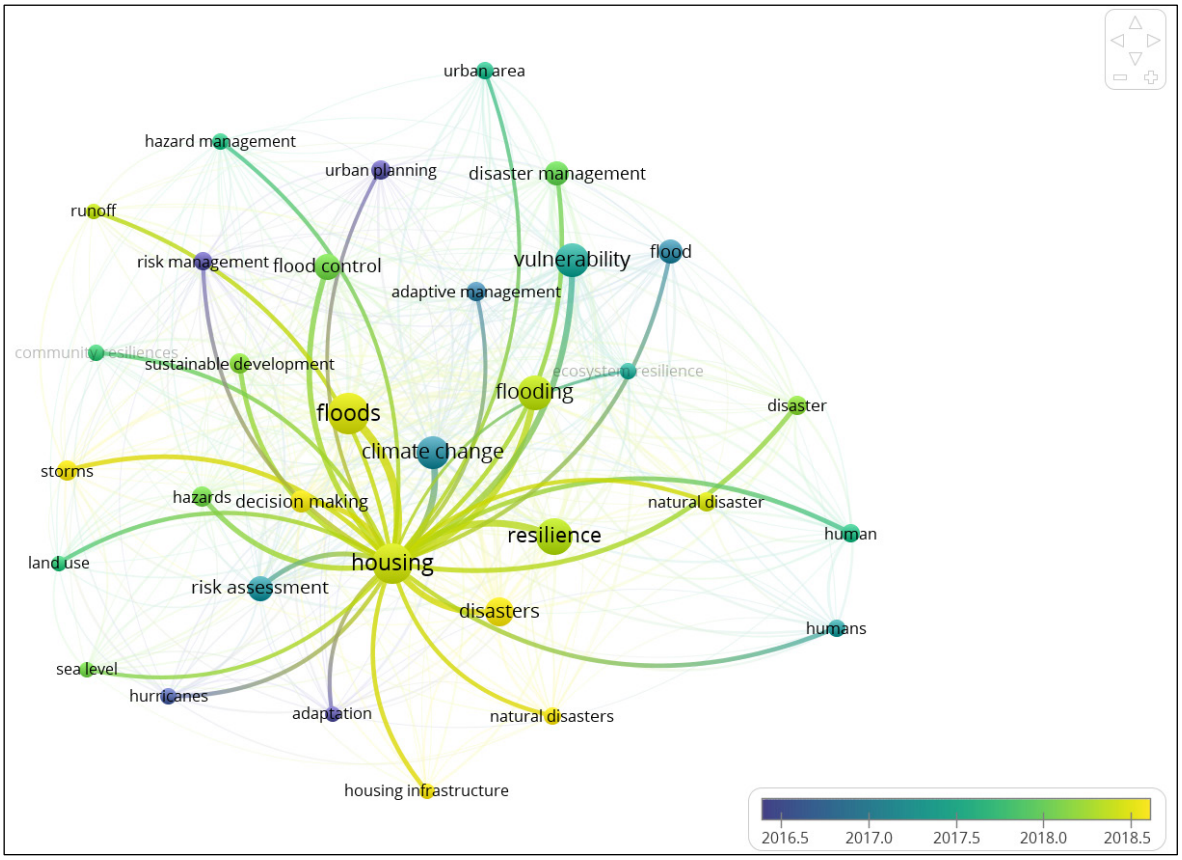

Figure 7. shows a detailed visualization of the second most occurring keywords; variables (Housing)

