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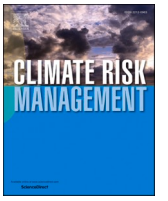

A bibliometric and topic analysis of climate justice: Mapping trends, voices, and the way forward

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A B S T R A C T

The field of climate justice has been growing in relevance since its conception in 1997. This paper presents a comprehensive bibliometric and topic modelling analyses to examine the evolution and trajectory of the climate justice literature. We analyse 1,683 publications covering the period from 1997 to 2021, highlighting foundational works, influential authors, leading nations and institutions, and prevailing research topics within this field. We employ Latent Dirichlet Allocation to uncover latent research trends in the literature providing a crucial baseline for future scholarly endeavours and policy development in the realm of climate justice.

Our results show that the field of climate justice has grown exponentially from less than 5 papers annually between 1997 and 2005, to around 200 papers annually in recent years. This growth has seen a diversification of research themes with an increase in papers around the topics of health, vulnerability and adaptation, and policy and activism. There has been a consistent backdrop of publications around the topics of sustainable development and policy, and international relations and carbon emissions. Other prominent topics in the literature include education and food security, and human rights and Indigenous people. The field has moved from theoretical research to examining actual examples of climate injustices, with an increased diversification of topics.

Future research could usefully focus on exploring future generations and more-than-human entities; the integration of climate justice and climate activism with broader struggles for justice; re-thinking climate adaptation "success" and "effectiveness" through the lens of climate justice, and the ramifications of the Global Goal on Adaptation on climate justice led-approaches that are inclusive, build on human rights approaches, and extend the scale of adaptation analysis beyond the local. It is imperative to prioritise addressing the climate justice needs of those most affected by climate change, transcending national borders, generational gaps, cultural differences, and even the well-being of various species. Such a holistic approach will help inform and refine global climate policy and action.

1. Introduction

Over the last three decades, the topic of climate justice has emerged in various spaces and formats. Climate activists use the term climate justice as a rallying call for global action (Piispa and Kiilakoski, 2021). Political leaders discuss how (or if) climate justice is being achieved through the various climate change agreements created and enacted (be it at the international, national, or local scale) (Ciplet et al., 2013). Legal scholars explore international and domestic laws to understand what climate justice is and how it can be achieved through new legislation or legal cases. Philosophers theorise and debate universal and cosmopolitan conceptualisations of climate justice. Social scientists examine what climate justice means in terms of how individuals and communities experience the

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impacts of climate change as well as actions to address changes. Practitioners are also using climate justice as a criteria to assess the success of climate mitigation and adaptation projects. The mounting importance of climate justice (within academia, activism and policy-making) is shown through recent Intergovernmental Panel on Climate Change's (IPCC) Working Group II (Impacts, Vulnerability and Adaptation) reports (Pörtner et al., 2022), including climate justice as a cross-cutting theme as well as academic conferences, university courses and research institutes all created to research and/or teach about the topic (Harris, 2019). In addition, the ever-expanding number of publications devoted to exploring climate justice demonstrates how the field is a rapidly advancing and flourishing area of study. Indeed, each year, there are now hundreds of new publications being released that examine climate justice through case studies, legal and policy analysis, theoretical works, and surveys; therefore, it is sometimes difficult for researchers (and other interest parties) to keep track of the key priorities, seminal pieces of work, and overarching body of knowledge about climate justice. This paper fills a critical gap in the literature by providing an in-depth analysis of the development of the climate justice scholarship from its inception to mid-2021, which charts the key themes that were and are present within peer-reviewed publications focused on climate justice. Based on our bibliometric review, we developed a conceptual framework of climate justice and present a future research agenda for the field.

Climate justice encompasses theory, activism, policy and practices and includes knowledge about the justice dimensions of climate change-related discussions and decisions. Amid the advancement of research, policies and projects aimed at understanding and tackling climate change, the topic of climate justice is garnering greater attention, which addresses complex, multi-faceted moral and ethical issues surrounding climate change mitigation and adaptation policies and actions (Schlosberg and Collins, 2014). The overarching subject of climate justice first gained widespread political attention in 2000 at the sixth UNFCCC Conference of Parties (COP 6) in the Hauge (Netherlands) and is now a common discussion point concerning debates about the impacts of and responses to climate change as it combines social and environmental justice aspects (Alves and Mariano, 2018). The Mary Robinson Foundation, an environmental non-governmental organisation, defines climate justice as linking:

> *human rights and development to achieve a human-centred approach, safeguarding the rights of the most vulnerable people and sharing the burdens and benefits of climate change and its impacts equitably and fairly*. (Mary Robinson Foundation, 2021)

The definition, which some scholars and activists widely cite, reflects distributive framings of environmental justice that focus on how environmental "bads" (such as the negative impacts of climate change and environmental degradation) and environmental "goods" (such as clean water, air, as well as the positive impacts of climate change) are distributed across spaces and populations (Newell et al., 2021). However, different definitions reflect the various fields, actors and organisations engaging in climate justice work and research. Sometimes represented as an issue of human rights, climate justice discussions within the domains of climate adaptation scholarship are typically focussed on the distributional impacts of climate change, with the poorest and most disadvantaged disproportionately negatively experienced by climate change. Climate justice studies that explore mitigation dimensions are focused on what nations are the biggest producers of greenhouse gas (GHG) emissions that induce climate change. A cross-cutting theme (shared across mitigation and adaptation literature) is how the most privileged nations and groups redistribute the impacts of the harms they create to burden the poor and marginalised somewhere else (Rice et al., 2023). Climate justice can be considered as a conceptual framework (rather than a universal theory) that situates climate change as intersecting with social inequalities in ways that manifest as social and ecological violence. Over the past two decades, climate justice (a theory, movement, and practice) has expanded through research, grassroots campaigning, political debates, and public dialogue, with non-governmental organisations (NGOs), scholars and decision-makers increasingly focusing on the linkages between climate change, uneven development, and human rights (Adelman, 2016).

