



# A bibliometric analysis on the research trends of climate change effects on economic vulnerability

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## Abstract

The climate change effect has received a crucial concern from global policymakers as well as academic researchers. The climate change effect is a real-world issue threatening the existence of species and human beings, thus causing the economic vulnerability. Apart from policymakers, academic researchers are showing their concern on the effect of climate change on economic and socioeconomic vulnerability through publishing research articles in the recent decade. In light of the revolution of research articles, this study applied a bibliometric analysis on the academic research articles to explore the publication trends, themes, impacts, and potential scopes for further studies. Both the Scopus and the Web of Science online databases were used to search for journal articles linked to climate change effects and economic vulnerability. The final data of 229 journal articles were analyzed using bibliometric and visualization tools “Biblioshiny” and “VOSViewer.” The findings unveiled an uprising trend in publications and posited several themes, mainly exposure, sensitivity, drought, and flood by means of climate change effects that affect economic vulnerability. Based on the findings and review of literature, several research gaps were identified and offered opportunities for further studies. The policymakers can attribute attention to encouraging more research in several areas in addition to agriculture and coastal regions.

**Keywords** Bibliometric analysis · Climate change · Economic vulnerability · Socioeconomic vulnerability

## Introduction

Climate change effects signify persisting statistical moves of the earth’s climate system that result in new climate patterns (UNFCCC 2011). The industrial revolution has changed the climate system that led to persisting global warming, drought, and flooding over the past century (Khazalah and Gopalan 2019). An agreement within the UNFCCC (the United Nations Framework Convention on Climate Change)

held in 2016 offers scope for all countries to contrivance measures to lessen, adapt, and combat climate change (Bodansky 2016; Dimitrov 2016; Parker et al. 2017; Vanhala and Hestbaek 2016). Climate change is the concurrent threat that situates lives in danger every day. It negatively affects human lives as well as the agriculture sector by changing the quality of water, air, and food supply (Applebaum et al. 2016; Kniel and Spanninger 2017). Approximately a loss of \$2–4 billion per year is projected by 2030 due to climate change issues (WHO 2021). This distressing economic consequence demands local and international strategies to lessen climate change in order to build a resilient system to tackle this change. Idiosyncratically, this threat hence the effect of climate change in economic vulnerability is diverse and global (Defar 2017; Kalhapure et al. 2019). In recent decades, climate change issues have received crucial attention among researchers as well as policymakers. Accordingly, academic researchers have been measuring climate change effects in several research constituents. Economic vulnerability and socioeconomic vulnerability have been crucially investigated in the climate change research domain. Expectantly, a quite number of academic studies have been

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conducted in this research constituent and demand for exploration of research trends and performance.

Climate change in terms is a wide scientific discipline, and measuring research activity on climate change might not be useful. In this study, climate change on economic and socioeconomic vulnerability research activities was explored. The assessment of climate change research activity will enable us to identify the current directions of the study, thus positing future study suggestions. Henceforth, it will also help to identify past research depth and themes on economic vulnerabilities and their measurements. Finally, it will allow exploring the trend and response to the United Nations Framework Convention on Climate Change (UNFCCC) agreement, particularly gauging the scopes and initiatives. The linkage between sustainable development, climate change adaptation (CCA), and disaster risk reduction (DRR) is necessary for community resilience and sustainable livelihood. The preamble to the UNFCCC, adopted in 1992, specifically notes that “Responses to climate change should be coordinated with social and economic development in an integrated manner.” Therefore, acknowledging and promoting the consistency between the Paris Agreement, Sendai Framework, and 2030 Agenda are essential for aligning with a holistic approach (Cubie and Natoli 2022).

Vulnerability can be comprehended as a complicated system that is not easily measurable (Adger 2006; Birkmann 2013). Klein and Nicholls (1999) considered “natural vulnerability” as one of the “socioeconomic vulnerability” determinants. On the other hand, Cutter (1996) regards the “biophysical” and the “social” dimension of vulnerability as an independent component. According to the terminology proposed by Brooks (2003), finally, “social vulnerability may be viewed as one of the determinants of biophysical vulnerability.” Economic or socioeconomic vulnerability refers to climatic events, and exposure refers to the existence of people, livelihoods, infrastructure, or economic, social, or cultural assets in places and settlements that can be adversely affected (IPCC 2014; Liu and Chen 2021).

Several studies have been conducted in relation to climate change and its effect on economic as well as socioeconomic vulnerability (Becerra et al 2020; Brown et al 2020; da Silva et al 2020; Lima and Bonetti 2020; Rana 2020; Sweileh 2020; Zyoud and Fuchs-Hanusch 2020; Kim et al 2021; Shaffril et al 2021; Shahbaz et al 2021; Chen et al 2022). For instance, Chen et al. (2022) shed light on a comprehensive and systematic understanding of ecological vulnerability. Shahbaz et al. (2021) showed a nexus between tourism and environmental degradation, which also concluded with how the research direction is shifting from tourism, energy consumption, and economic growth to eco-tourism and reach environmental sustainability. Shaffril et al. (2021) proposed the guidelines for developing a systematic review, precisely climate change-related

studies. Kim et al. (2021) investigated the research trends in vulnerability studies for the last 20 years. This study proposed a framework to assess the use of the vulnerability concept in disaster risk management and its changes over time using the bibliometric analysis. In light of this evidence, recent studies have been focusing on different areas such as tourism, economic growth, and risk management in response to climate change effects.

Zyoud and Fuchs-Hanusch (2020) mapped climate change research in the Arab world. Meanwhile, Rana (2020) studied to guide future researchers in integrating climate change and disaster resilience. Henceforward, Lima and Bonetti (2020) proposed to analyze the worldwide scientific production on the social vulnerability of coastal populations based on climate change and extreme events. da Silva et al. (2020) investigated the research trends for multidimensional flood risk management under climate changes and also provided guidelines for decision-making in urban dynamics. In a different context, Brown et al. (2020) examined the persistently high energy bills borne by low-income households in the USA using bibliometric analysis. Becerra et al. (2020) investigated the geospatially of climate change perceptions on coastal regions based on bibliometric analysis and also examined the research interactions. Idiosyncratically, Sweileh (2020) assessed the research activity on climate change and health, emphasizing infectious diseases. Within the above shreds of evidence, many research articles are deemed to be published in the last decades. Further, a bibliometric method is considered as the potential and popular method to assess research trends and guide future studies.