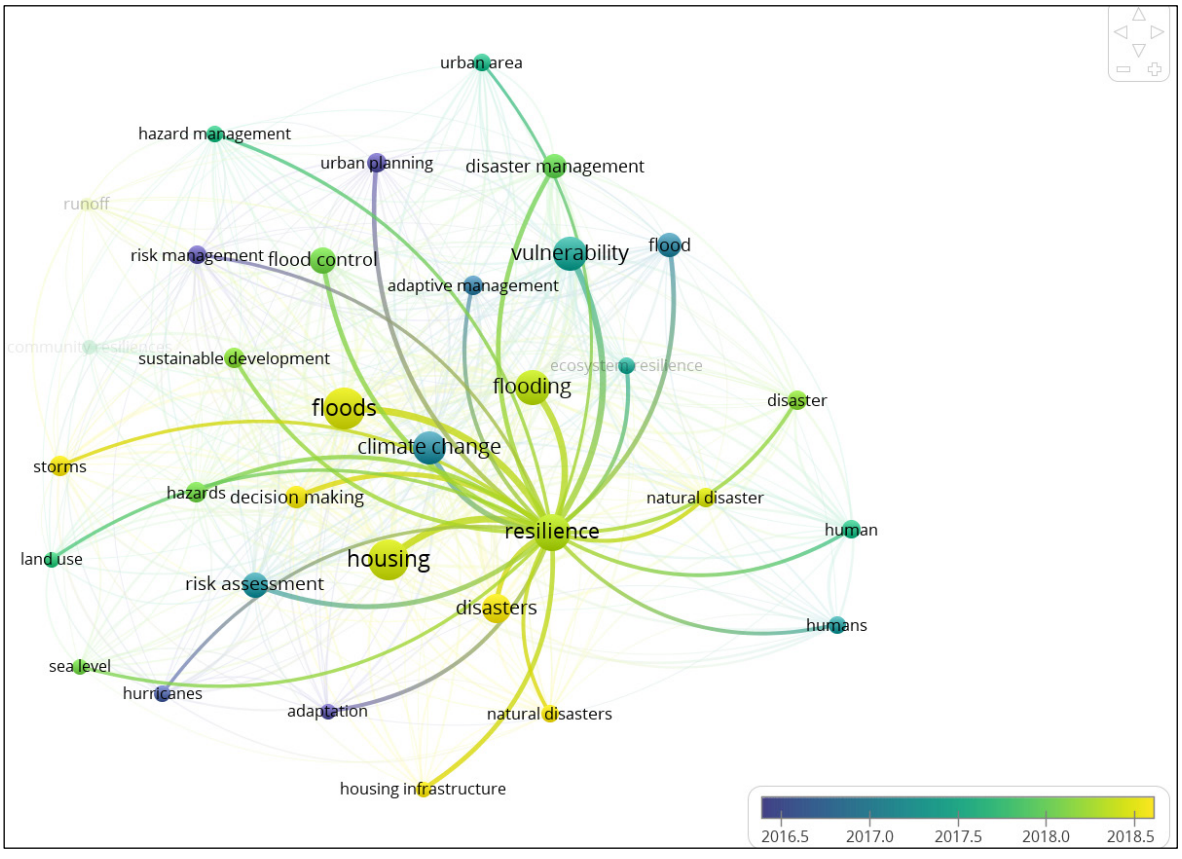

Figure 8. shows the visualization of the third most occurring keywords; variables (Resilience)