Climate justice, however, finds itself in a paradox; although it is quickly developing a mass of information about how climate injustices exist (and are worsening) around the globe (Ciplet et al., 2013; Harris, 2019), there is little agreement as to what actions can be taken to mitigate or avoid climate injustices. Instead, much of the current scholarship is directed at charting climate justice activism (Axon, 2019; Bond et al., 2020) rather than exploring policies or projects that directly reduce climate injustice (Holland, 2017). Moreover, the developing climate justice sphere of study is plagued by questions about what counts as climate justice (or injustice) and divergences between climate change mitigation and adaptation. In addition, a wealth of literature that, although not specifically on climate justice, nevertheless contributes to climate justice theorising and inquiries (including philosophy, environmental justice, human rights, political ecology, and sustainable development) (Atapattu, 2018). Such a broad knowledge base means that climate justice scholarship remains highly fragmented, which includes challenges identifying types of knowledge that exist outside the peer-reviewed literature, such as Indigenous Knowledge (IK) and the embodied realities of climate change (and other environmental risks) in the Global North and Global South (Cultural Survival, 2022; Ford et al., 2016).

Likewise, there are notable differences between mitigation and adaptation scholarship. On the one hand, climate change adaptation researchers generally employ small-scale local case study-based research (using mixed or qualitative research methods) with a focus on the effectiveness, equity and efficiency (including distributive and procedural justice) of adaptation policies and practices at the local level (Sultana, 2022), even if larger data sets are also used (e.g. Berrang-Ford et al., 2021). On the other hand, climate mitigation scholars typically focus on global or national scales and often employ quantitative methods to investigate the distribution of emissions and mitigation measures (including issues of equality and equity) (Torpman, 2019). The apparent disconnect between scales and focus (between mitigation and adaptation) potentially constrains the capacities of researchers, policy-makers, and practitioners to create policies and strategies that can engender just processes and outcomes for different populations (both humans and more-than-humans). In turn, this may restrict our abilities to create robust (empirically informed) theoretical frameworks that can guide policy-making and strategies. Rigorous methods that outline the wider linkages between the diverse body of scholarship being published on climate justice are missing, which is essential to ensure that knowledge is being created that can feed into creating policies and projects that address climate change.

Researchers have begun to research peer-reviewed scholarship on climate justice. To date, the majority of these literature reviews have fallen into two categories: 1) narrative reviews of particular themes, conceptual frameworks, or methodologies (Newell et al., 2021; Tschakert et al., 2021); 2) systematic reviews on specific trends or topics (Alves and Mariano, 2018). For instance, Alves and Mariano (2018) reviewed 53 papers that explored climate justice and human development published between 2008-mid-2017. Other recent narrative reviews of climate justice scholarship include those examining intergenerational justice (Gonzalez-Ricoy and Rey, 2019), multi-species justice (Tschakert et al., 2021), and international climate agreements (Okereke and Coventry, 2016). These and other publications offer key insights into particular patterns and themes and methodological and theoretical advancements within the broad field of climate justice studies (Rice et al., 2023). However, there are limited attempts to review the wide range of research being conducted in the field to identify the current knowledge gaps to embark on new investigations into climate justice. Few bibliometric analyses have been undertaken on the social dimensions of climate change, including climate change communication (Asmi et al., 2019), mitigation (Moreira et al., 2022) and adaptation (Nalau and Verrall, 2021) in general. Yet, to our knowledge, there has been no attempt (at least not within the published scholarship) to undertake a systematic bibliometric analysis of the quickly expanding climate justice field. Accordingly, we set out to conduct a bibliometric review of the peer-reviewed literature, which allows us to describe and evaluate the current intellectual territory. Thus, the objective of our paper is to undertake a bibliometric review of 1683 papers (obtained using a keyword search in the Scopus database) on the development and existing state of the scholarship on climate justice and to identify key topics as well as critical gaps in the literature. Through a bibliometric review, we can identify key publications and authors that helped the field of climate justice develop, as well as highlighting the new research agendas that can improve our existing body of knowledge moving forward. In Section 2, we describe the bibliometric methodology, which includes the justification for selecting the papers and analysis. Then, in Section 3, our results are presented and discussed. Lastly, the article's conclusions are presented in Section 4, focusing on the future research agenda.

2. Methods

In this paper, we employ a bibliometric methodology. The aim of bibliometric methodology, which emerged as a distinct method over the last decade, is to identify and analyse research publications, citations and sources of information (Malanski et al., 2021; Moreira et al., 2022). Bibliometric analysis does not analyse the findings of studies but instead documents and synthesises broad trends and the structure and composition of the field of study. It allows researchers to identify the networks of authors, journals, and documents (Waltman et al., 2010). Bibliometric methods employ bibliometric data to create images of specific fields of study. The key results of literature reviews that employ bibliometric analysis are the number of research publications and citations, as well as word analysis and "mapping" of a specific field of research. Thus, considering the primary objective of this research is to conduct a literature review using bibliometric analysis of the research on climate justice, a bibliometric analysis of the published peer-reviewed literature on the topic was conducted.

