

Article

An Analysis of Publications on Climate Change Communication Using a Bibliometric Lens

Khairul Hafezad Abdullah ¹ 

¹ Senior Lecturer, School of Business Management, UUM College of Business, Universiti Utara Malaysia, Malaysia. ORCID: 0000-0003-3759-6541. E-mail: khafezad@uum.edu.my

ABSTRACT

The effectiveness of climate change communication is incommunicado when there is a lack of comprehensive efforts to increase public knowledge and encourage proactive steps. The main objective of this study is to examine the evolving trends in publication and the developmental trajectory within climate change communication research, development, and publications. This study utilised datasets from the Scopus and Web of Science (WoS) databases, which were further analysed using the ScientoPy and VOSviewer. The findings suggest that there has been a notable increase in the number of publications since 2008, particularly in the WoS database, indicating a growing recognition and a more focused endeavour by researchers to delve into climate change communication. The most frequent keywords employed by past researchers were “Climate Change”, “Climate Change communication”, and “Climate communication”. The emergence of keywords such as “social media”, “science communication”, “environmental communication”, “framing”, and “climate action” in the year 2020 onwards signifies their recent prominence. Examining research growth and trends in climate change communication provides valuable insights into the advancements, recurring topics, and prominent individuals within this discipline. In a nutshell, the current study highlights the significance of proficient communication in tackling the intricate issues associated with climate change that can be a reference to potential readers and future researchers keen on this domain.

Keywords: climate change communication; climate communication; science communication; social media; climate action.

RESUMO

A eficácia da comunicação sobre mudanças climáticas fica comprometida quando há uma falta de esforços abrangentes para aumentar o conhecimento público e incentivar medidas proativas. O principal objetivo deste estudo é examinar as tendências evolutivas na publicação e a trajetória de desenvolvimento na pesquisa, desenvolvimento e publicações sobre a comunicação de mudanças climáticas. Este estudo utilizou conjuntos de dados das bases Scopus e Web of Science (WoS), que foram posteriormente analisados utilizando ScientoPy e VOSviewer. Os resultados sugerem que houve um aumento notável no número de publicações desde 2008, especialmente na base de dados WoS, indicando um reconhecimento crescente e um esforço mais focado por parte dos pesquisadores para explorar a comunicação de mudanças climáticas. As palavras-chave mais frequentemente empregadas por pesquisadores anteriores foram “Mudanças Climáticas”, “Comunicação de Mudanças Climáticas” e “Comunicação Climática”. A emergência de palavras-chave como “mídias sociais”, “comunicação científica”, “comunicação ambiental”, “enquadramento” e “ação climática” a partir do ano de 2020 sinaliza sua recente proeminência. Examinar o crescimento e as tendências da pesquisa em comunicação de mudanças climáticas fornece insights valiosos sobre os avanços, temas recorrentes e indivíduos proeminentes dentro desta disciplina. Em suma, o estudo atual destaca a importância de uma comunicação eficiente para enfrentar os problemas complexos associados às mudanças climáticas, podendo servir como referência para leitores em potencial e futuros pesquisadores interessados nesse domínio.

Palavras-chave: comunicação de mudanças climáticas; comunicação climática; comunicação científica; mídias sociais; ação climática.



Submissão: 23/08/2023



Aceite: 09/10/2023



Publicação: 27/10/2023



Introduction

Climate change communication is incommunicado to convey significant input to the global population if efficacious actions to enhance public awareness and promote proactive measures have not been taken utterly. Climate change communication is vital since it has a multifaceted impact on different sides of society, encompassing politics, economics, social dynamics, and human welfare (Chainan and Sutthisima 2021). The effects caused by climate change across multiple dimensions necessitate our proactive efforts to safeguard the environment, human beings, and their interconnected welfare (Stapleton 2019). Notwithstanding the growing prevalence of climate change news coverage, there remains a notable deficit in public knowledge and comprehension of this issue (Schmidt et al. 2022). It is imperative for public health professionals to proficiently convey the human implications of climate change and educate populations regarding its significant threat to global health (Ros et al. 2020).

Engaging individuals, communities, and populations in climate communication and action is essential, and using frameworks like the Six Americas perspective can be valuable in this process (Howarth, Lane, and Slevin 2022). Facilitated by non-judgmental and holistic approaches, such as free community festivals, place-based climate action can potentially mobilise societal change (Schmidt et al. 2022). Understanding the effects of climate change is necessary to drive action, and projecting the potential consequences of extreme climate events, like flooding, onto familiar places can make the impacts more concrete and encourage action (Rodrigues et al. 2021). Building a system that presents personalised climate information based on individual values can also enhance climate communication and motivate action (Rasmussen, Kirchhoff, and Lemos 2017).

Climate change is a fast-moving and often ambiguous topic, making extracting information from textual sources complex using popular keyword-based models (Varini et al. 2020). Additionally, the terminology used in climate change reporting can vary, presenting challenges for scholars trying to understand the variables that impact mediated communication (Pinto, Gutsche, and Prado 2019). Furthermore, analysing news articles and related data on climate change requires customised methods that take advantage of keywords and metadata (Chawathe 2020). Communicators face challenges such as cultural and political conflict, psychological barriers, and confronting false information without contributing to divergence (Markowitz and Guckian 2018). Therefore, the examination and evaluation of climate change communication necessitate acknowledging and resolving these obstacles while also considering the dynamic characteristics of the subject matter to engage with a wide range of individuals effectively.

Climate change communication literature demonstrates numerous theories, concepts, and growing trends that shape the topic (Merkel et al. 2020). Critical theoretical frameworks such as the “knowledge-deficit” model have given way to more nuanced approaches such as the “psychological distance” theory, which emphasises the importance of perceived relevance and proximity in engaging audiences (Kidd et al., 2019; Hathaway, 2020). Concepts like “framing” have become popular, demonstrating how communications are purposefully created to impact public perceptions and actions (Anderson 2019). Also, the rise of digital media has given experts new chances to learn more about online activism, social media dynamics, and the spread of false information in communicating about climate change (Aitken 2018). Markowitz and Guckian (2018) discovered that cultural, political, and socioeconomic factors significantly shape communication strategies and public opinion.

Using bibliometric analysis is a potent approach for researchers to acquire significant insights about research trends, patterns, and the progression of scientific publications (Aziz, Abdullah, and Samsudin 2021). This study uses bibliometric analysis to comprehend the nature of published works, including citations, authors, journals, and keywords. This method is vital because the bibliometric technique resides in its capacity to offer evidence-based insights into the scholarly domain by quantitatively analysing the datasets provided (Abdullah,



Roslan, and Ishak 2023). It has happened as bibliometric analysis is predicated upon using measurable metrics, such as citation counts and publication patterns. By doing this, bibliometric analysis allows for a complete evaluation of research trends and the academic influence of a particular body of work (Ma, Su, and Li 2021).