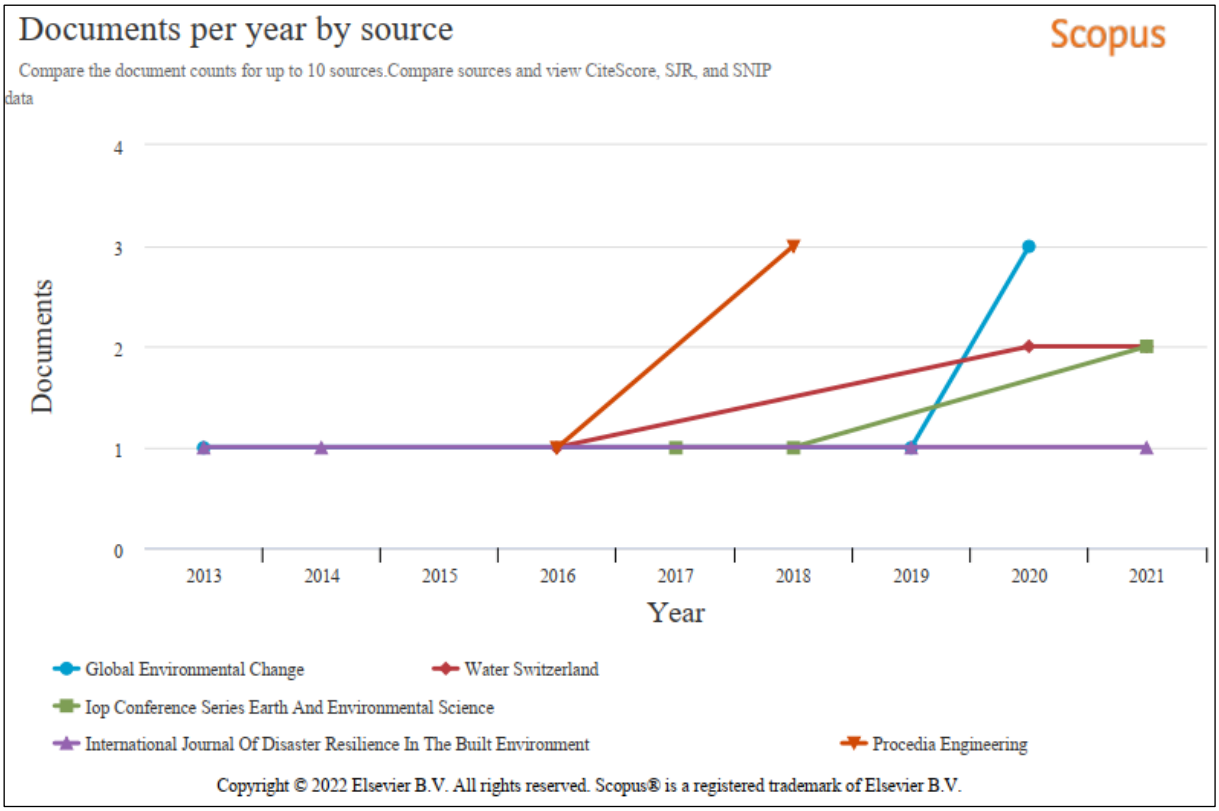

Figure 9. shows publications per year by source

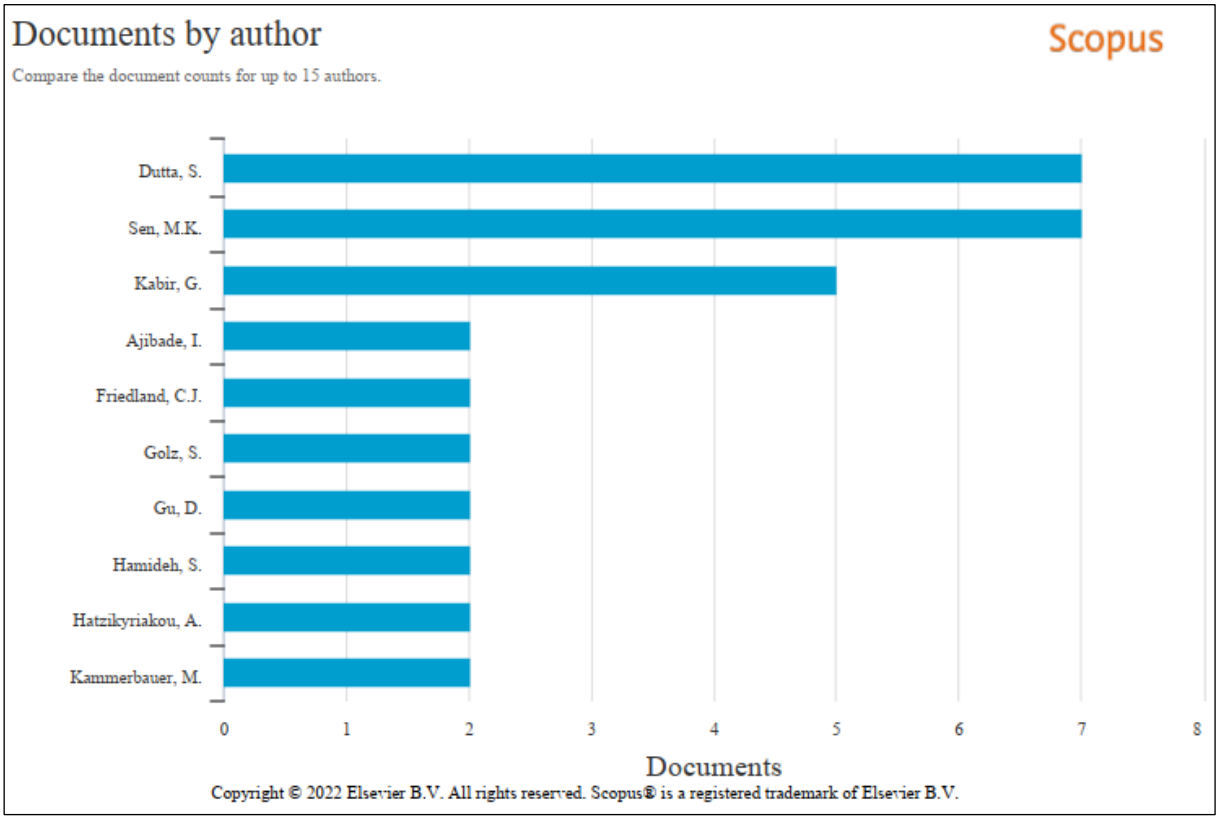

Figure 10. Documents by authors

7. Authors with the Highest Citation

An analysis is done on the number of documents that authors have contributed in connection to flood resilience for housing. The quantity of citations a scholar receives demonstrates their level of influence within a given field [51]. Table 3 shows various authors with their total citations as well as the number of single-authored documents and total link strength in flood resilience for housing according to a Scopus database extraction. The aforementioned information demonstrates that both Ajibade I. and Mcbean G. have a total citation of 187 each and a document count of 2 giving each of them an average citation count of 93.5 per document. However, both Dutta S., and Sen M.K have a total citation of 46 each and a document count of 7 each giving each of them an average citation count of 6.57 per document. Fig. 10 shows the total number of single-authored and co-authored documents produced by an author in the Scopus database. From Table 3 and Fig. 10, it is observed that both Ajibade I. and Mcbean G are the most cited researcher with the greatest impact. While both Dutta S., and Sen M in terms of the number of published documents, are the most influential researchers.

8. Co-authorship Network

The knowledge of existing academic and scientific collaborative linkages within a research field improves access to experts, specialisations, money, and performance [52, 53]. A co-authorship network is shown in Fig. 11, where each node stands for a different author and the links connecting the authors signify the working relationship that has been built through the co-authorship of the articles. This might encourage scholars to work together on research projects, improve communications, and produce better research results [26]. claimed that because co-authorship is the road map for academic collaboration, a lack of collaboration in the sciences may be an indicator of a lower level of research productivity. Co-authorship is, therefore, proof of the productivity of research. In light of this, it is crucial to look at the co-authorship network in the field of research on flood resilience for housing.