A corpus of 1827 documents was retrieved from the Scopus database using the rscopus package (version 0.6.6; Muschelli, 2019) in R (version 4.1.3; R Core Team, 2022) on 09/12/2021 using the query: *"climate justice" OR "environmental justice" OR "social justice" AND "climate change" OR "global warming"*. Results were filtered to keep those classified as "article"," review", "book chapter", "book"," conference paper", and "note" published in English. Documents classified as "Letter", "erratum", "short survey", and "conference review" were omitted. Results were further filtered to keep those only containing the required metadata, including a description (e.g., an abstract or other text of similar length), author name(s), author affiliation(s), publication date and journal (or publisher), and citation count. After filtering, the corpus contained 1683 documents covering the years 1997–2021.

First, the corpus is summarised by: (1) the number of publications through time; (2) the topmost published in journals; (3) the most productive countries (by author affiliation); and (4) the most published authors. Second, author and country collaboration networks are built. Finally, document descriptions are: (1) evaluated for co-occurrences of words across the corpus; (2) analysed using Latent Dirichlet Allocation (Blei et al. 2003); and (3) analysed for the most commonly mentioned countries.

2.1. Probabilistic topic models

Topic modelling is a statistical method that attempts to determine a latent structure from a collection of documents (Boyd-Graber et al., 2014), the 'topics' in a given corpus. Here, topic models were built using LDA based on each document's available text (e.g., abstracts). LDA is an unsupervised machine learning method that determines the probability (γ) of a given document (d) belonging to each of k topics based on their shared text (Blei, 2012). Documents are clustered hierarchically into topics characterised by their most frequently occurring words, with each document assigned a probability of belonging to each of the k topics (Perry and McGlone, 2021). The number of topics (k) is a pre-defined parameter that can be statistically determined; however, it is ultimately a subjective choice (Murakami et al., 2017). Statistical approaches were found to be uninformative, suggesting between 2 and 30 topics with a mean of 16. Thus, we modelled a range of topics ($k = [4, 10]$) and qualitatively assessed the results, settling on $k = 6$ based on the author's expert opinion.

Stopwords (common words such as "it", "the", and "and") were removed from the texts before building the topic model using the tidytex package (version 0.3.2; Silge and Robinson, 2016) in R. Search query terms were also removed to facilitate modelling the topics within the corpus. Words in the text are also stemmed (e.g., "environmental" is reduced to "environment") using the Porter approach to improve the identification of latent topics using the SnowballC package (version 0.7.0; Bouchet-Valat, 2020). Lemmatisation (reducing words to their root meaning, e.g., "drive" and "drove" become commonised to "drive") was also experimented with but made little difference to the topic model, so word stemming was preferred.

2.2. Country mentions

Document texts were searched for the most commonly mentioned counties by matching words against the list in the country code package (version 1.3.1; Arel-Bundock, Enevoldsen and Yetman, 2018). The country code list includes alternative names for countries to match their common name (i.e., the US, USA and United States are all matched to the United States). The frequency of country mentions can give an idea of where is being talked about the most, in contrast to the countries publishing the most literature. The caveat of this approach is that while it provides information on which countries are mentioned most frequently, it does not determine why they are mentioned. For example, a country may be frequently mentioned due to high carbon emissions or vulnerability to climate change. Some country names may also be conflated with city or region names (e.g., Georgia, the country, may be confused with Georgia, the state); however, this is expected to have little influence in this corpus.

Beginning our research with an understanding of the evolving terrain of climate justice literature, we uncovered dominant publication patterns, notable authors, and areas of geographical concentration. This involved a bibliometric analysis, thoroughly outlined in the preceding section (our full data set can be accessed here). We present the crucial findings from our study, which will describe the parameters of climate justice research. In addition, we present a conceptual framework of climate justice based on our results, which encompasses both the key themes as well as the critical gaps in the climate justice scholarship.

3. Results

Through an in-depth bibliometric analysis, our research aimed to shed light on the contours of climate justice research. By examining a large dataset (more than 1600 publications) over a long period (1997–2021), we could identify the research trajectories that developed over time and the key researchers and journals contributing to climate justice discourse. As a result, our findings offer an overview of academic engagement with climate justice both as a theory and a social movement.

3.1. Core journals, authors, and research collaboration networks

As of 1 July 2021, 1683 publications from the Scopus database focused on climate justice (based on the terms employed by authors in keywords, abstracts, and titles) (Table 1). The scholarship consists primarily of articles (N = 1167, 69 %) but also includes chapters in books (N = 192, 11 %), reviews (N = 156; 9 %), books (N = 104, 6 %), and onference papers (N = 46, 2.7 %). The journals that published the most papers on the topic of climate justice include Environmental Justice, which was established in 2008 (N = 35); Climatic Change (N = 35); Sustainability (N = 31); Global Environmental Change (N = 29); Local Environment (N = 27); Geoforum (N = 25); Wiley Reviews: Climate Change (N = 22); Environmental Politics (N = 21); Climate Policy (N = 20); Development (N = 18) (see Table 2).

The scholars who authored the most publications were J. Paavola (N = 10) (2008), J.T. Roberts (N = 9) (Roberts, 2009) and P.K. Nicholas (N = 7) (Nicholas and Breakey, 2017) (see Fig. 1). However, the majority of published authors were not specialists in the field of climate justice, having authored one publication. The most cited publications within this literature were by Eakin and Luers (2006), Leach (2010), Walker (2012), Thomas and Twyman (2005), Paavola and Adger (2006), Goodman (2012), Eriksen (2011), Pretty et al. (2010), Kabisch et al. (2016), and Bulkeley (2013) (see Fig. 2). There was limited overlap between the most productive authors and most cited publications, except for Paavola.