Bibliometric analysis within climate change communication aims to furnish crucial information concerning climate communication and offer valuable insights into ongoing research trends and patterns. Asmi et al. (2019) scrutinised the social dimensions of climate change communication in the contemporary era. The researchers inferred that further inquiry is necessary to tackle methodological and theoretical concerns within climate change communication research and development. Chen et al. (2022) conducted a bibliometric analysis of research on climate change communication. Their findings indicate that climate change communication research has emerged as a distinct and autonomous field of study, experiencing a period of rapid advancement. The primary goal of this study is to investigate the changing patterns of publication and the developmental trajectory in climate change communication research.

Methodology

This study utilised bibliometric approaches to explore the quantitative and analytical aspects of climate change communication research, development, and publications, as discussed in the subsequent sub-sections.

Selection of databases and keywords

Selecting suitable databases for bibliometric research is fundamental to obtaining relevant and comprehensive datasets (Mohadab, Bouikhalene, and Safi 2020). This study uses Scopus and Web of Science (WoS) databases to retrieve climate change communication publications. Scopus is an all-inclusive abstract and citation database encompassing diverse scientific subjects (Romero-Perdomo et al. 2022). This all-inclusive approach guarantees the inclusion of a broad spectrum of research on climate change communication. Despite this, WoS is a prominent citation database that includes many academic disciplines and prioritises scholarly publications (Li, Rollins, and Yan 2018). Likewise, WoS is identified for its heavy emphasis on scholarly publications, traditionally the most extensive accessible database for bibliometric analysis (Echchakoui 2020). This practice confirms that the datasets used in the current study result from esteemed and reliable sources.

This study employs specified keywords to obtain relevant datasets from both Scopus and WoS databases. The keywords considered were “climate change communication” and “climate communication”. These keywords were searched within the title, abstract, and keywords and carried out on July 1, 2023. The study did not apply language restrictions during this process, but the datasets were limited until December 31, 2022.

Software and datasets analysis

Using the software tools ScientoPy and VOSviewer, the retrieved datasets were analysed. These applications extracted significant patterns, trends, and insights from the collected datasets (Abdullah and Sofyan 2023). Initially, the datasets were analysed with ScientoPy by combining and removing duplicates (Ruiz-Rosero, Ramirez-Gonzalez, and Viveros-Delgado 2019). VOSviewer is a software application designed for constructing and evaluating bibliometric networks to provide visually informative representations of the collected data (Liu et al. 2022). This study used VOSviewer to identify the emerging clusters related to climate change communication research. Through the visualisation of the term co-occurrence, VOSviewer facilitated the identification of the intellectual framework and thematic patterns within the corpus of scholarly works.

The bibliometric methodologies utilised in this investigation are illustrated in Table 1. When used collectively, bibliometric approaches offer a complete comprehension of the growth of a particular topic,

identification of significant contributors, analysis of prominent works, and identification of prevalent themes. These elements are the fundamental basis for comprehensively analysing climate change communication publications. This study offers insights into the dynamic research landscape of climate change communication. The following research questions will be addressed throughout this study:

1. Research Question 1 (RQ1): How has the research volume of climate change communication evolved?
2. Research Question 2 (RQ2): What are the top ten most institutions that shape research about climate change communication?
3. Research Question 3 (RQ3): What are the top ten most cited papers of seminal works that explore climate change communication?
4. Research Question 4 (RQ4): Which keywords and themes are prevalent in research publications related to climate change communication?

Table 1. Bibliometric techniques

Research Question	Bibliometric Technique	Data Source	Software	Analysis Approach
RQ1: Research Volume Evolution	Publication Trend Analysis	Scopus & WoS	ScientoPy	Timeline analysis
RQ2: Top Institutions	Analysis of productive institution	Scopus & WoS	ScientoPy	Trend analysis
RQ3: Most Cited Papers	Citation analysis	Scopus & WoS	ScientoPy	Citation Count Ranking
RQ4: Prevalent Keywords & Themes	Evolution analysis and co-occurrence analysis	Scopus & WoS	ScientoPy and VOSviewer	Evolution analysis and Network visualisation

Source: Author's Generated Table.

Pre-processing datasets

Pre-processing was performed on the datasets to facilitate the integration of Scopus and WoS datasets while removing duplicates. The described procedure generated an additional dataset that can be utilised for further analysis. Using ScientoPy, the bibliographic datasets execute preliminary processing. During this phase, ScientoPy employs a standardisation process to replace the author's name with a semicolon when retrieving metadata from the Scopus database. Furthermore, the process involves the elimination of dots, commas, and special characters from both databases' metadata to eliminate duplicate entries with the same names and authors (Ruiz-Rosero, Ramirez-Gonzalez, and Viveros-Delgado 2019).

The information in Table 2 demonstrates that the initial results of the gathered data consist of 1553 raw datasets obtained from Scopus and WoS publications. Due to the automated document-type filtering approach, this study removed 216 publications, accounting for 13.90% of the datasets. At the outset, 1337 publications were identified before commencing eliminating duplicates. The total number of duplicate entries identified in this inquiry was 525 (39.30%), encompassing data from both databases. In due course, 812 papers have been deemed suitable for inclusion in the continuing study. Among these, 659 publications (81.20%) were sourced from the WoS, while the remaining 153 (18.80%) were obtained via Scopus. The number of validated datasets fulfils the minimum criteria for conducting bibliometric analysis with more than 300 datasets (Donthu et al. 2021). Furthermore, it is vital to possess datasets with over 100 articles to conduct efficacy bibliometric analysis. Alternatively, datasets with fewer than 100 publications require systematic or scoping review methodologies.


Table 2. Data integration and duplicates exclusion

Data Pre-processing Output	Information	Number	Percentage (%)
Initial results	Raw data from Scopus and WoS	1553	-
	Automatic type-filter publication to remove non-related document	216	13.90
	Total publications after selecting document types (Research articles, conference papers, book chapters, review papers, and proceedings)	1337	-
	Publications in WoS	662	49.50
	Publication in Scopus	675	50.50
	Duplicated publications in both databases	525	39.30
Duplicated removal results	Duplicated publications from WoS	3	0.50
	Duplicated papers from Scopus	522	77.30
	Total publications after eliminating duplicates	812	-
Final results	Publications in WoS	659	81.20
	Publications in Scopus	153	18.80

Source: Author's Generated Table.

Results

This section provides an overview of the findings derived from analysing datasets utilising the ScientoPy and VOSviewer software. The utilisation of graphical depictions is essential in aiding readers' comprehension of the trends and advancements in research on climate change communication.

Research volume evolution

The increase in scholarly publications on climate change communication is closely tied to the quantitative assessment of publication frequency. The current assessment entails the surveillance and analysis of the number of scholarly articles produced within a designated timeframe, providing insightful insights into the developmental path and diverse degrees of scholarly involvement in these interrelated fields. Figure 1 illustrates the progression and development of scholarly publications. The discussed research was published in 2000, signifying two decades from its commencement.