Table 3. Authors with the highest citation

SN	Author	Documents	Citations	Total link strength
1	Ajibade I.	2	187	2
2	Chen Y.	2	6	0
3	Dutta S.	7	46	16
4	Friedland C.J.	2	13	2
5	Golz S.	2	33	2
6	Gu D.	2	6	7
7	Hamideh S.	2	6	7
8	Hatzikyriakou A.	2	62	2
9	Kabir G.	5	36	11
10	Kammerbauer M.	2	29	2
11	Laskar J.I.	2	10	5
12	Laskar S.A.	2	10	6
13	Lin N.	2	62	2
14	Mcbean G.	2	187	2
15	Naumann T.	2	33	2
16	Orooji F.	2	13	2
17	Sen M.K.	7	46	16
18	Seong K.	2	4	4
19	Sutley E.J.	2	6	7
20	Vahanvati M.	2	22	0
21	Van de lindt J.W.	2	6	7
22	Wamsler C.	2	29	2

The VOSViewer was employed for this investigation. The threshold limit for the number of documents of an author was set at 8. 19 authors met the threshold as visualized in Fig. 11. The nodes are coloured based on researchers' network links. Three sets of collaboration links can be seen, Dutta, S., and Sen, M.K. with a link strength of 19, and Kabir, G. with a link strength of 16. Mostafavi, A. with a link strength of 14 Dong, S. with a link strength of 11, and Li, Q. with a link strength of 9. Again, Wang, H. and Wang, S. with a link strength of 4, Wang, Y. with a link strength of 2, Zhang, J. with a link strength of 3, Li, Y. with a link strength of 2, and Zhang, Y. with a link strength of 1. The largest cluster comprises three authors: Dutta, S., Sen, M.K., and Kabir, G. These authors have the strongest network of all the authors in flood resilience for housing with the highest total link strength. Researchers' interconnectedness and distance from one another further illustrate how they impact one another [54]. In terms of collaboration, there are two closed-loop circuits in Fig. 11, demonstrating that the researchers working on these circuits have developed excellent working relationships, such as the circuit of, Dutta, S., Sen, M.K., and Kabir, G. This demonstrates the strength of their relationship, which is also apparent in the results of their research. Collaborations increase output. However, it is significant to highlight that the entire network of researcher partnerships in the field of flood resilience for housing is rather small, which indicates the necessity for authors to work collaboratively to address the key problems in flood resilience for housing. The best researchers in flood resilience for housing are also listed in Table 4.