A co-author collaboration network (Fig. 3) of the top 70 most strongly linked authors shows eleven different clusters (consisting of more than three scholars co-authoring publications together) can be detected, with the most extensive set (including highly cited author B.K. Sovacool) consisting of nine researchers. Researchers with the greatest bond strength (co-authoring six papers) include L.C. Stringer and A. J. Dougill, and S. Breakey and P.K. Nicholas. In turn, all four authors are among the fifteen most productive authors in the field (with between 6 and 7 publications in the period covered by our review) and are considered influential authors in the development of the field of climate justice. Interestingly, none of the authors with the strongest collaboration networks (as shown through co-authorship) are amongst the top ten most cited authors. Strong linkages between researchers (shown through co-authorship) do not necessarily translate into higher citations within climate justice studies. Still, it can increase researchers' productivity (in terms of the number of publications they can publish).

The most productive countries (see Fig. 4), which we deduced by examining the location of authors' institutional affiliations, were located in the Global North (developed countries) rather than the Global South (developing countries). English-speaking United States of America (N = 1051) was the most productive country, followed by the United Kingdom (N = 483), Australia (N = 192), Canada

Table 1
Publication type.

Publication Type	Number
Article	1167
Review	156
Note	18
Book	104
Book Chapter	192
Conference Paper	46

Table 2
Top 15 most popular journals.

Number of papers	Journal name
35	Environmental Justice
35	Climatic Change
31	Sustainability
29	Global Environmental Change
27	Local Environment
25	Geoforum
22	Wiley Interdisciplinary Reviews: Climate Change
21	Environmental Politics
20	Climate Policy
18	Development
15	International Journal of Environmental Research and Public Health
15	Ethics, Policy and Environment
15	Journal of Environmental Studies and Sciences
12	Journal of Human Rights and the Environment
12	Climate Change Management

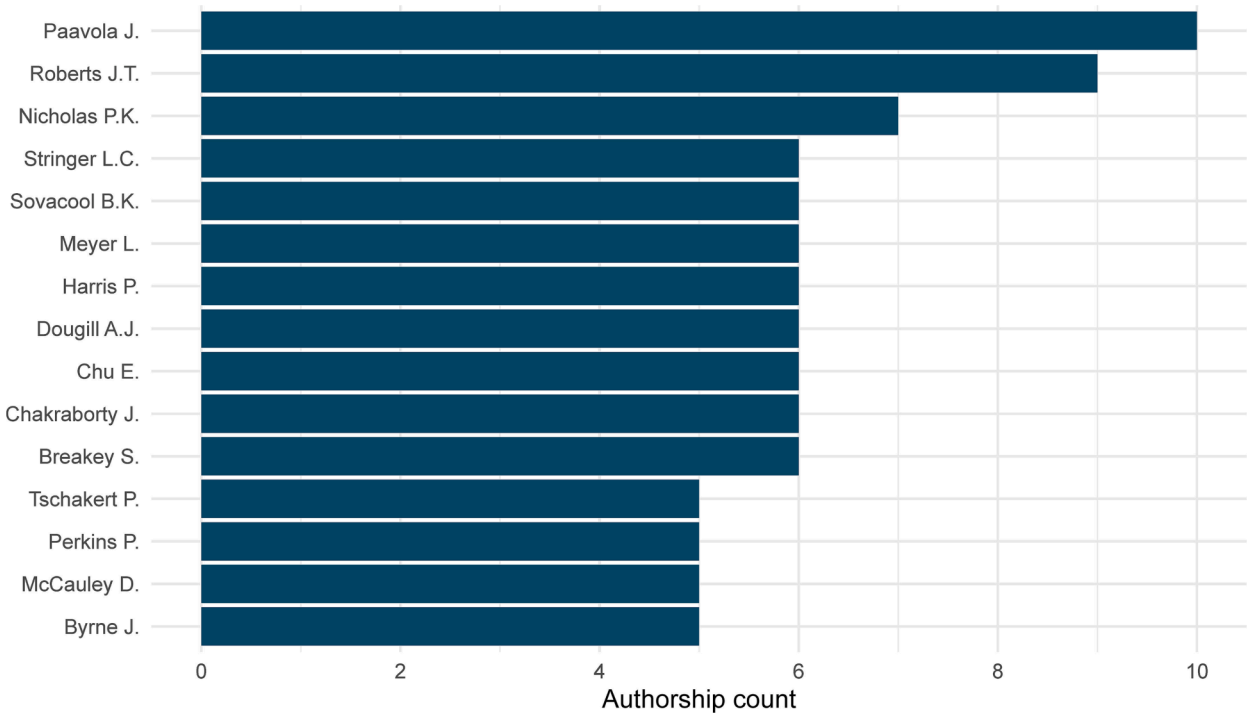

Fig. 1. Fifteen most productive authors.

(N = 191), and Germany (N = 113). Other productive countries included the Netherlands (N = 65), Sweden (N = 64), Spain (N = 49), South Africa (N = 44), India (N = 39), Brazil (N = 37), Norway (N = 37), New Zealand (N = 35), France (N = 33) and China (N = 32). Since many publications include more than one author, some countries' productivity totals may be inflated. However, irrespective of any inflation, examining the authors' geographical location reveals that most scholars writing about climate justice are situated at institutions in the Global North, which contrasts with the location of case study sites.