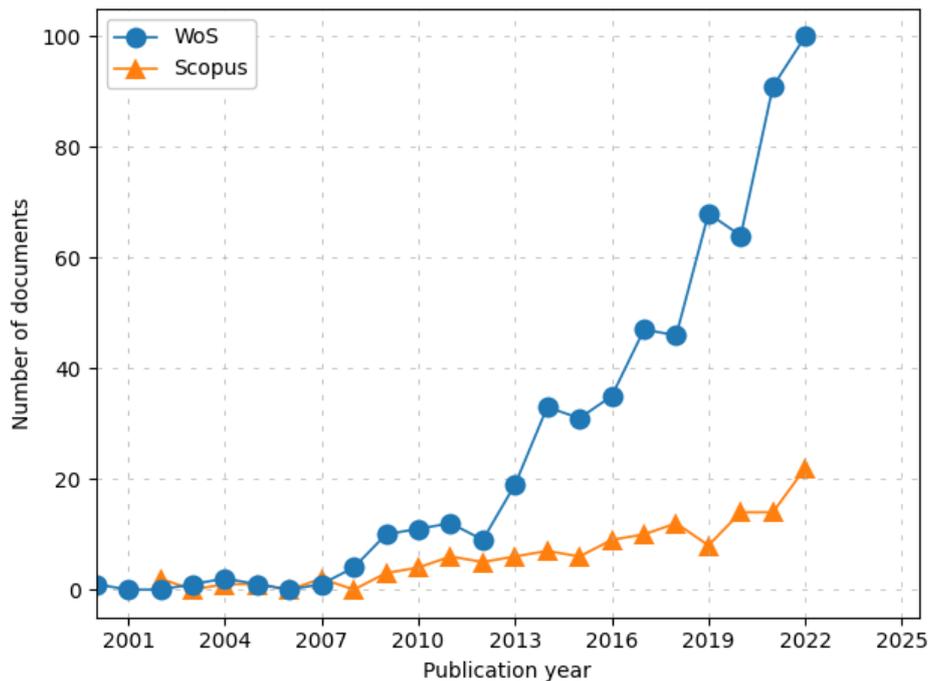


Figure 1. The evolution of publications. Source: Author's Figure (Generated using ScientoPy).

Figure 1 illustrates identifiable trends in advancing scholarly articles on climate change communication evolution. Limited presence in the WoS and Scopus databases was seen for the fields described in the research articles throughout the early 2000s. Between the mid-2000s, there was a noticeable increase in published works, coinciding with a progressive rise in scholarly interest in climate change communication. 2008 is a noteworthy turning point in the publication progression, marked by a substantial surge in published works, particularly for the WoS database. Since 2012, there has been a consistent upward trend in published publications, suggesting growing scholarly attention towards the convergence of climate change communication. The post-2012 period exhibits a notable surge in published works, particularly in WoS databases. This is evident from the observed growth in research publications within the specified fields in both databases. 2021 and 2022 demonstrate a significant rise in publishing output, with major contributions from both databases.

Top institutions

The examination of the institution that has demonstrated the most significant degree of engagement in the study of climate change communication is paramount. Gaining a comprehensive understanding of the critical institutions that have a significant impact on research related to climate change communication is crucial for staying informed about the newest advancements, effective methodology, and innovative approaches in this rapidly evolving field. Figure 2 illustrates the hierarchical arrangement of the top ten universities with the highest level of productivity in terms of their research contributions in the field of climate change communication.

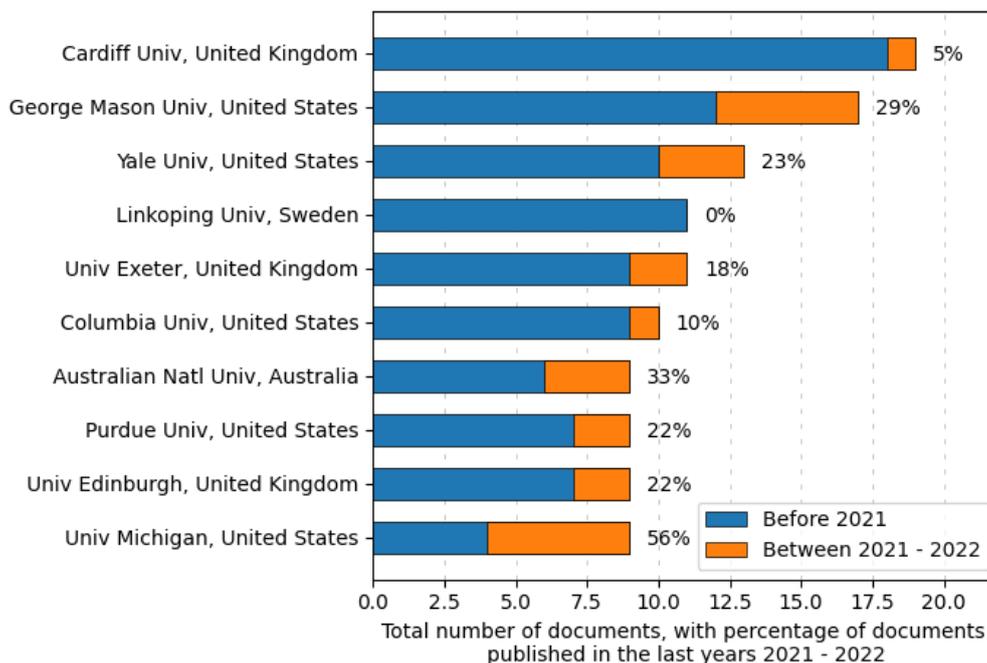


Figure 2. The top ten most active institutions. Source: Author's Figure (Generated using ScientoPy).

According to the data presented in Figure 2, the universities that occupied the top three positions in the ranking were Cardiff University in the United Kingdom, George Mason University in the United States, and Yale University in the United States. Institutions with more incredible aggregate publication figures generally signify a robust research output and scholarly engagement. In this particular instance, Cardiff University emerges as the frontrunner with 19 publications, closely trailed by George Mason University, which boasts 17 publications. Yale University is associated with 13 academic publications.

The percentage of documents published in the last two years (PDLY) indicates how much of an institution's research output has been published in the most recent two-year period (2021 and 2022). A higher PDLY value suggests that the institution produces and publishes new research. In this study, the top three institutions with the highest PDLY were the University of Michigan, United States, Australian National University, Australia, and George Mason University, United States. The University of Michigan leads with a PDLY of 56%, indicating that more than half of their total document count for this period was published in the last two years. Australian National University follows with a PDLY of 33%, and George Mason University comes next with a PDLY of 29%.

A high value of PDLY may indicate that these institutions have demonstrated significant engagement in producing and disseminating recent scholarly research, potentially making valuable contributions to ongoing academic dialogues and emerging trends in climate change communication. Nonetheless, akin to the aggregate count of publications, examining the research's calibre, influence, and importance is imperative when evaluating an institution's research performance.

Most cited papers

Table 3 compiles the ten articles often mentioned in climate change communication research. Gaining a comprehensive understanding of the primary documents frequently cited in this field enables researchers, policymakers, and practitioners to establish a strong foundation, stay informed about recent developments, and



actively contribute to formulating practical approaches in comprehending the fundamental concepts related to research on climate change communication.

The data in Table 3 presents a list of publications along with their authors, titles, source titles, and citation counts. These publications are related to climate change communication and have been cited several times. The top three publications with the highest number of citations were written by O'Neill and Nicholson-Cole (2009), Moser (2010), and Lee et al. (2015).