Exploring research activity on the effect of climate change on economic vulnerability enables us to classify the national and international input to this area. The application of the bibliometric technique is appropriate to display the research pattern and activity, growth, and volume in a particular area (Donthu et al. 2021; Sweileh 2020). The bibliometric analysis defines as “a quantitative method for examining the knowledge structure and development of research fields through the examination of related publications” (Bamel et al 2021). Predominantly, this approach also detects crucial research themes and active scholars, institutions, and countries for future planning and funding (Sweileh et al. 2017). Further, it will help to find the hot spots discoursed by scholars and the research gaps (Sweileh 2020). A very few studies considered bibliometric study in related to environmental studies, for instance, Priovashini and Mallick (2022) analyzed academic documents to identify the drivers of environmental migration, and Singh et al. (2021) identified the key environmental factors of agricultural practices to demonstrate the scopes for future studies. As per concern, the scarce study focused on climate change and economic vulnerability using bibliometric analysis. Since the studies linked to the effect of climate change on

economic vulnerability are still emerging, these studies can be analyzed to gauge the themes and sub-themes for further research works.

To fill the gap as well as to develop a comprehensive bibliometric study, this study aims to (i) identify the research progression, (ii) assess the influential articles and their themes, (iii) discover the geographical focuses, and (iv) scopes for future studies. The remainder of the structure of this paper is as follows: methods, the bibliometric methods and data extraction; results, findings from bibliometric analyses; discussion, review of recent literature and suggestions for future studies; and conclusion with limitation.

## Methods

Several types of qualitative and quantitative review methods, meta-analyses, systematic literature, and bibliometric analysis are observed in the past studies (Apriliyanti and Alon 2017; Maditati et al. 2018; Zupic and Čater 2015). Although meta-analysis and systematic literature reviews are similar to the bibliometric analysis in nature, it is different in approach. Meta-analysis enables researchers to handle a large number of academic articles and affords a nuanced synopsis of a particular area. However, the academic documents are inclined to be less diverse, and the diversification of prevailing articles and the presence of publication bias may have a contrary effect on the validity of the findings obtained through meta-analysis (Junni et al. 2013). On the other side, the systematic literature reviews applying typical techniques entail a narrow choice of study, thus inclined to include fewer documents for a review (Snyder 2019). Thus, a bibliometric analysis is a mathematical and statistical application to investigate reading documents (Pritchard 1969) in order to evaluate the quality and quantity of published documents perceiving trends of a particular research domain (Sweileh et al. 2017). Idiosyncratically, this method benefits a translucent, reproducible quest and review processes that enhance the reliability of the findings and reduce the subjective bias of the literature review (Maditati et al. 2018; Zupic and Čater 2015).

This study applied the bibliometric method to achieve the scope of the anticipated objectives. In light of the magnitude of Scientometrics for the exploration, analysis, and prediction of academic literature (Martínez et al. 2015), a bibliometric approach was chosen for this study. “Biblioshiny” package under bibliometrix package in the R (Aria and Cuccurullo 2017) and VOSViewer version 1.6.17 (van Eck and Waltman 2010) were used for the data analysis and visualization.

Generally, two categories are mainly manifest in bibliometric techniques: performance and science mapping. Performance analysis explores the contributions of academic

research foundations to an exact area (Cobo and Herrera 2011). It is a standard method in reviews to exhibit the performance of various research elements such as the number of research documents, authors, citations, sources, and publication growth, similar to the profile or background of respondents generally presented in empirical studies, albeit more statistically (Donthu et al. 2021; Durieux and Geveno 2010). Meanwhile, science mapping explores the networks between research fundamentals (Baker et al. 2021) related to intellectual and structural networks within research constituents (Donthu et al. 2021). This approach considers citation and co-citation analysis, co-occurrence, and collaboration networks (Alam et al. 2021). This study considers research influence (citation analysis, co-citation, collaboration) and main research hotspots (e.g., co-occurrence of keywords) within climate change research and economic vulnerabilities.

Citation analysis exposes the knowledge and basis accumulated by scholars that several generations carried through further studies. In other words, citation analysis depicts the relevance and justification of several constituents in accompanying documents. Further, citation analysis deepens the particular research area to the extent of expansion and is pertinent to other databases and areas (Alam et al. 2021; Donthu et al. 2021). The rationale of citation is to represent the influence and impact of published documents measured based on cited by other documents within or outside a particular dataset (Scopus or WoS). Meanwhile, co-citation analysis is an intellectual base that is the source of knowledge evolution (Huang et al. 2020). It comprises an assortment of co-citation in documents that is an “evolutionary network,” and a trajectory of co-citation network is formed by the cited academic documents (Chen 2006).

Collaboration/cooperation is one of the protuberant forms of scientific mapping. Authorship is a basic bibliometric expressive form of a scientific publication; its patterns and trends describe research disciplines’ social and cognitive edifice (Glänzel 2001; Huang et al. 2020). Kretschmer (1994) stated that collaboration is observed through the occurrence of acquaintances between authors of the bibliography was resulted by the number of detected linkages by cooperation in quantity to the number of statistically anticipated ones. Accordingly, it applies to scientific cooperation among industry, institutions, and research collaboration at the local and international level (Glänzel 2001). In the current study, co-authorship and collaboration between affiliated countries are presented in the current study due to available information in the dataset.

Keywords are abstracts of an academic research article field, for instance, the co-occurrence of keywords that appeared in different documents may indicate the main research hotspots of a particular discipline (Hou and Wang 2021). In other words, keywords enable the focus and enhancement of the main content of the research field,

whereby high frequencies of keywords appear to depict the hotspots in the stated research field (Huang et al. 2020).

## Data extraction

The two most popular online databases were used to extract data for this study (Aria and Cuccurullo 2017). To begin with a search in the databases, “climate change” and “economic vulnerability” terms were used following the structured approach (Alam et al. 2021; Cobo and Herrera 2011; Singh et al. 2021) and full. In order to spine all the variances of the term in the research trends, several other terms were included based on the authors’ keywords suggestion (Kantamaneni et al. 2018; Jeganathan et al. 2021; Sahana et al. 2021), such as “climate crisis, climate variability and change, global warming, global temperature rise, global precipitation change, sea-level rise, greenhouse gas emission, and socioeconomic vulnerability.” The results of search terms were veiled from “all fields” (WoS) and “Title, Abstracts and Keywords” (Scopus) till the 18th of September 2021. Table 1 presents the data extraction process for this study. Henceforward, the results were refined by choosing only research articles, selected subject categories, and documents which are written in English. Upon merging both data files, 108 documents were removed, 99 documents due to duplication, and nine documents due to book chapters and conference proceedings as the study only focused on journal articles. The rationale behind removing book chapters and conference proceedings is to keep the analysis within a particular domain that considers only impactful research articles

published after peer-reviewed. Lastly, 222 journal articles were considered for bibliometric analysis and visualization. Subsequently, several impactful recent journal articles, as well as grey literature, were thoroughly reviewed to discuss and comprehend the scopes for future studies.