In most instances, the countries that were the focus of research (country name listed as a case study or example in the abstract) were not the same as those listed as the most productive countries (in terms of authorship affiliation) (see Figs. 4 and 5). The United States was still the most frequently reported site of research attention (N = 94). Moreover, the majority of countries (N = 11) that appeared in the top 15 research sites (these could include case studies, examples, or even meeting locations) were not recorded amongst the top 15 most productive countries (based on author affiliation). Countries like Italy (N = 70), Belize (N = 59), Iceland (N = 47), Mexico (N = 21), and Benin (N = 17) ranked highly as the focus of research about climate justice. Still, far fewer researchers from those countries were writing and publishing about climate justice (at least in the peer-reviewed sources listed on Scopus). Global South nations, in particular those in the Central and South Americas (Belize, Bolivia, Brazil, Colombia, and Mexico) and Africa (Benin, Niger, Guinea), received a far higher degree of attention from scholars who were/are based at institutions located in Global North.

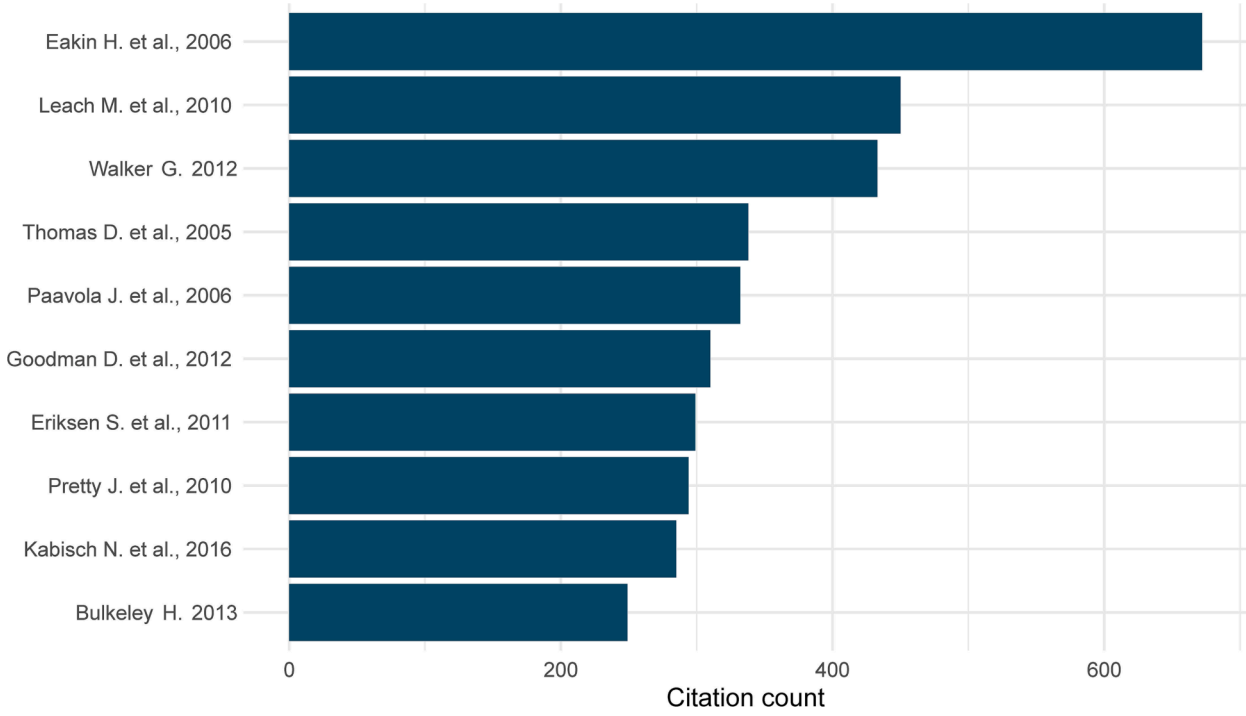

Fig. 2. The most citation publications on climate justice.

3.2. *Temporal evolution of the literature*

To monitor the development of the annual number of publications on climate justice since its inception, our study did not set a start date for searching in the Scopus database, which allowed us to identify publications from 1997 until mid-2021 (the date of our review). Fig. 6 depicts the evolution of climate justice scholarship in connection to the number of studies published each year. The number of total publications (see Fig. 6) demonstrated quasi-exponential growth during the period 1 January 1997 to 1 July 2021 (our review period), with a marked increase between 2008 and 2021, a testament to the growing importance of climate justice within the broader fields of climate change mitigation, adaptation, global environmental change (34 publications in 2008, 166 in 2018, 183 in 2019, 238 in 2020, and 192 in the first six months of 2021).

Our findings demonstrate that climate justice publications slowly emerged into academic discussions and debates about international climate agreements and questions to do with how to fairly and effectively distribute the benefits and burdens of climate change in the late 1990s; the first article mentioning climate justice in 1997 (the year of the third Conference of Parties that resulted in the Kyoto Protocol) there was a slow uptake of climate justice in the early years following its first mention, with fewer than ten publications per year until 2006. Since then, the number of publications per year has proliferated, reaching 238 papers in 2020 (in the data captured by Scopus). Climate justice research has developed over time, from focusing mainly on global and national emissions contributions to analysing justice at numerous scales, including the local. This change has allowed for a more in-depth examination of what is considered just when making adaptation decisions. Concurrently, works on the subject have become more varied, addressing a wide range of topics. Despite the expansion and broadening of study themes, essential frames of climate justice, such as distributive justice and procedural justice, as well as fundamental concerns, such as climate change and uneven development, continue to be critical.