O'Neill and Nicholson-Cole (2009) discuss using positive engagement strategies to communicate about climate change. It emphasises the importance of visual and iconic representations in fostering understanding and concern about climate change issues. The high number of citations (763) suggests that this approach to climate change communication has had a significant impact and resonance within the academic and scientific community.

Table 3. The top ten most cited papers

Rank	Authors	Title	Source Title	Cited by
1	(O'Neill and Nicholson-Cole 2009)	Fear won't do it promoting positive engagement with climate change through visual and iconic representations	Science Communication	763
2	(Moser 2010)	Communicating climate change: history, challenges, process and future directions	Wiley Interdisciplinary Reviews-Climate Change	670
3	(Lee et al. 2015)	Predictors of public climate change awareness and risk perception around the world	Nature Climate Change	570
4	(Pidgeon and Fischhoff 2011)	The role of social and decision sciences in communicating uncertain climate risks	Nature Climate Change	428
5	(Poortinga et al. 2011)	Uncertain climate: an investigation into public scepticism about anthropogenic climate change	Global Environmental Change-Human and Policy Dimensions	423
6	(Scannell and Gifford 2013)	Personally relevant climate change: the role of place attachment and local versus global message framing in engagement	Environment and Behavior	413
7	(Cook, Lewandowsky, and Ecker 2017)	Neutralising misinformation through inoculation: Exposing misleading argumentation techniques reduces their influence	Plos One	359
8	(Smith and Leiserowitz 2014)	The role of emotion in global warming policy support and opposition	Risk Analysis	279
9	(Ockwell, Whitmarsh, and O'Neill 2009)	Reorienting climate change communication for effective mitigation forcing people to be green or fostering grass-roots engagement?	Science Communication	256
10	(Morton et al. 2011)	The future that may (or may not) come: how framing changes responses to uncertainty in climate change communications	Global Environmental Change	240

Source: Author's Generated Table.

Moser (2010) provides an overview of the history, challenges, and processes of communicating climate change. It also outlines potential future directions for climate change communication. With 670 citations, it indicates that the insights and perspectives presented by Moser have been widely recognised and referenced by other researchers and experts in the field.

Lee et al. (2015) investigate the factors that influence public awareness and risk perception related to climate change on a global scale. It identifies predictors contributing to how individuals perceive and understand climate change risks. With 570 citations, this research has influenced discussions around public perception of climate change and has likely contributed to subsequent studies in the field.

Prevalent keywords and themes

Identifying and analysing keywords and subjects are commonly used to discern the dominant patterns and focal points within a specific academic discipline (Abdullah, Roslan, and Ishak 2023). Therefore, it is imperative to comprehend the prevailing keywords and themes in the academic literature on climate change communication. This understanding is essential for maintaining a high level of knowledge, making meaningful contributions to the field, guiding research efforts, and ensuring climate change management's ongoing significance and effectiveness.

Figure 3 shows the ten most used keywords by previous authors and the percentage of documents published in the last two years, 2021 and 2022 (PDLY). Based on Figure 3, "Climate Change", "Climate Change communication", and "Climate communication" were listed as the top three. The results hold significant importance in contributing knowledge and practices in understanding climate change communication. "Climate change" is the most frequently used keyword among the authors. It appears a total of 255 times in the documents analysed.

Additionally, 40% of the documents that use this keyword were published in the last two years (2021 and 2022). "Climate change communication" is the second most commonly used keyword, appearing 152 times. Around 34% of the documents using this keyword were published in 2021 and 2022. The keyword "Communication" is mentioned 48 times and represents a broad term that might encompass various communication aspects, not limited to climate change. Around 25% of documents with this keyword were published in 2021 and 2022.

The percentage of documents published in the last two years indicates the proportion of documents related to a specific keyword published in the most recent two-year period (2021 and 2022). In this study, around 59% of the documents containing the keyword "Science communication" were published in 2021 and 2022. Approximately 50% of the documents using the keyword "Environmental communication" were published in 2021 and 2022. About 48% of the documents containing the keyword "Framing" were published in the last two years (2021 and 2022). These keywords with high PDLY values suggest that recent research activity and interest have been focused on the communication aspects of science, the environment, and framing within the context of climate change and related topics.

The utilisation of VOSviewer in mapping analysis facilitates a comprehensive comprehension of climate change communication. The graphical representation depicted in Figure 4 illustrates the co-occurrence of authors' terms, with a minimum threshold of 10 occurrences. As a result, of the 1825 keywords that were analysed, only 19 keywords met the predefined threshold requirement.

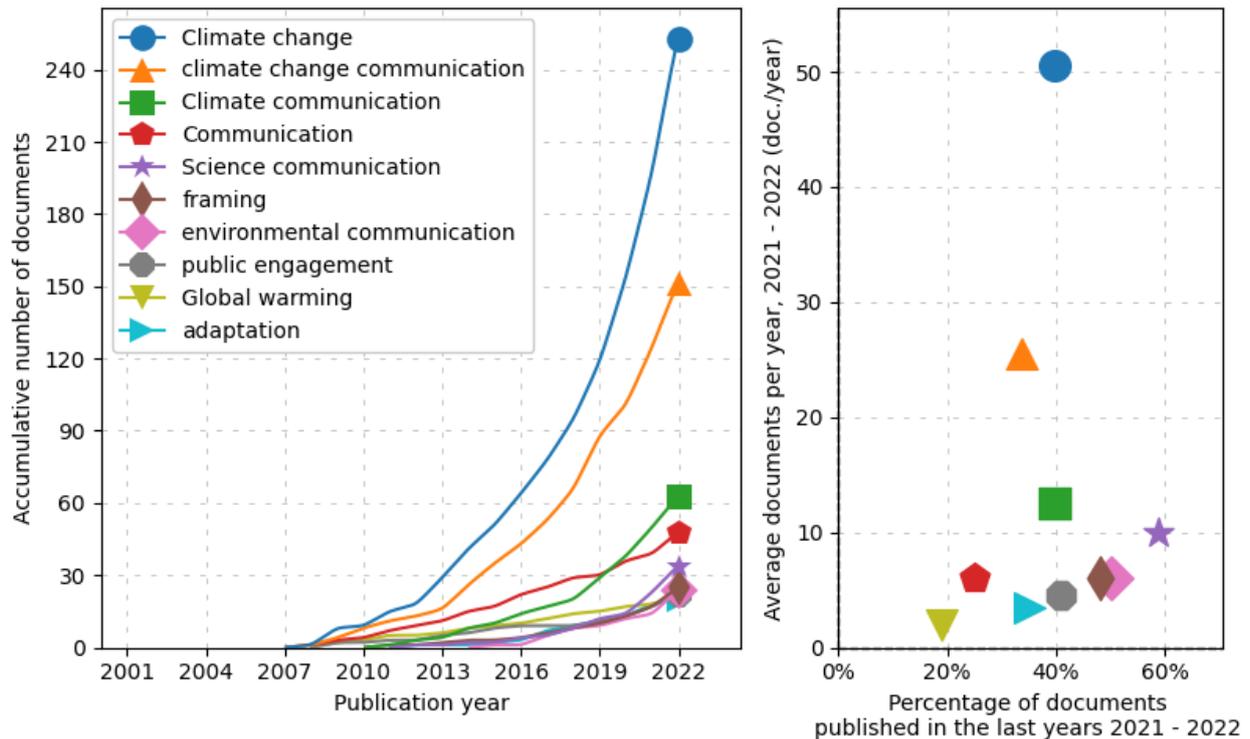


Figure 3. The ten most used keywords by previous authors. Source: Author's Figure (Generated using ScientoPy).