## Findings

### Performance Analysis

Table 2 presents the descriptive statistics of understudy research documents linked to the effect of climate change on economic vulnerability. Subsequently, the publication is considered as productivity, and citation measures refer to the influence and impact (Donthu et al. 2021). Meanwhile, citation per document and *h*-index cartels both publications and citations to evaluate the research performance (Durieux and Gevenois 2010). Based on the results, a total of 120 journal sources were used to publish 229 research documents from 1990 to the present, with an average of seven documents in a year. Total 814 authors had written these documents, while 17 documents were written by sole author and 212 documents by multi-authors. Almost four authors ( $CI=3.76$ ) cooperated to produce a document with a value of 0.72 collaboration coefficient.

IPCC Third Assessment Report (2001), Climate Change 2001, is an assessment of scientific and socioeconomic information on climate change by the Intergovernmental Panel on Climate Change (IPCC), a significant report for

**Table 1** Data extraction process

Selection of key topic (Date: 18/9/2021) (Climate change to economic vulnerability)	
<p><b>Online database</b> (The Web of Science)</p> <p><b>Input search query</b> (full records)            (“climate change” OR “climate crisis” OR “climate variability and change” OR “global warming” OR “global temperature rise” OR “global precipitation change” OR “sea level rise” OR “greenhouse gas emission”) AND (“economic vulnerability” OR “socioeconomic vulnerability”)</p> <p><b>Result:</b> 242 documents</p> <p><b>Refine:</b>            Document types: articles            Subject categories: Environmental sciences, Environmental studies, geosciences multidisciplinary, green sustainable science technology, public environmental occupational health, development studies, economics, regional urban planning, social sciences interdisciplinary            Language: English</p> <p><b>Refined result:</b> 173 documents</p> <p><b>Extracted:</b> bibtex format            Duplicate: 99 documents            Filtered documents on “Biblioshiny” package            Total data for analysis: <b>229</b></p>	<p><b>Online database</b> (The Scopus)</p> <p><b>Input search query</b> (Titles, keywords, abstract)            (“climate change” OR “climate crisis” OR “climate variability and change” OR “global warming” OR “global temperature rise” OR “global precipitation change” OR “sea level rise” OR “greenhouse gas emission”) AND (“economic vulnerability” OR “socioeconomic vulnerability”)</p> <p><b>Result:</b> 243 documents</p> <p><b>Filter:</b>            Document types: articles            Subject categories: Environmental sciences, social sciences, earth and planetary sciences, agricultural and biological sciences, energy, economics, econometrics and finance, business, management and accounting            Language: English</p> <p><b>Refined result:</b> 164 documents</p>

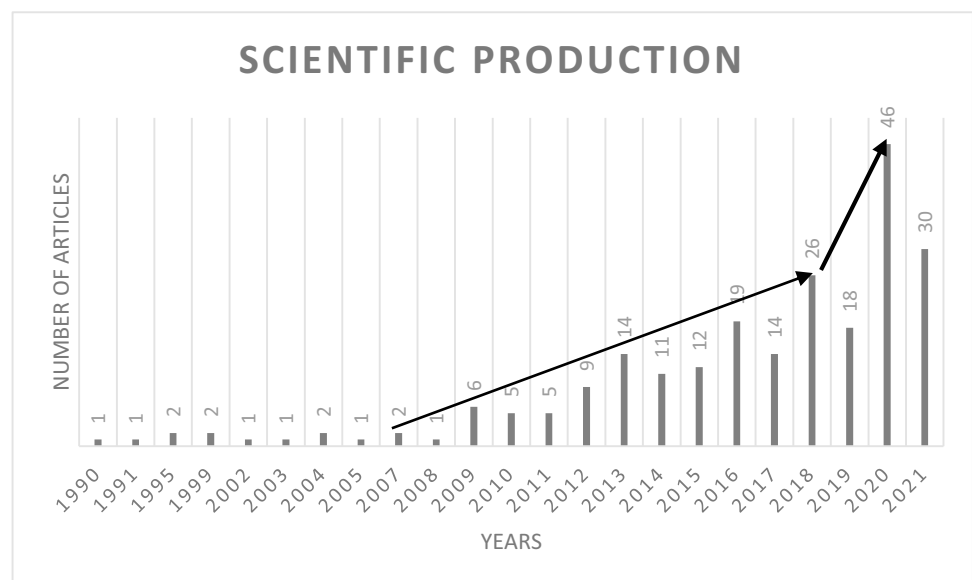
**Table 2** Descriptive results

Main information	Description	Results
Publication sources	Frequency distribution of sources as journals	120
Documents (D)	Total number of documents	229
Authors (A)	Total number of contributing authors	814
Single-authored documents (SD)	Total number of sole authored documents	17
Multi-authored documents (MD)	Total number of co-authored documents (D-SD)	212
Total active years (T)	Total periods of publication by research area	31
Productivity per year (PY)	Total documents/number of active years (D/T)	7.39
Total citations (TC)	Total citations received by documents	5,156
Average citations/year (AC)	Average citations per year of publications (TC/T)	166.32
Collaboration index (CI)	The extent of collaboration $\{(A/D)/D\}$	3.76
Collaboration coefficient (CC)	Standardizes the extent of author cooperation between 0 and 1 $\{1-(D/A)\}$	0.72
<i>h</i> -index	<i>h</i> number of documents cited at least <i>h</i> times (an evaluation of influence)	31
<i>g</i> -index	<i>g</i> number of documents cited at least <i>g</i> <sup>2</sup> times (an evaluation of impact)	33

climate change. The IPCC was established in 1988 by the United Nations Environment Programme (UNEP) and the UN's World Meteorological Organization (WMO). The IPCC is organized into three working groups (WG): WGI, Scientific aspects of climate; WGII, Vulnerability, consequences, and options; and WGIII, Limitation and mitigation options. Climate Change 2007, the Fourth Assessment Report (AR4) was published in 2007 and is the fourth in a series of reports intended to assess scientific, technical, and socioeconomic information that concern climate change, its potential effects, and options for adaptation and mitigation. The Fifth Assessment Report (AR5) of the United Nations Intergovernmental Panel on Climate Change (IPCC) is the fifth in a series of such reports and was completed in 2014.

Figure 1 displays the publication phases is related to climate change constituents. In 1992, UNFCCC (United

Nations Framework Convention on Climate Change) formed in "Earth Summit," thus addressing the climate change consequences (UN 2020). Hence, it received the attention of academic researchers in 1990. Yohe (1990) has published the first and only document linked to climate change effect on economic vulnerability, entitled "The cost of not holding back the sea: Toward a national sample of economic vulnerability." Predicting future costs caused by the sea-level rise led by greenhouse emissions was demonstrated as economic vulnerability (Yohe 1990). The gradual growth in the publication has begun from 2009 to the present. This trend unveiled the potential attention of academic researchers relating to the climate change effect on economic vulnerability. In other words, academic researchers are crucially considering and demonstrating the climate change issues impacting economic vulnerability in the recent decade.