The first publication discussing climate justice occurred in 1997. In that year, the journal article "International fairness and justice in addressing global climate change," written by Ian H. Rowlands, discussed efforts to advance an international agreement covering the allocation of future greenhouse gas (GHG) emissions amongst OECD countries (Rowlands, 1997). Rowlands observed that OECD countries were advocating for different rules regarding the distribution of GHG emissions and trying to reach an agreement. However, different conceptions of justice were evident in international negotiations about how much individual (or groups of) countries within the OECD should be permitted to emit, what GHG emissions reduction targets were needed, and what mitigation actions should be used. To create an international climate mitigation agreement that was fair, equitable and efficient, Rowlands proposed a dual strategy that included a short-term agreement in which a standard flat rate of emissions was allocated to every country in the OECD and a longer-term agreement in which emissions were differentially distributed to each country (based on a criterion to be determined at a later date). Early publications, which numbered less than ten each year between 1997 and 2005, similarly employed a distributive framing of climate justice, which focused on how the benefits and burdens of climate change are distributed equitably amongst different populations (typically framed in terms of discussions of nation-states or future generations) (Page, 1999). Most researchers

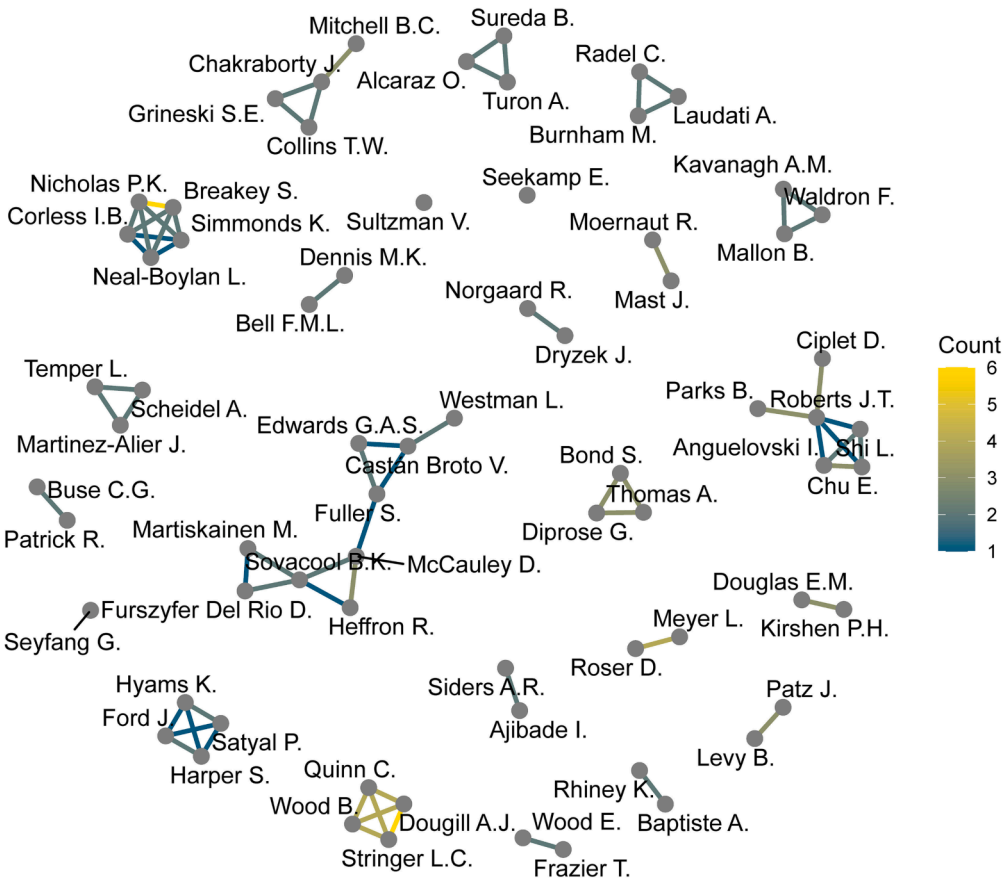

Fig. 3. Co-author collaboration network of the top 70 most strongly linked authors. *Each node represents an author, and each edge (link between authors) is coloured by the number of joint publications.*

concentrated on the explorations of justice within climate change negotiations and agreement-making at the global scale, emphasising the conflict between countries in the Global North (Annex 1) and the Global South (non-Annex one as per the Kyoto Protocol). Debates and disputes were occurring at the time between which countries (or rather blocs of countries) were more or less responsible (differential responsibility) for causing climate change and how this translated into climate policies, finance, and direct actions to reduce GHG emissions and adapt to the impacts of climate change. The most common distributive justice framing articulated within the scholarship (reflective on international climate agreements such as the UNFCCC and its Kyoto Protocol) was that of historical responsibility (Common But Differentiated Responsibilities = CBDR). Historically, many Global North countries, specifically long-standing industrialised nations including the USA, Canada, Germany, New Zealand, France, and Japan, contributed the most to rising greenhouse gas emissions through their rapid and exponential use of fossil fuels (tied to industrialisation, urbanisation, deforestation and other processes of rapid social-ecological changes) from the late eighteenth and early nineteenth century onwards. These countries and their citizens benefited economically, politically, and socially (although benefits were not always equally distributed) from high-GHG emissions ways of life, and even now (in 2023), they enjoy a higher standard of living than most people living in countries of the Global South.

Issues of ethics and justice in climate change mitigation policies, strategies and projects received significant attention from scholars. Existing analyses typically concentrate on identifying the critical tenets of fair "burden sharing" for reducing GHG emissions (shared amongst individuals or nations) with the aim of preventing dangerous climate change and stabilising rising temperatures to a safe level (Hjorthen, 2020; Torpman, 2019).