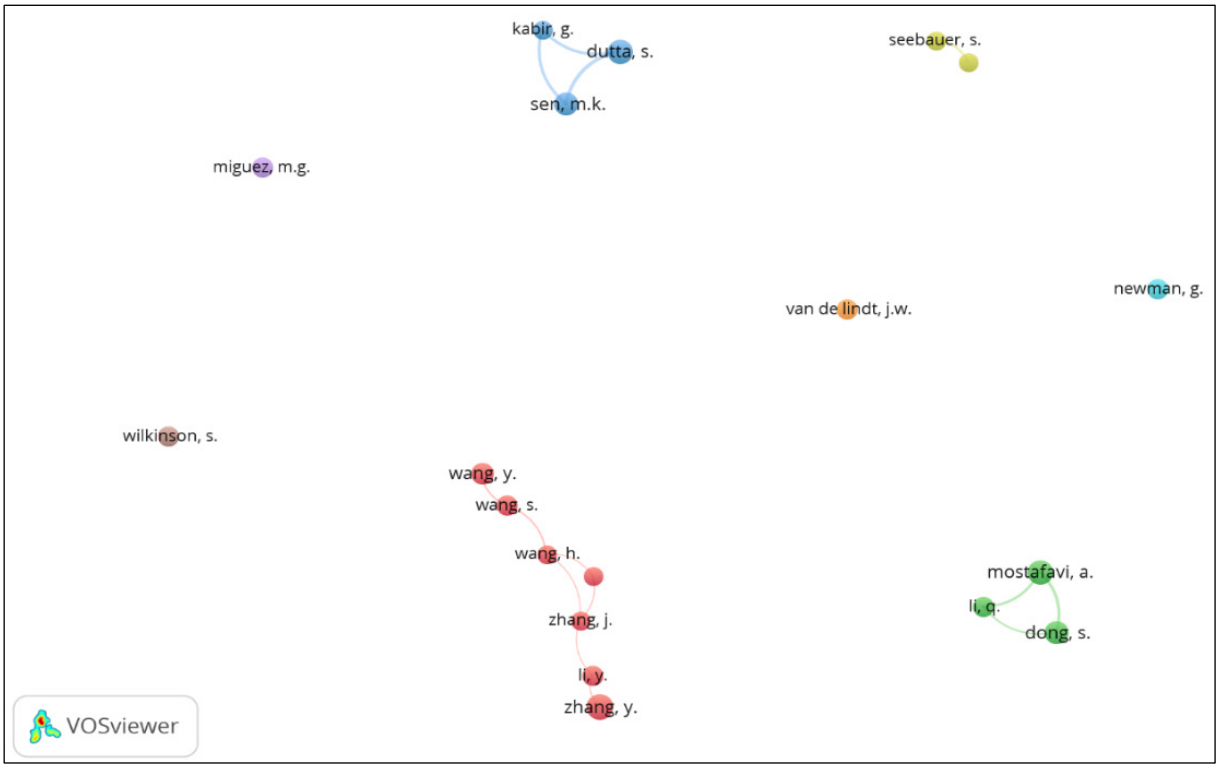

Figure 11. Co-authorship analysis

Table 4. Prominent researchers in flood resilience for housing

SN	Author	Documents	Citations	Total link strength
1	Dong, S.	12	157	11
2	Dutta, S.	13	70	19
3	Kabir, G.	8	37	16
4	Li, Q.	9	68	9
5	Li, Y.	9	49	2
6	Miguez, M.G.	9	137	0
7	Mostafavi, A.	13	151	14
8	Newman, G.	9	50	0
9	Seebauer, S.	8	69	4
10	Sen, M.K.	11	47	19
11	Thaler, T.	8	56	4
12	Van de lindt, J.W.	9	112	0
13	Wang, H.	8	21	4
14	Wang, J.	8	23	2
15	Wang, S.	9	57	4
16	Wang, Y.	10	86	2
17	Wilkinson, S.	9	52	0
18	Zhang, J.	8	20	3
19	Zhang, Y.	14	63	1

9. Network of Countries

Knowledge of well-known countries in a field of study may encourage research collaborations, funding access, and study exchange among scholars [54, 55]. Recognizing diligent countries in a field of research also helps. The VOSViewer was used for the analysis to identify these countries. Based on the number of publications produced in a country, the United States and the United Kingdom ranked highest with 50 and 24 publications respectively. Furthermore, the United States and the United Kingdom had citations of 907 and 177 respectively. Again, their total link strengths are 12 and 11 respectively. These parameters indicate that they are the largest contributors to flood resilience for housing-related research. This could be explained by the high number of floods that occur inside their geographical boundaries. The two leading countries are connected. As a result, research organisations in these active countries should be involved in policy creation and reformation to promote research collaborations and enhance research output in flood resilience for housing. The number of documents, citations, and total link strength reflects the degree to which each country has contributed to the improvement of flood resilience for housing. The total link strength indicates that each country's documents have had an impact on one or more of the other countries engaged in these studies; the largest total link strengths are seen in the United States, the United Kingdom, and Australia. The publications in the research domain are shown in Fig. 12 and Table 5, and the co-citation relationships between the countries are visualised in Fig. 13. The significance of the findings is to foster countries' intra and extra research collaborations as well as access to funding.

10. Articles with the Highest Citation

The articles with the highest citation as well as their authors and year of publication are shown in Table 6. Fig. 14 shows the visualization of authors with the most cited articles represented in Table 6 and the link between the published articles and other authors in terms of citation. Ajibade I., (2013, 2014) had two documents with citations of 118 and 69 respectively. Brown A. (2012) and Keenan J.M. (2018) had a citation of 106 each. Hauer F.R (2016) had a citation of 92. Gamble J.I. (2013) and Porio E. (2011) had citations of 75 and 69 respectively. Cui Y. (2019) and Hatzikyriakou A. (2016) had citations of 56 and 50 respectively.

Ajibade I., Brown A., and Keenan J.M. were identified as some of the most cited authors on flood resilience for housing. The visualization shows the co-citation network

between the authors involved in the study of flood resilience for housing. The documents' proximity demonstrates how closely related they are to one another in terms of citation.