**Fig. 1** Publication trend



## Science mapping

### Research influence

Table 3 displays the top 10 documents based on receiving both global and local citations. A review paper that discussed the benefits of biofuels from economic, environmental, and energy security perspectives (Demirbas 2009) received the highest global citation (677 total citations with an average of 52 citations per year). Meanwhile, Brouwer et al. (2007) examined the complex linkage between poverty, vulnerability, and environmental risk in Bangladesh and received the highest local citations (11) and second-highest global citations (256). Based on their findings, less ingress to productive natural assets and with lower earnings households encounter higher exposure to flooding risk. Meanwhile, Hagenlocher et al. (2013) unveiled high percentages of young, illiterate, unemployed, and household workers that tend to posit higher vulnerability to dengue fever in the eastern, north-eastern, and western part of Cali in Colombia and received second-highest local citations (4) and 79 global citations. By demonstrating the coastal communities, especially those engaged in fishing and agriculture, were highly sensitive to driven threats of climate change, Salik et al. (2015) ranked third-highest local cited (4) that also received 46 global citations. On the other hand, Harlan et al. (2013) assessed neighborhood scores based on three factors, socioeconomic vulnerability, unvegetated area, and elderly/isolation, on deaths caused by heat exposure in Arizona from 2000 to 2008, and it received third-highest global citations (207 and an average of 23 per year). These highly cited documents elucidated the socioeconomic vulnerability exposure by means of several factors such as dengue fever, flood, and climate change effect.

Figure 2 presents the co-citation network in academic published documents related to climate change and economic vulnerability. Each node represents an author of a cited document; the larger node represents a greater number of citations received by that document. The circle denotes the nodes' betweenness centrality greater than or equal to 0.1 (Huang et al. 2020).

A document which was written by Cutter et al. (2003) is the most influential document cited by many documents within the selected data sample and displayed the largest network based on the map. This document constructed a social vulnerability index (SoVI) for the USA using 1990 data. The authors reduced variables to 11 independent variables from 42 variables using the factor analytic approach that provides overall scores of vulnerabilities often are diverse for each country. They also stated that vulnerability to environmental hazards refers to the potential for loss as losses diverge geographically, over the period, and between different social groups. In the same cluster, Turner et al. (2003) proposed a conceptual framework of the vulnerability of united human–environment systems with complex and diverse relationships. Hence, Adger (2006) reviewed research backgrounds of vulnerability to environmental change and challenges to integrating the domains of adaptation and resilience in further research. This document is deemed to be frequently co-cited in this cluster.

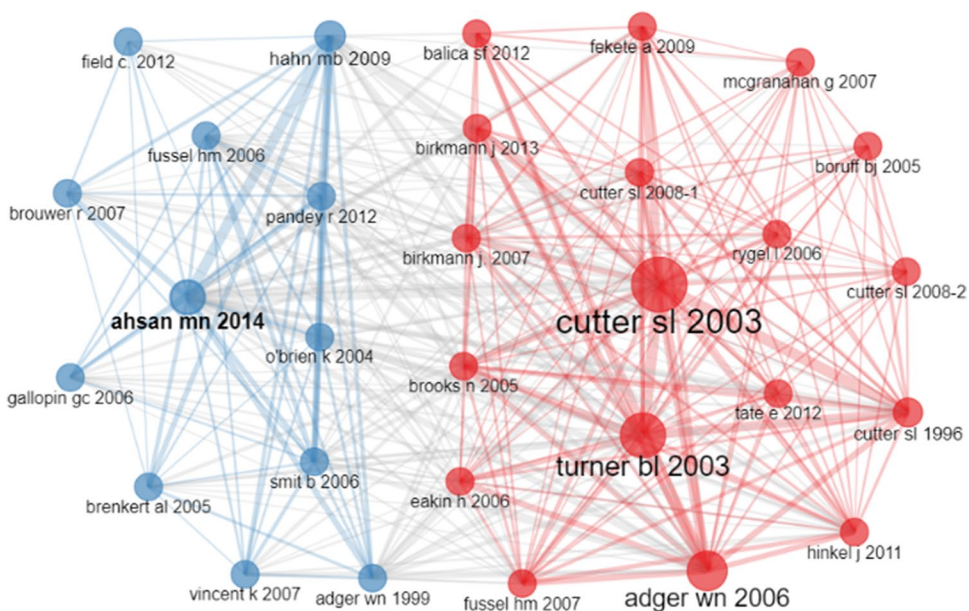
In another cluster, an impactful document was written by Ahsan and Warner (2014), which developed a socioeconomic vulnerability index (SeVI) for climate change exaggerated communities in the southwestern coastal area of Bangladesh. They demonstrated economic, social, and disaster frequency as more influential indicators of adaptive capacity, sensitivity, and exposure, respectively. Another top-ranked document written by Brouwer et al. (2007) is also

**Table 3** Top 10 articles based on global and local citations

Rk	Article	TGC	TGC/Y	Article	TLC	TGC	Ratio %
1	Demirbas A, 2009, Appl Energy	677	52.08	Brouwer R, 2007, Risk Anal	11	256	4.30
2	Brouwer R, 2007, Risk Anal	256	17.07	Hagenlocher M, 2013, Int J Health Geogr	4	79	5.06
3	Harlan SI, 2013, Environ Health Perspect	207	23	Salik Km, 2015, Ocean Coast Manage	4	46	8.70
4	Warner K, 2010, Nat Hazards	171	14.25	Sorg L, 2018, Nat Hazards	4	25	16.00
5	Hall Jw, 2005, Nat Hazards	154	9.06	Mazumdar J, 2016, Nat Hazards	3	25	12.00
6	Ahsan Mn, 2014, Int J Disaster Risk Reduct	124	15.5	Malakar K, 2017, Clim Dev	3	17	17.65
7	Handmer Jw, 1999, Mitigation Adapt Strateg Global Change	119	5.17	Sam As, 2017, Nat Hazards	3	15	20.00
8	Holand Is, 2011, Nor Geogr Tidsskr	112	10.18	Felsenstein D, 2014, Nat Hazards	2	49	4.08
9	Kienberger S, 2009, Nat Hazards Earth Syst Sci	96	7.38	Melkonyan A, 2014, Sci Total Environ	2	5	40.00
10	Torresan S, 2012, Nat Hazards Earth Syst Sci	90	9	Kienberger S, 2014, Int J Health Geogr	2	49	4.08

(s): Rk. rank, TGC total global citations, TGC/Y total global citations/publication periods, TLC total local citations, Ratio=(TLC/TGC) \*100; local citations = number of citations received in the particular database