Information in Figure 4 emphasises that the keywords “climate change” are closely associated with “communication”, “climate communication”, “science communication”, “environmental communication”, “framing”, and “global warming”. The keyword “climate change” appeared in 2019. The keyword “climate change communication” appeared in 2018, and it was closely linked to “public engagement”, “risk perception”, “risk communication”, “climate communication”, and “science communication”.

Significantly, according to the VOSviewer mapping analysis conducted in this study, it was observed that the terms “social media”, “science communication”, “environmental communication”, “framing”, and “climate action” emerged prominently starting from the year 2020. The appearance of these specific terms in academic literature starting from 2020, as demonstrated by utilising VOSviewer mapping, signifies the progressive developments in climate change communication. The statement posits a growing emphasis among researchers in many areas, including utilising social media, enhancing communication in science and the environment, adopting effective framing tactics, and advocating for actionable measures to tackle the difficulties posed by climate change.

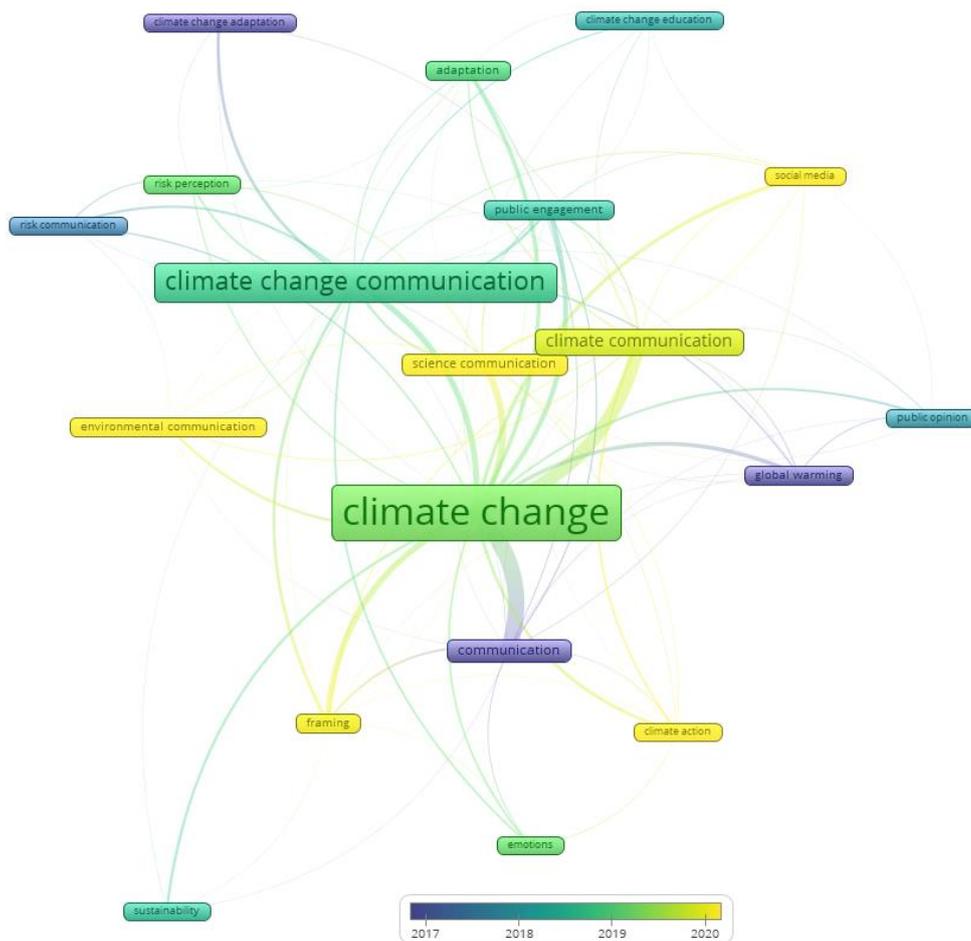


Figure 4. The overlay visualisation of authors' keywords. Source: Author's Figure (Generated using VOSviewer).

Discussion

The increase in scholarly publications on climate change communication holds significant importance for the body of knowledge and real-world practices. This growth is intricately linked to the quantitative assessment of publication frequency, which provides valuable insights into the evolution of research in this field over time (Abdullah, Roslan, and Ishak 2023). The current evaluation involves tracking and analysing the number of scholarly articles published within a specific timeframe, shedding light on the developmental trajectory and the varying degrees of intellectual engagement within these interconnected domains.

Figure 1, depicting the evolution of publications, visually captures the trends and shifts in scholarly engagement with climate change communication. The research articles' presence in the WoS and Scopus databases throughout the years reflects the educational efforts to contribute to the discourse. Notably, during the early 2000s, research articles in these databases were limited, suggesting a relatively nascent interest in the field. Climate change communication publications were limited in the early 2000s due to the shifting focus of the area. Initially, the emphasis was on conveying the physical science of climate change, uncertainties, and mitigation options (Moser 2017). However, as science progressed and the understanding of climate change impacts and adaptation grew, communication shifted towards engaging the public (Fox and Rau 2017).

The mid-2000s marked a turning point, as evidenced by a pronounced uptick in published works. This increase aligns with a growing scholarly recognition of the importance of effectively communicating climate change-related information to diverse audiences. The surge in publications from 2008 onwards, especially in



the WoS database, signifies a heightened awareness and a more concerted effort by researchers to address climate change communication in-depth. This happened as researchers focused on various aspects of climate change communication, including messaging, language, imagery, messengers, communication channels, media, and audience segmentation (Happer 2017). Climate change communication is more likely to persuade when the message and the messenger resonate with the audience's values and identities (Goldberg et al. 2021). The field has evolved from conveying the physical science of climate change and mitigation options to engaging the public on impacts and adaptation (Ballantyne 2016).

The examination of productive institutions in climate change communication, as depicted in Figure 2, holds immense significance in understanding the propagation of research on climate change communication. Cardiff University, George Mason University, and Yale University are identified as prominent contributors to climate change communication research. Understanding the institutions that lead in research related to climate change communication is vital for several reasons, and this information provides valuable insights to readers. One reason is that identifying the top institutions actively engaged in climate change communication research allows readers to stay informed about the newest advancements, methodologies, and innovative approaches within this rapidly evolving field. Institutions at the forefront of research often pioneer new concepts, methodologies, and technologies that shape the trajectory of climate change communication practices. Climate change communication research has emerged as a distinct and rapidly advancing area of study, with significant potential for further exploration in light of evolving perspectives on climate change and the changing global landscape (Chen et al. 2022).