Far less attention is devoted to visualising justice as it links to who should be responsible for initiating and financing adaptation actions and how adaptation is funded. While the two questions (who and how) are interrelated, adaptation finance raises some specific justice concerns (as noted by Ciplet, one of the top 15 most productive researchers) (Ciplet et al., 2013; Khan et al., 2020). Some of these connect to matters of distributive justice and what adaptation means for burden-takers. Indeed, adaptation involves considering the diversity of burdens (economic, social, cultural, and ecological) and burden-sharing arrangements. This includes the distribution of the impacts of climate change on individuals, communities, businesses, and nations, with certain countries or populations more vulnerable to climate change (taking on more climate-related harms or burdens) than others, including humanitarian responses to climate extremes (Hjorthen, 2020). Likewise, some nations, communities or households endured more significant costs (economic,

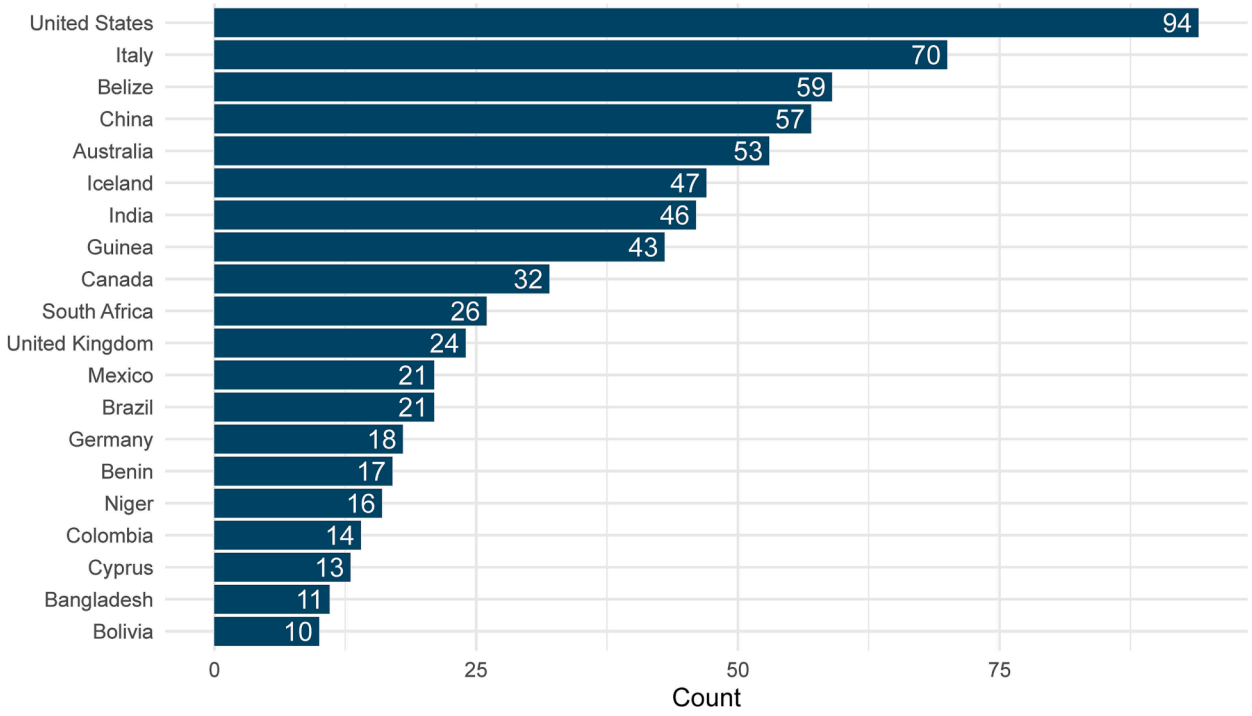

Fig. 4. Countries mentioned as a site of research in reviewed articles.