**Fig. 2** Co-citation network map. Note: the color of nodes represents the different clusters or groups

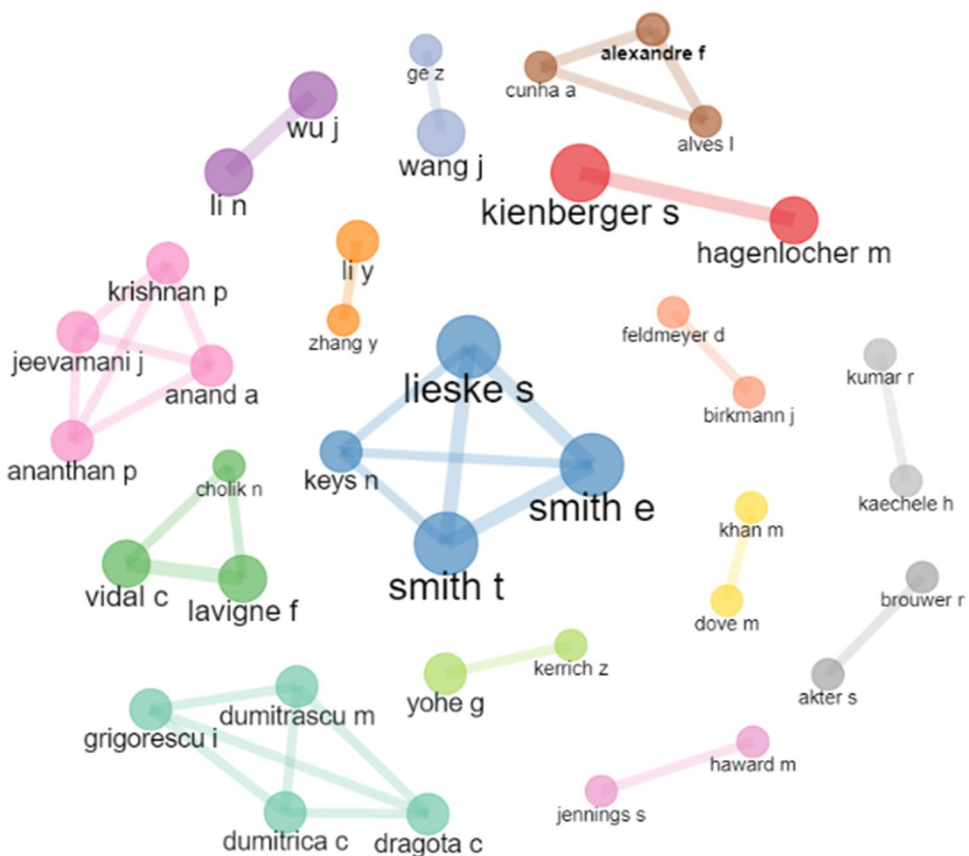


co-cited in this cluster, which discussed the complex linkage between poverty, vulnerability, and environmental risks.

Figure 3 displays the co-authorship of documents relevant to economic vulnerability and climate change. The graph shows a total of 10 clusters and exhibits a considerable

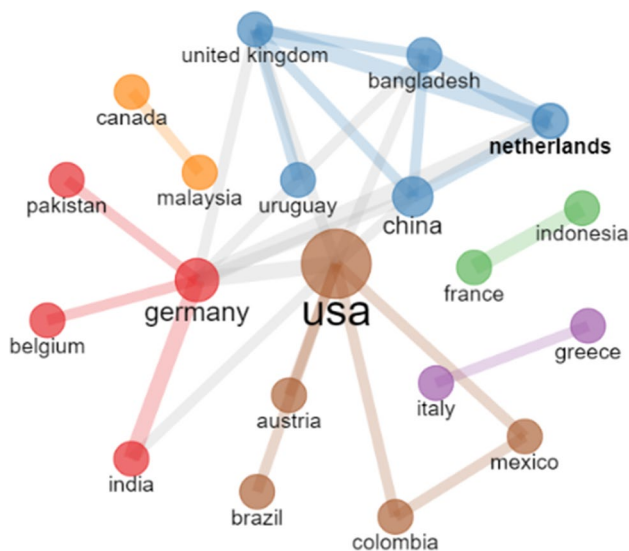
strong collaboration among authors within the clusters. Three remarkable clusters represent a wider range of cooperation between authors. Three clusters represent four authors that collaborated to publish documents. The greatest number of publications produced by blue-colored cluster

**Fig. 3** Authors collaboration network. Note: each node represents an author in the map, and the bigger node depicts the greater number of publications written by the author. The color of nodes represents a cluster, and edge connections display the cooperation between authors, and the closer cooperation is represented by a thicker line



is represented by Lieske S, Smith T, Smith E, and Keys N. They have produced four documents and affiliated in University Sunshine Coast, Brisbane, Queensland, Australia. Another cluster represented by Dragota C, Dumitrica C, Dumitrascu M, and Grigorescu I have produced two documents affiliated with the Romanian academy. The pink-colored cluster represents Anand, Krishnan, Ananthan, and Jeevamani affiliated in various institutions produced one document.

The collaboration network within affiliated countries is exhibited in Fig. 4. Accordingly, the affiliated country collaboration represents the cooperation of authors at the international level. The figure demonstrates the largest network among the USA, Italy, Austria, Brazil, and Columbia, where the USA displayed the highest collaboration. Similarly, China, the Netherlands, Bangladesh, UK, and Uruguay show another extended collaboration in publishing documents related to climate change and economic vulnerability. Meanwhile, Germany is deemed to have stronger collaboration with India, Pakistan, and Belgium. These results illustrate that the effect of climate change on economic vulnerability has been carried out at the international level to produce extensive and effective research outcomes. Cooperation between authors, institutions, and countries carries out diverse and most potential research outcomes. More significantly, cooperation between countries, especially between developed, developing, and least developed countries, further it forms an opportunity to share and learn consequences regarding the issues and opportunities to provide competent and robust solutions. Further, it helps to mitigate the gaps and boundaries between countries.



**Fig. 4** Collaboration within affiliated countries. Note: the color of nodes represents the different clusters or groups

## Main research hotspots

The academic research co-occurrence network map for economic vulnerability and climate change was strained to scientifically quantify the core research hotspots. In Fig. 5, each node presents a keyword, the size of the node displays the frequency of keyword appearance in the documents, and the thickness of lines represents the higher frequency of keyword co-occurrence. In addition, the thickness of lines represents the amount of nearness of the connection.

As observed in Fig. 5, climate change has the greatest frequency as the topic field of search (115 times). At the same time, economic vulnerability appeared only 105 times, even it is another subject of the search field in the sample. Thus, the economic vulnerability appeared 17 times, while socioeconomic vulnerability appeared 32 times. The figure exhibits a cluster with relevant research themes with variables. For instance, the theme climate change mainly adopted factors such as socioeconomics, status, vulnerability and factors, climate effect, human, extreme event, and sustainable development (Cutter et al. 2003; Hagenlocher et al. 2013; Harlan et al. 2013). Further, this cluster mostly analyzed data using spatiotemporal and principal component analysis. Meanwhile, the cluster led by vulnerability denotes variables like drought, climate change adaptation, hazard management and assessment, flood, risk assessment, and livelihood (Ahsan and Warner 2014; Brouwer et al. 2007).