Understanding the most cited publications in climate change communication is crucial for researchers, policymakers, and practitioners as they provide a solid foundation and inform recent advancements in the field. These seminal works lay out fundamental concepts, theories, and methodologies that have stood the test of time and are critical for comprehending the core principles of climate change communication (Howarth, Parsons, and Thew 2020). Familiarity with these papers equips policymakers and practitioners with valuable insights into effective communication strategies, public perception drivers, and risk assessment methodologies, which can inform the design of communication campaigns, policy interventions, and engagement strategies grounded in research-backed knowledge (Moernaut, Mast, and Pauwels 2018).

The keyword analysis results, as presented in Figure 3 and the VOSviewer mapping analysis depicted in Figure 4, contribute significantly to the knowledge and practices related to understanding climate change communication. Analysing prevalent keywords and themes is a standard method to uncover dominant patterns and central topics within an academic discipline (Abdullah and Sofyan 2023). Understanding these keywords is crucial for staying well-informed, making meaningful contributions, guiding research efforts, and ensuring climate change management's ongoing relevance and effectiveness (Abdullah, Roslan, and Ishak 2023).

The results in Figure 3 highlight the most used keywords by previous authors. "Climate Change", "Climate Change communication", and "Climate communication" emerge as the top three keywords. The frequency of usage of these keywords in previous research indicates the significance of these concepts in the academic discourse on climate change (Mah et al., 2020; Wynes et al., 2021). These keywords highlight the central themes of climate change and communication in the research landscape, emphasising the importance of understanding and effectively communicating about climate change (Salas Reyes et al. 2021). The prominence of these keywords suggests that researchers recognise the need to address climate change and engage in effective communication strategies to promote understanding and action (Bayes, Bolsen, and Druckman 2023).

The Percentage of Documents Published in the Last Two Years (PDLY) values provides insights into recent research activity and focus (Bornmann and Williams 2020). For instance, high PDLY values for keywords



like “Science communication,” “Environmental communication,” and “Framing” suggest that recent research has been concentrated on understanding communication aspects in the context of science, the environment, and framing as they relate to climate change (Appelgren and Jönsson 2021). Hence, effective science communication interventions must be carefully designed, considering global challenges, rapid technological developments, and information overload.

VOSviewer mapping analysis, shown in Figure 4, reveals the evolving connections among author keywords. The appearance of keywords like “social media,” “science communication,” “environmental communication,” “framing,” and “climate action” starting in 2020 is significant. It indicates a growing emphasis on these topics among researchers. This points to the field’s dynamism and the evolving strategies being explored to communicate climate change issues effectively (Lidberg 2021). The appearance of keywords like “social media” and “climate action” in academic literature since 2020 suggests a shift in focus towards contemporary challenges and emerging areas of interest. This reflects the field’s responsiveness to societal changes, technology advancements, and the urgency of addressing climate change through actionable measures (Merzdorf, Pfeiffer, and Forbes 2019).

Conclusion

Exploring scholarly publications on climate change communication yields valuable insights into the field’s progress, themes, and key contributors. This study delved into various dimensions, shedding light on prominent institutions, influential publications, prevalent keywords, and evolving trends. The findings underscore the importance of effective communication in addressing the complex challenges of climate change.

The analysis of productive institutions highlighted Cardiff University, George Mason University, and Yale University as leaders in generating climate change communication research. With their prolific output and high PDLY values, these institutions advance knowledge and practical strategies within the field.

The examination of most cited papers emphasised seminal works by O’Neill & Nicholson-Cole (2009), Moser (2010), and Lee et al. (2015), which have significantly impacted climate change communication discourse. These papers provide a foundation for understanding effective communication strategies, historical perspectives, and public perception dynamics.

The exploration of prevalent keywords and themes, as revealed by Figure 3 and VOSviewer mapping, illuminates the evolving landscape of climate change communication research. The appearance of keywords such as “social media,” “science communication,” and “climate action” underscores the field’s adaptability to contemporary challenges and solutions.

While this study contributes valuable insights, certain limitations should be acknowledged. The analysis is constrained by the selected datasets and timeframes, potentially missing out on relevant publications outside the chosen sources. Moreover, the analysis primarily focuses on quantitative aspects, overlooking the nuanced qualitative aspects that contribute to the impact of research. The categorisation and interpretation of keywords might also be subject to subjective biases.

Undertake a qualitative analysis to delve deeper into the content, methodologies, and theoretical frameworks of highly cited publications, providing a richer understanding of their impact. Besides, investigating how insights from climate change communication research can intersect with other fields, such as psychology, sociology, and environmental science, to foster interdisciplinary collaboration is interesting to research further.

Acknowledgements

The author extends his sincere gratitude to the editors and reviewers for their invaluable contributions in elevating this article to meet rigorous academic standards.

References

- Abdullah, Khairul Hafezad, Mohd Firdaus Roslan, and Noor Syazwani Ishak. 2023. "Unearthing Hidden Research Opportunities through Bibliometric Analysis: A Review." *Asian Journal of Research in Education and Social Sciences* 5 (1): 251–62. <https://doi.org/10.55057/ajress.2023.5.1.23>.
- Abdullah, Khairul Hafezad, and Davi Sofyan. 2023. "Machine Learning in Safety and Health Research: A Scientometric Analysis." *International Journal of Information Science and Management* 21 (1): 17–35. <https://doi.org/10.22034/ijism.2022.1977763.0>.
- Aitken, Mhairi. 2018. *Public Interest Communication*. Edited by Jane Johnston and Magda Pieczka. *Public Interest Communication: Critical Debates and Global Contexts*. Routledge. <https://doi.org/10.4324/9781315185521>.
- Anderson, Alison. 2019. "Climate Change Communication in the United Kingdom." In *Oxford Research Encyclopedia of Climate Science*. Oxford University Press. <https://doi.org/10.1093/acrefore/9780190228620.013.458>.
- Appelgren, Ester, and Anna Maria Jönsson. 2021. "Engaging Citizens for Climate Change—Challenges for Journalism." *Digital Journalism* 9 (6): 755–72. <https://doi.org/10.1080/21670811.2020.1827965>.
- Asmi, Fahad, Muhammad Azfar Anwar, Rongting Zhou, Dong Wang, and Aqsa Sajjad. 2019. "Social Aspects of 'Climate Change Communication' in the 21st Century: A Bibliometric View." *Journal of Environmental Planning and Management* 62 (14): 2393–2417. <https://doi.org/10.1080/09640568.2018.1541171>.
- Aziz, Fadzli Shah Abd, Khairul Hafezad Abdullah, and Sharina Samsudin. 2021. "Bibliometric Analysis of Behavior-Based Safety (BBS): Three Decades Publication Trends." *Webology* 18 (Special Issue 02): 278–93. <https://doi.org/10.14704/WEB/V18SI02/WEB18072>.
- Ballantyne, Anne Gammelgaard. 2016. "Climate Change Communication: What Can We Learn from Communication Theory?" *Wiley Interdisciplinary Reviews: Climate Change* 7 (3): 329–44. <https://doi.org/10.1002/wcc.392>.
- Bayes, Robin, Toby Bolsen, and James N. Druckman. 2023. "A Research Agenda for Climate Change Communication and Public Opinion: The Role of Scientific Consensus Messaging and Beyond." *Environmental Communication* 17 (1): 16–34. <https://doi.org/10.1080/17524032.2020.1805343>.
- Bornmann, Lutz, and Richard Williams. 2020. "An Evaluation of Percentile Measures of Citation Impact, and a Proposal for Making Them Better." *Scientometrics* 124 (2): 1457–78. <https://doi.org/10.1007/s11192-020-03512-7>.