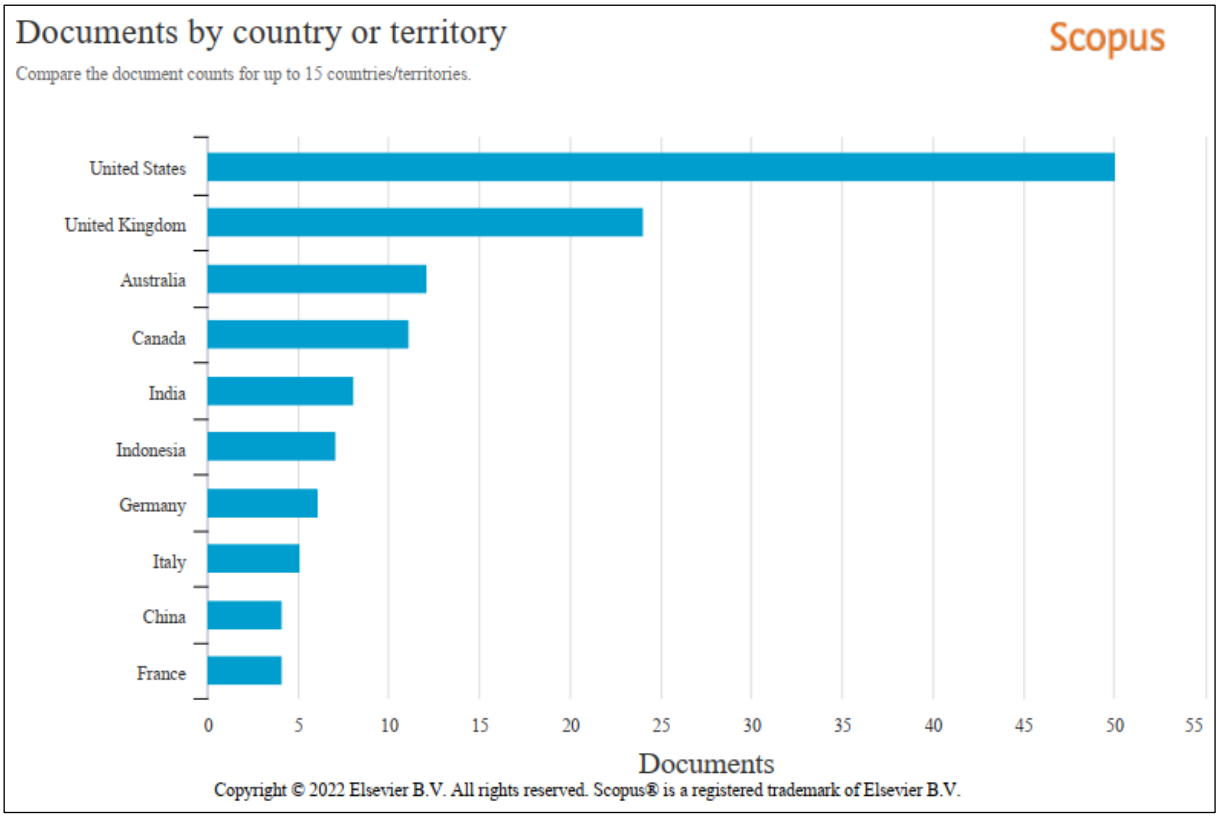

Figure 12. shows the publications per country in the research domain

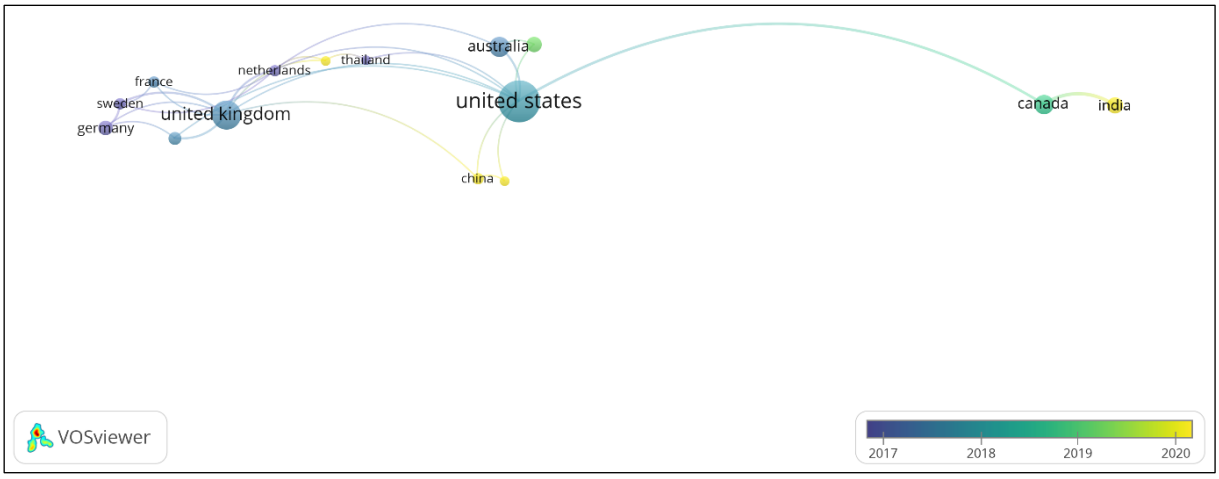

Figure 13. shows the visualization of the co-citation relationship between the countries

Table 5. The publications per country in the research domain

S/N	Country	Documents	Citations	Total link strength
1	Australia	12	83	4
2	Bangladesh	3	22	3
3	Canada	11	327	8
4	China	4	74	3
5	France	4	28	3
6	Germany	6	100	4
7	India	8	53	5
8	Indonesia	7	18	2
9	Italy	5	77	4
10	Japan	4	63	0
11	Netherlands	4	52	7
12	Philippines	4	92	0
13	South Korea	3	14	2
14	Sweden	4	72	6
15	Thailand	3	118	2
16	United Kingdom	24	177	11
17	United States	50	907	12