Another theme led by socioeconomic conditions relates to adaptive capacity, exposure, sensitivity, risk (Salik et al. 2015), and decision-making that applied spatial analysis focused in coastal zone predominantly Australia. Focusing on Bangladesh, adaptive management gained attention with related variables such as disaster management, natural disaster, and adaptation linked to climate change. Figures 6 and 7 present the thematic evolution of keywords in climate change and economic vulnerability research constituents periodically. By observing and demonstrating the findings from keywords co-occurrence, this study summarized the research hotspots for this particular topic as below;

- 1) The research hotspots related to climate change mainly focused on flood risk, adaptation, and sea-level rise from 1990 to 2015. Since the UN brought the climate change issue in the early 1990s, academic researchers have attempted to investigate its effect on sea level thus flood risks. Hence, it became a global concern to both policymakers and academic researchers.
- 2) Followingly, the concern over climate change and its effect on vulnerability, including economic, social, and socioeconomic, cater more academic research starting from 2016. In between 2016 and 2018, researchers focused on various topics linked to climate change such as drought, exposure, adaptive capacity, risk, and tem-





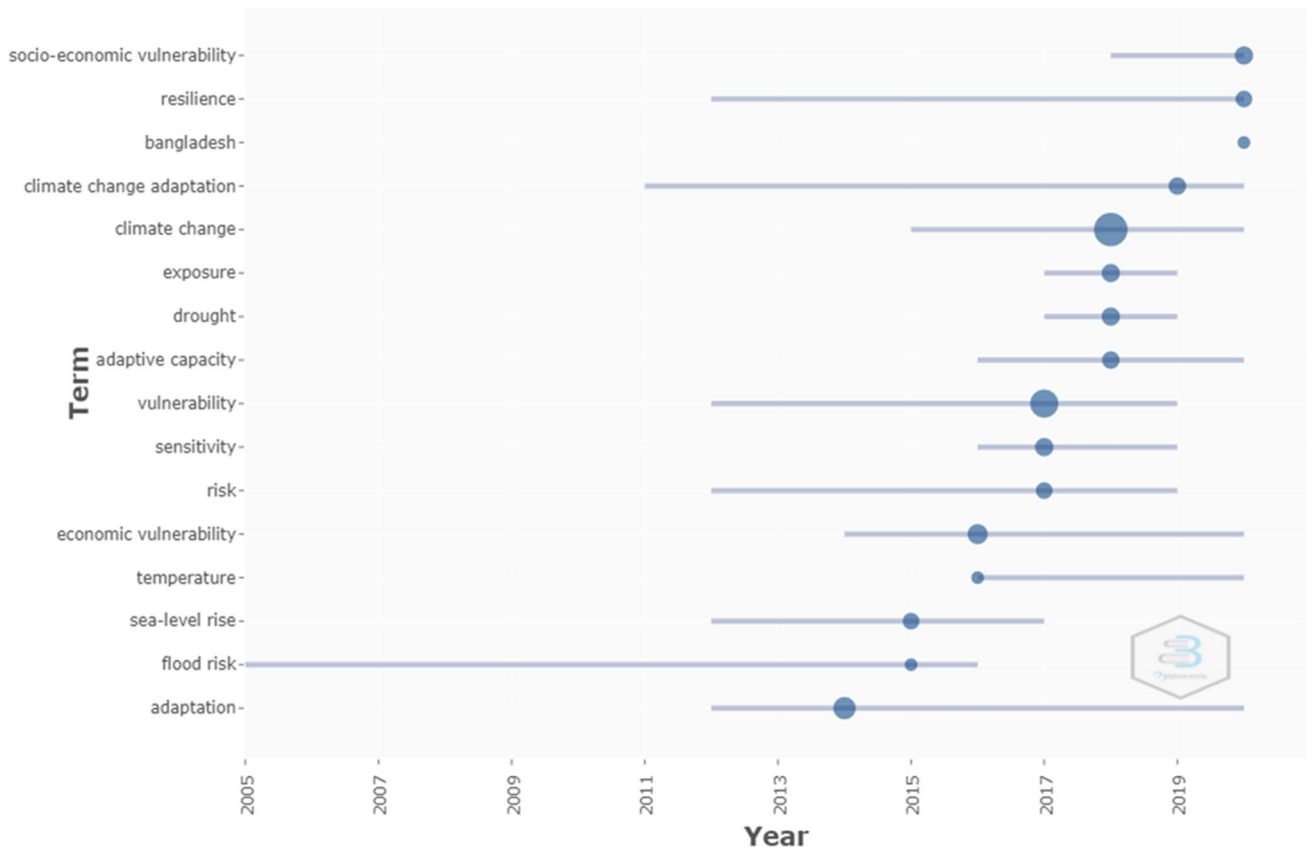
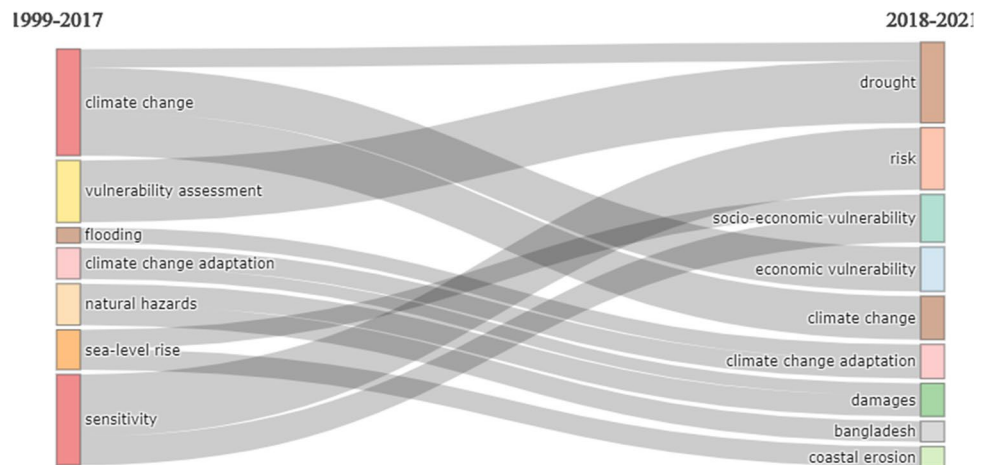


Fig. 6 Trend topics showed from 2005 to 2020 as the publication growth is observed from 2005

Fig. 7 Thematic evolution of keywords represents the themes of research constituent



economic activities and their impact on climate change. This study also emphasized emergency management is based on the reality that no matter how thorough investigations and mitigation of changing climate. In the following year, Wheaton and Maciver (1999) demonstrated an adaptation framework to enhance benefits and reduce economic and social vulnerabilities persuaded by climate change in the same year. Wheaton and Maciver (1999) also

clarified the linkages between climate change adaptation and mitigation based on the framework of the IPCC Working Group. Hence, the most recent studies emphasized the impact of sea-level rise, flood risk, climate change mitigation, and adaptation strategies to reduce the effects of climate change (Miller 2018, Hummel et al. 2021, Han and Mozumder 2021, Wu 2021, Neumann et al. 2021, Martyr-Koller et al. 2021). Earlier researchers focused on

the impact of sea-level rise rather than flood risk in the 90 s (Yohe 1990, Yohe 1991, Turner et al. 1995).