- Chainan, Pimonpan, and Viroj Sutthisima. 2021. "Climate Change Communication in Southeast Asia from Journalist Perspective in the Context of Thailand: Raising Awareness by Environment Communication." In *Social Transformations in India, Myanmar, and Thailand: Volume I*, 1:85–97. Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-15-9616-2_6.
- Chawathe, Sudarshan S. 2020. "Topic Analysis of Climate-Change News." In *2020 10th Annual Computing and Communication Workshop and Conference, CCWC 2020*, 543–49. <https://doi.org/10.1109/CCWC47524.2020.9031122>.
- Chen, Denghang, Yanlong Guo, Chenyang Wang, Yinrui Xu, and Han Zhang. 2022. "Dispersion and Disparity: Bibliometric and Visualized Analysis of Research on Climate Change Science Communication." *International Journal of Environmental Research and Public Health* 19 (23). <https://doi.org/10.3390/ijerph192315766>.
- Cook, John, Stephan Lewandowsky, and Ullrich K.H. Ecker. 2017. "Neutralizing Misinformation through Inoculation: Exposing Misleading Argumentation Techniques Reduces Their Influence." *PLoS ONE* 12 (5): 1–21. <https://doi.org/10.1371/journal.pone.0175799>.
- Donthu, Naveen, Satish Kumar, Debmalya Mukherjee, Nitesh Pandey, and Weng Marc Lim. 2021. "How to Conduct a Bibliometric Analysis: An Overview and Guidelines." *Journal of Business Research* 133 (March): 285–96. <https://doi.org/10.1016/j.jbusres.2021.04.070>.
- Echchakoui, Saïd. 2020. "Why and How to Merge Scopus and Web of Science during Bibliometric Analysis: The Case of Sales Force Literature from 1912 to 2019." *Journal of Marketing Analytics* 8 (3): 165–84. <https://doi.org/10.1057/s41270-020-00081-9>.
- Fox, Emmet, and Henrike Rau. 2017. "Disengaging Citizens? Climate Change Communication and Public Receptivity." *Irish Political Studies* 32 (2): 224–46. <https://doi.org/10.1080/07907184.2017.1301434>.
- Goldberg, Matthew H., Abel Gustafson, Seth A. Rosenthal, and Anthony Leiserowitz. 2021. "Shifting Republican Views on Climate Change through Targeted Advertising." *Nature Climate Change* 11 (7): 573–77. <https://doi.org/10.1038/s41558-021-01070-1>.
- Happer, Catherine. 2017. "Belief in Change: The Role of Media and Communications in Driving Action on Climate Change." In *Climate Change and the Humanities*, 9781137551:177–97. London: Palgrave Macmillan UK. https://doi.org/10.1057/978-1-137-55124-5_9.
- Hathaway, Julia Robertson. 2020. "Climate Change, the Intersectional Imperative, and the Opportunity of the Green New Deal." *Environmental Communication* 14 (1): 13–22. <https://doi.org/10.1080/17524032.2019.1629977>.
- Howarth, Candice, Matthew Lane, and Amanda Slevin. 2022. *Addressing the Climate Crisis*. Edited by Candice Howarth, Matthew Lane, and Amanda Slevin. *Addressing the Climate Crisis: Local Action in Theory and Practice*. Cham: Springer International Publishing. <https://doi.org/10.1007/978-3-030-79739-3>.



- Howarth, Candice, Laurie Parsons, and Harriet Thew. 2020. "Effectively Communicating Climate Science beyond Academia: Harnessing the Heterogeneity of Climate Knowledge." *One Earth* 2 (4): 320–24. <https://doi.org/10.1016/j.oneear.2020.04.001>.
- Kidd, Lindall R., Georgia E. Garrard, Sarah A. Bekessy, Morena Mills, Adrian R. Camilleri, Fiona Fidler, Kelly S. Fielding, et al. 2019. "Messaging Matters: A Systematic Review of the Conservation Messaging Literature." *Biological Conservation* 236 (May): 92–99. <https://doi.org/10.1016/j.biocon.2019.05.020>.
- Lee, Tien Ming, Ezra M. Markowitz, Peter D. Howe, Chia Ying Ko, and Anthony A. Leiserowitz. 2015. "Predictors of Public Climate Change Awareness and Risk Perception around the World." *Nature Climate Change* 5 (11): 1014–20. <https://doi.org/10.1038/nclimate2728>.
- Li, Kai, Jason Rollins, and Erjia Yan. 2018. "Web of Science Use in Published Research and Review Papers 1997–2017: A Selective, Dynamic, Cross-Domain, Content-Based Analysis." *Scientometrics* 115 (1): 1–20. <https://doi.org/10.1007/s11192-017-2622-5>.
- Lidberg, Johan. 2021. "Science Communication: The 'Weight of Evidence' Approach and Climate Change." *Handbook of Global Media Ethics*, 711–21. https://doi.org/10.1007/978-3-319-32103-5_36.
- Liu, Zhen, Lingfeng Ren, Chang Xiao, Ke Zhang, and Peter Demian. 2022. "Virtual Reality Aided Therapy towards Health 4.0: A Two-Decade Bibliometric Analysis." *International Journal of Environmental Research and Public Health* 19 (3). <https://doi.org/10.3390/ijerph19031525>.
- Ma, Chengquan, Hao Su, and Hongjun Li. 2021. "Global Research Trends on Prostate Diseases and Erectile Dysfunction: A Bibliometric and Visualized Study." *Frontiers in Oncology* 10 (February): 1–10. <https://doi.org/10.3389/fonc.2020.627891>.
- Mah, Andrea Y.J., Daniel A. Chapman, Ezra M. Markowitz, and Brian Lickel. 2020. "Coping with Climate Change: Three Insights for Research, Intervention, and Communication to Promote Adaptive Coping to Climate Change." *Journal of Anxiety Disorders* 75 (May): 102282. <https://doi.org/10.1016/j.janxdis.2020.102282>.
- Markowitz, Ezra M., and Meaghan L. Guckian. 2018. *Climate Change Communication. Psychology and Climate Change: Human Perceptions, Impacts, and Responses*. Elsevier Inc. <https://doi.org/10.1016/B978-0-12-813130-5.00003-5>.
- Merkel, Sonia Hélène, Angela M. Person, Randy A. Pepler, and Sarah M. Melcher. 2020. "Climate Change Communication: Examining the Social and Cognitive Barriers to Productive Environmental Communication." *Social Science Quarterly* 101 (5): 2085–2100. <https://doi.org/10.1111/ssqu.12843>.
- Merzdorf, Jessica, Linda J. Pfeiffer, and Beth Forbes. 2019. "Heated Discussion: Strategies for Communicating Climate Change in a Polarized Era." *Journal of Applied Communications* 103 (3). <https://doi.org/10.4148/1051-0834.2269>.
- Moernaut, Renée, Jelle Mast, and Luc Pauwels. 2018. *Handbook of Climate Change Communication: Practice of Climate Change Communication. Handbook of Climate Change Communication: Practice of Climate Change Communication*. Vol. 1.