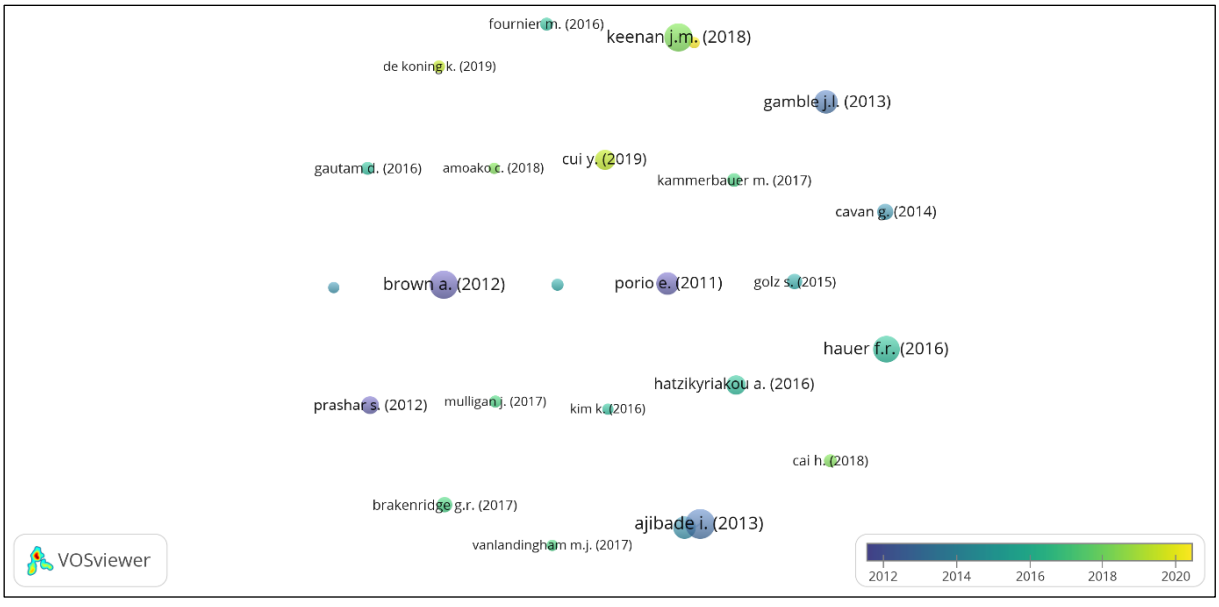

Figure 14. The visualization of authors and years with the most cited articles

Table 6. Articles, citations, and publications year

S/N	Document	Year of publication	Citations	Links
1	Porio E.	2011	69	0
2	Brown A.	2012	106	0
3	Prashar S.	2012	43	0
4	Gamble J.I.	2013	75	0
5	Ajibade I.	2013	118	1
6	Greenberg M.R.	2014	18	0
7	Ajibade I.	2014	69	1
8	Cavan G.	2014	37	0
9	Golz S.	2015	32	0
10	Lamond J.E.	2015	19	0
11	Kim K.	2016	18	0
12	Hatzikyriakou A.	2016	50	0
13	Hauer F.R.	2016	92	0
14	Fournier M.	2016	23	0
15	Gautam D.	2016	23	0
16	Vanlandingham M.J.	2017	18	0
17	Brakenridge G.R.	2017	33	0
18	Mulligan J.	2017	20	0
19	Kammerbauer M.	2017	27	0
20	Keenan J.M.	2018	106	1
21	Cai H.	2018	22	0
22	Amoako C.	2018	17	0
23	Cui Y.	2019	56	0
24	De koning K.	2019	19	0
25	Rumbach A.	2020	17	1