Another key topic is climate change vulnerability for this present research, where the contemporary researchers are showing interest in the socioeconomic aspect (Sahana et al. 2021, Biswas and Nautiyal 2020, Jeganathan et al. 2021, Li et al. 2021, Sreya et al. 2021). The current global temperature is rising, reflecting the present research trend where many studies focus on drought, temperature, and risk of changing climate (Mdungela et al. 2017, Dumitraşcu et al. 2018). Another significant issue is adaptive capacity, adaptation, disaster management, and resilience to reduce the impact of climate change, which is necessary towards sustainable livelihood for society's well-being. In light of these findings, the present researchers are trying to find the necessary solutions to build a resilient and sustainable community to fight against climate change (Fazey et al. 2021; Islam et al. 2021, Haas et al. 2021, Howarth and Parsons 2021, Son et al. 2021, Mensah et al. 2021).

Additional research direction was identified regarding climate change mitigation is biofuel. The topmost cited article is a critical review of biorefineries for biofuel highlighted by Demirbas (2009). The top-cited research paper by Brouwer et al. (2007) assessed socioeconomic vulnerability in terms of flooding and environmental risks in Bangladesh. Following, Ahsan and Warner (2014) developed a socioeconomic vulnerability index (SeVI) to assess climate change risks in southwestern coastal Bangladesh. Similarly, Hall et al. (2005) based on flood vulnerability assessment in England and Wales. Alternative interesting research direction is an environmental health issue; for example, Harlan et al. (2013) assessed the vulnerability based on heat-related mortals. Warner et al. (2010) proved that socioeconomic vulnerability could be affected by socioeconomic conditions and political conditions based on climate change and environmental degradation. Handmer et al. (1999) found the societal vulnerability due to climate change based on food security.

Low-lying coastal areas are the most vulnerable regions due to sea-level rise. Bangladesh as a geographical location has been discussed and linked to climate change researchers because the country is more exposed to the Bay of Bengal, where the Bangladeshi coast are going to be more affected due to sea-level rise and inundation (Bell et al. 2021, Mohiuddin et al. 2021, Rahman et al. 2021). One of the highly cited research is by Torresan et al. (2012), which assessed the coastal vulnerability to climate change hazards for the North Adriatic Sea.

The major climate change factors are socioeconomic status, human, extreme events, climate effect, and sustainable development. The reason of socioeconomic status is the crucial factor because poor people are the most vulnerable group due to climate change impacts because of the less adaptive capacity. When a disaster occurs, poor people

are unable to recover because of limited resources (Lome-Hurtado et al. 2021, Hallegatte et al., 2020). A small section of human activities threatens world species with changing climate change. Moreover, the present research has a focal point of economic vulnerability. Human beings suffer broadly due to massive economic losses due to global temperature and sea-level rise (Nishiura et al. 2020, Geest and Warner 2020).

Key methodologies are being used to assess vulnerability and risk, such as flood risk assessment, coastal vulnerability index, erosion vulnerability assessment, and climate change vulnerability assessment, for instance, social vulnerability index, socioeconomic vulnerability index, economic vulnerability index, asset, and infrastructure vulnerability assessments are some of the popular assessment methods to investigate the climate change vulnerability in terms of economic aspect (Kantamaneni 2016; Kantamaneni et al. 2018; Oo et al. 2018; Spielman et al. 2020). The economic vulnerability index is significantly implemented in the UK by Kantamaneni (2016, 2018). Kantamaneni et al. (2018) measured economic vulnerability by assessing the coastal vulnerability index in the coastal areas of the UK. Kantamaneni (2016) assessed the coastal infrastructure vulnerability, which can purpose as a primary susceptibility appraisal from which a map of probable intensities of vulnerability can be generated to allow cost–benefit analysis. On the other hand, Shaha et al. (2021) had assessed both social and economic aspects to measure vulnerability to climate change-induced natural disasters; the study also calculated the composite socioeconomic vulnerability index (SeVI). Noy and Yonson (2018) showed the determinants of economic vulnerability to natural hazards; the number of fatalities and the cost of damage are the main proxies for disaster risk and hazard characteristics; some directly use proxies for the hazards, such as wind speed or the magnitude of an earthquake, and GDP per capita as a proxy for economic development, which is negatively correlated with the fatalities across tropical cyclone, drought, and flood hazards.

Lieske, Smith, Smith, and Keys have published the maximum publications collaboratively, and their research was based on socioeconomic vulnerability to climate change on the Australian coast (Smith et al. 2015, 2016). Previous economic vulnerability of climate change-related studies identified that Bangladesh, due to coastal vulnerability and more exposure due to sea-level rise and the coastlines of Bangladesh, projected to increase with the sea-level rise through 2100 (Bell et al. 2021). Researchers have widely emphasized that Bangladesh is related to climate change studies as it is one of the most vulnerable geographical locations. Thus, scarce studies on other low-lying countries are also vulnerable due to climate change and rising sea levels, such as Maldives (Gussmann and Hinkel 2021), Sri Lanka (Wickramasinghe et al. 2021), and Asia Pacific Island countries



— Fiji, Solomon Island, Vanuatu, Tuvalu, Samoa, Nauru, Palau, and Marshall Islands (McNamara et al. 2021; Shea et al. 2021) and the remaining islands in a different part of the world. The present bibliometric review analyzed that future studies need to be more extensive research on remaining low-lying countries. The present research has also found that present researchers have emphasized the link between climate change and economic vulnerability, which is crucial for a potential scope for future development and adaptation (Jeganathan et al 2021; Sahana et al 2021; Sun et al. 2021). Authors from the USA, India, and China are conducting more research on the economic impact of climate change and especially economic vulnerability assessments whether these countries are the major emitters of greenhouse gas emissions. It has appeared that the major players are ready to take the initiative of clean energy, renewable energy, carbon trading, or zero-emission policy to save the environment (Cail and Criqui 2021; Nong et al. 2021). Based on the bibliometric analysis, the greatest frequency as the topic after climate change and vulnerability is adaptation. Adaptation strategies are necessary to reduce the impact of climate change (Ahmed and Turchini 2021) which is a major reason to conduct more research on this topic. After that, drought is another crucial topic that major researchers were focused on due to temperature rises. Sea-level rise and flooding are major topics that the researchers emphasized. Due to temperature rises, the sea-level rise and coastal flooding have become common phenomena because of melting the ice glaciers (Kushawaha et al. 2021). Scientists have been recurrently warning about extreme weather events, which will continue to increase due to global warming (IPCC 2014; Anser et al. 2020; Islam et al. 2021; Li et al. 2021; Tebaldi et al. 2021; Wang et al. 2022).