- Mohadab, Mohamed El, Belaid Bouikhalene, and Said Safi. 2020. "Bibliometric Method for Mapping the State of the Art of Scientific Production in Covid-19." *Chaos, Solitons and Fractals* 139: 110052. <https://doi.org/10.1016/j.chaos.2020.110052>.
- Morton, Thomas A., Anna Rabinovich, Dan Marshall, and Pamela Bretschneider. 2011. "The Future That May (or May Not) Come: How Framing Changes Responses to Uncertainty in Climate Change Communications." *Global Environmental Change* 21 (1): 103–9. <https://doi.org/10.1016/j.gloenvcha.2010.09.013>.
- Moser, Susanne C. 2010. "Communicating Climate Change: History, Challenges, Process and Future Directions." *Wiley Interdisciplinary Reviews: Climate Change* 1 (1): 31–53. <https://doi.org/10.1002/wcc.11>.
- . 2017. "Climate Change Communication." In *International Encyclopedia of Geography*, 1–8. Wiley. <https://doi.org/10.1002/9781118786352.wbieg0310>.
- O'Neill, Saffron, and Sophie Nicholson-Cole. 2009. "‘Fear Won’t Do It’ Promoting Positive Engagement with Climate Change through Visual and Iconic Representations." *Science Communication* 30 (3): 355–79. <https://doi.org/10.1177/1075547008329201>.
- Ockwell, David, Lorraine Whitmarsh, and Saffron O'Neill. 2009. "Reorienting Climate Change Communication for Effective Mitigation Forcing People to Be Green or Fostering Grass-Roots Engagement?" *Science Communication* 30 (3): 305–27. <https://doi.org/10.1177/1075547008328969>.
- Pidgeon, Nick, and Baruch Fischhoff. 2011. "The Role of Social and Decision Sciences in Communicating Uncertain Climate Risks." *Nature Climate Change* 1 (1): 35–41. <https://doi.org/10.1038/nclimate1080>.
- Pinto, Juliet, Robert E. Gutsche, and Paola Prado. 2019. "Introduction: Critical Challenges in Communicating Climate Change." In *Climate Change, Media & Culture: Critical Issues in Global Environmental Communication*, 1–12. Emerald Publishing Limited. <https://doi.org/10.1108/978-1-78769-967-020191003>.
- Poortinga, Wouter, Alexa Spence, Lorraine Whitmarsh, Stuart Capstick, and Nick F. Pidgeon. 2011. "Uncertain Climate: An Investigation into Public Scepticism about Anthropogenic Climate Change." *Global Environmental Change* 21 (3): 1015–24. <https://doi.org/10.1016/j.gloenvcha.2011.03.001>.
- Rasmussen, Laura Vang, Christine J. Kirchhoff, and Maria Carmen Lemos. 2017. "Adaptation by Stealth: Climate Information Use in the Great Lakes Region across Scales." *Climatic Change* 140 (3–4): 451–65. <https://doi.org/10.1007/s10584-016-1857-0>.
- Rodrigues, Kameron B., Shweta Khushu, Mukut Mukherjee, Andrew Banister, Anthony Hevia, Sampath Duddu, and Nikita Bhutani. 2021. "Powering Effective Climate Communication with a Climate Knowledge Base." *ArXiv Preprint ArXiv*, 1–5. <https://doi.org/https://doi.org/10.48550/arXiv.2107.11351>.
- Romero-Perdomo, Felipe, Juan David Carvajalino-Umaña, Jaime Leonardo Moreno-Gallego, Natalia Ardila, and Miguel Ángel González-Curbelo. 2022. "Research Trends on Climate Change and Circular Economy from a Knowledge Mapping Perspective." *Sustainability* 14 (1): 521. <https://doi.org/10.3390/su14010521>.



- Ros, Ana Viamonte, Regina Larocque, Rachel Fortinsky, and Patrice Nicholas. 2020. "Addressing Climate Change Communication: Effective Engagement of Populations for Climate Action in the US and Globally." *Annals of Global Health* 86 (1): 1–4. <https://doi.org/10.5334/aogh.2900>.
- Ruiz-Rosero, Juan, Gustavo Ramirez-Gonzalez, and Jesus Viveros-Delgado. 2019. "Software Survey: ScientoPy, a Scientometric Tool for Topics Trend Analysis in Scientific Publications." *Scientometrics* 121 (2): 1165–88. <https://doi.org/10.1007/s11192-019-03213-w>.
- Salas Reyes, Raúl, Vivian M. Nguyen, Stephan Schott, Valerie Berseth, Jenna Hutchen, Jennifer Taylor, and Nicole Klenk. 2021. "A Research Agenda for Affective Dimensions in Climate Change Risk Perception and Risk Communication." *Frontiers in Climate* 3 (October): 1–10. <https://doi.org/10.3389/fclim.2021.751310>.
- Scannell, Leila, and Robert Gifford. 2013. "Personally Relevant Climate Change: The Role of Place Attachment and Local versus Global Message Framing in Engagement." *Environment and Behavior* 45 (1): 60–85. <https://doi.org/10.1177/0013916511421196>.
- Schmidt, Victor, Alexandra Luccioni, Mélisande Teng, Tianyu Zhang, Alexia Reynaud, Sunand Raghupathi, Gautier Cosne, et al. 2022. "Climategan: Raising Climate Change Awareness By Generating Images of Floods." In *ICLR 2022 - 10th International Conference on Learning Representations*, 1–27. <https://doi.org/https://doi.org/10.48550/arXiv.2110.02871>.
- Smith, Nicholas, and Anthony Leiserowitz. 2014. "The Role of Emotion in Global Warming Policy Support and Opposition." *Risk Analysis* 34 (5): 937–48. <https://doi.org/10.1111/risa.12140>.
- Stapleton, Sarah Riggs. 2019. "A Case for Climate Justice Education: American Youth Connecting to Intragenerational Climate Injustice in Bangladesh." *Environmental Education Research* 25 (5): 732–50. <https://doi.org/10.1080/13504622.2018.1472220>.
- Varini, Francesco S., Jordan Boyd-Graber, Massimiliano Ciaramita, and Markus Leippold. 2020. "ClimaText: A Dataset for Climate Change Topic Detection." *ArXiv Preprint*, 1–13. <https://doi.org/https://doi.org/10.48550/arXiv.2012.00483>.
- Wynes, Seth, John Kotcher, and Simon D. Donner. 2021. "Can Citizen Pressure Influence Politicians' Communication about Climate Change? Results from a Field Experiment." *Climatic Change* 168 (1–2): 1–20. <https://doi.org/10.1007/s10584-021-03215-9>.