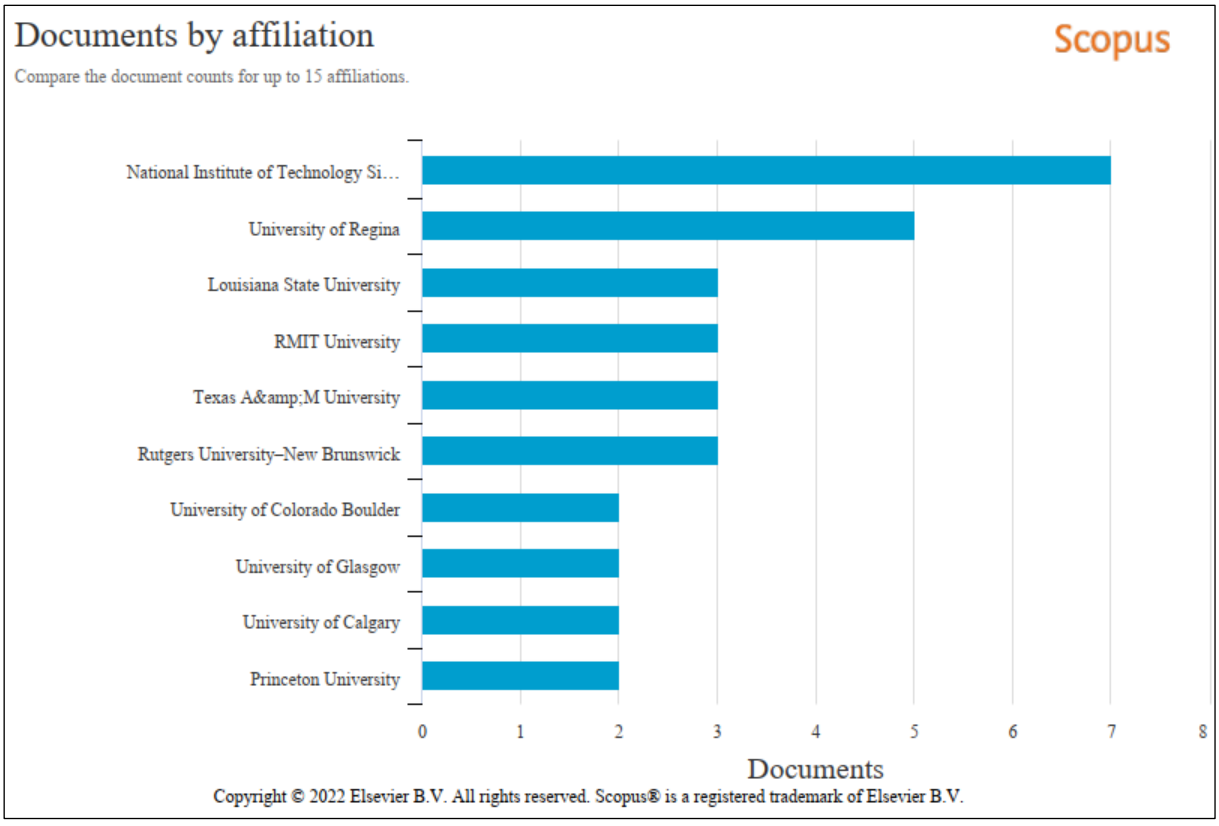

Figure 15. Research institutions with the most impact

11. Impact of Research Institutions

Fig. 15 shows the research institutions with the most impact on the study of flood resilience for housing in terms of documents. The National Institute of Technology Si and the University of Regina has had the biggest influence on flood resilience for housing with 7 and 5 documents respectively.

12. Limitations

The quality of the data gathered will have an impact on this study because it used a data-driven methodology. Additionally, the analysis was only conducted using the Scopus database because it contained the maximum number of papers on flood resilience for housing as opposed to the Web of Science (WOS) database. It should be made clear that this study only looked at English-language materials, and the sources studied were journal articles and conference papers.

13. Conclusions

The study used a sequential method for gathering data from Scopus, choosing a tool, data mining, processing, analysing the data, visualising, and presenting the results, interpreting the data, discussing the results, identifying gaps, setting limitations, and drawing a conclusion. To examine the status and trends of flood resilience for housing research, it offers a scientometric review. The Scopus core collection database yielded a total of 155 bibliographic records. Because subjective biases can affect the results of literature reviews, scientometric techniques can improve the review procedure by utilising computing capacity to help overcome this shortcoming.

Co-authorship network analysis, Research keywords analysis, and Network of countries analysis were used to determine and depict the state and patterns of flood resilience for housing research. As for the contributions and influence of the lead researchers identified in the co-authorship analysis, Dutta, S., Sen, M.K., and Kabir, G. were the top three. While the 33 major keywords in the field include; Adaptation, Adaptive Management, Climate Change, Community Resiliences, Decision Making, Disaster, Disaster Management, Disasters, Ecosystem Resilience, Flood, Flood Control, Flooding, Floods, Hazard Management, Hazards, Housing, Housing Infrastructure, Human, Humans, Hurricanes, Land Use, Natural Disaster, Natural Disasters, Resilience, Risk Assessment, Risk Management, Runoff, Sea Level, Storms, Sustainable Development, Urban Area, Urban Planning, and Vulnerability. These keywords contained both the present trend and the expected future orientations. The United States, the United Kingdom, and Australia are the top three countries in the Network of Countries on Flood Resilience for Housing in terms of publications, citations, and overall link strength. In terms of producing the most research on flood resilience for housing, The National Institute of Technology Si and the University of Regina were the most productive institutions. Additionally, these countries and institutions facilitated international collaboration in research.

Again, several core authors have published the most important research at these most productive institutions. The journals include the International Journal of Disaster Resilience in the Built Environment, Water Switzerland, Procedia Engineering, Top Conference Series Earth and Environmental Science, and Global Environmental Change. In the last ten years, these publications also saw high co-citation frequency and citation bursts, demonstrating they had a significant and ongoing impact on flood resilience for housing research. Research outputs have significantly increased since 2012. In the years that follow, one can anticipate the increase to continue.

In the area of flood resilience for housing research, this study offers useful information for both academics and practitioners. For researchers studying flood resilience in housing, the most important academics, countries, institutions, states of the field, and crucial topics were recognised. By extending the borders and the variety of keywords employed, future studies may broaden the research area. Future researchers, on the other hand, could concentrate on researching each of the keywords in flood resilience for housing to further focus their research. As seen by the articles and authors currently available, this is because the field lacks a substantial amount of literature. It would give a more detailed understanding of the context in which each keyword has been used concerning flood resilience for housing. Subjective biases can influence the outcomes of literature reviews, however, scientometric techniques can enhance the review process by leveraging computing power to assist address this flaw.

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