Climate change-related research works mainly focused on flood risk, adaptation, and sea-level rise between 1999 and 2015. Flood risk, sea-level rise, and adaptation are interconnected topics. Climate change, consequently, affects the sea-level rise, where adaptation strategies are a necessity to reduce the impact of climate change (Butler et al. 2021). However, since 2016, the socioeconomic or economics of climate change is becoming a top priority for climate change researchers (Roggero et al. 2019). Currently, the research trend is shown that resilience, drought, damages, and climate change adaptation are more emphasized in the majority of the climate change research.

## Future research

Economic vulnerability to climate change is an emerging research area that can be developed and extended by groundbreaking research and policies. Based on the bibliometric findings and literature review, socioeconomic vulnerability

has been broadly focused on climate change studies. The present research has emphasized only the economic aspect; however, this phenomenon has not been thoroughly or solely measured by climate change issues. Therefore, future studies can focus on the economic vulnerability exposure by means of climate change effect. Further, future researchers may extensively expand climate change vulnerability based on physical, environmental, and social aspects. Earlier vulnerability studies were focused on physical and environmental aspects, while the socioeconomic dimension received potential attention in the recent decade (Giupponi and Biscaro 2015). Subsequently, bibliometric findings showed a lack of research in small island countries, especially Pacific Island countries, which are vulnerable due to climatic and coastal hazards. This is a research gap and suggests conducting more research in coastal regions. Based on the co-occurrence and collaboration mapping, the majority of studies were conducted by European and American researchers, while only a few Asian countries (China, Indonesia, Malaysia, India, Pakistan, and Bangladesh) focused climate change effects on vulnerability; the majority of underdeveloped countries lacked vulnerability studies. Thus, future researchers can include Fiji island, Haiti, Caribbean islands, and other small islands to identify the potential damages and risk exposure by climate change effect. Besides, African countries, Ghana, Congo, Zimbabwe, Kenya, Uganda, and Tanzania; South Asian countries, Nepal, Bhutan, and Afghanistan; Southeast Asian countries, Vietnam, Cambodia, and Thailand can be observed in further studies to measure the climate change effect and exposure to economic vulnerability, while most of these tropical countries are the great producer of agricultural crops. On the other hand, Latin American countries, especially Brazil and Argentina, can be focused for researchers to examine the economic vulnerability exposure by means of climate change effect. Overall, it is important to measure and visualize the local economic vulnerabilities caused by the global climate change effect.

## Limitations

The present study has limitations because of the extensive bibliometric data in the future, which may evolve in an unexpected direction and cannot predict future research trends (Kim et al. 2021). The current study investigated the trend of economic vulnerability in climate change studies. However, publications outside of the Web of Science and Scopus database and corresponding citations were excluded in the current study, which may cause to missing of some influential articles. Future researchers can include other academic databases such as ResearchGate, Google Scholar, PubMed, DOAJ, and ProQuest for extensive research for further analysis. Additionally, this study only opted for journal articles by eliminating book chapters and conference proceedings.



Future studies may comprise these databases and documents to deliver comprehensive analysis and dodge biases. Finally, keywords selection is a critical process for any study; as a result, it might not be able to provide all important as well as focused studies in the database. Future studies may explore more using some software filtering to learn more search keywords to capture maximum data.

## Conclusion

The Sustainable Development Goals (SDGs), also known as Global Goals, closely align with disaster risk reduction (DRR), which involves understanding the scientific bases of a variety of natural and socioeconomic processes, capacity building of local authorities, communities, and other stakeholders for DRR. The SDG-13 on climate action has acknowledged significant targets to be fulfilled by 2030, including improving the understanding of disasters and enhancing education, awareness, adaptive capacity, adaptation, and resilience (Mal et al. 2018). The present study is aligned with the UNFCCC framework and SDGs to reduce the impact of climate change which can be implemented globally for future researchers.

A bibliometric analysis was applied to discover the publication trends, trending themes, influential publications, and potential research scopes for future studies to fill the gaps in methodological literature reviews on climate change effects on economic vulnerability. The findings acknowledged the growth in the publication in recent years, while several themes such as socioeconomic vulnerability were broadly investigated considering the disasters such as drought, flood, exposure, adaptation capacity, and sensitivity. Besides, several areas were focused on climate change effects on economic vulnerability, such as agriculture and coastal regions. Henceforth, trending topics have revealed economic vulnerability as an emerging topic since 2015. More so, the majority of studies have been focusing on more economic aspects, such as economic and socioeconomic vulnerability and damages which indicate that the economic loss and damage is a major concern for the present researchers to reduce the negative impact of climate change-induced extreme events. In brief, academic scholars have started to focus on the climate change issues that lead to economic vulnerabilities along with other challenging issues. Climate change issues have received significant attention from policymakers and academic scholars who are trying to develop and identify solutions to lessen the negative effect of climate change. Overall, quite a number of studies have been carried out to recognize the causes, challenges, and adaptations of climate change and their impacts on economic vulnerabilities.

Based on the bibliometric findings, academic publications grounded that the area is well-founded but not widely merged to provide potential solutions to climate change and its effect on economic vulnerabilities. However, the discipline is emerging based on the enlargement of climate change-related factors, socioeconomic and environmental vulnerabilities. The findings enabled the classification of several research gaps and established the scopes for future studies. Besides, the findings subsidize the knowledge as a reference for future studies. The current study can further assist researchers in profoundly understanding economic vulnerability through the climate change effect. The study also assists in knowing the vulnerability concept in terms of disaster risk reduction (DRR), disaster management, and climate change adaptation (CCA). Henceforward, the findings may assist experts with their suitable and operative approaches to augment their competence and performance. Lastly, policymakers may measure the trend and advanced enactment and adaptation policies to minimize economic, social, and environmental vulnerabilities caused by rapid climate change issues.

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**Data availability** The lead author confirms that all relevant data are presented in the article.

## Declarations

**Ethics approval** Not applicable.

**Consent to participate** Not applicable.

**Consent for publication** Not applicable.

**Conflict of interest** The authors declare no competing interests.

**Data transparency** The lead author confirms that the manuscript is an authentic, precise, and transparent of the study being reported.

The authors confirm that this manuscript has not been published elsewhere and is not under consideration by another journal or has not been submitted to a preprint server prior to submission on ESPR.

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