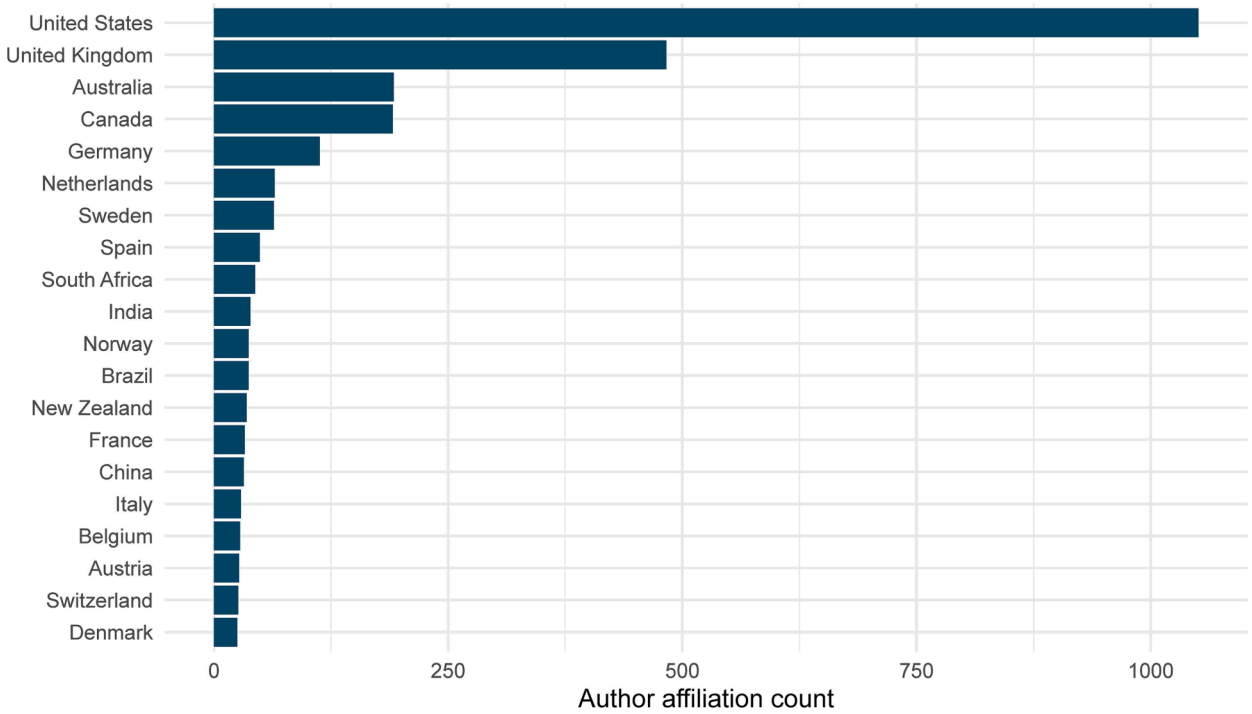

Fig. 5. Countries listed as most productive countries (in terms of authorship affiliation).

socio-cultural, environmental and emotional) from mitigation or adaptation actions than others. Distributive questions are also relevant to those who receive the benefits (of changing climate conditions, new climate mitigation technologies, and climate change adaptation interventions). It also raises procedural justice questions regarding fairness in decision-making and financing processes,

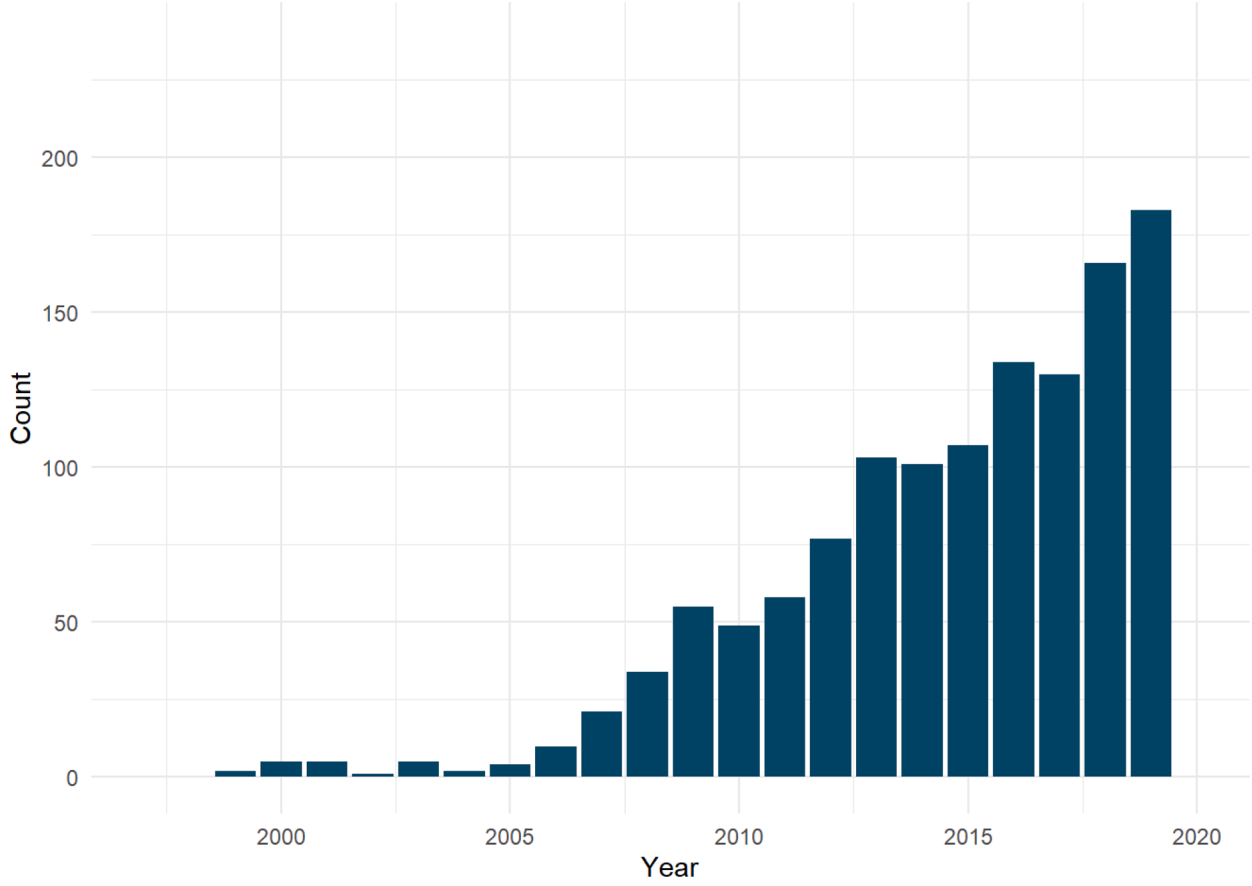

Fig. 6. Total number of climate justice publications.

such as relevant parties being able to participate and how adaptation funds are raised, accessed, administered, and allocated.

3.3. How has climate justice research developed over time?

The first decade of climate justice scholarship was mainly focused on distributional justice, specifically regarding climate change mitigation topics. The six modelled topics can be qualitatively characterised by their highest probability terms as 1) education and food security; 2) sustainability, development and policy; 3) international relations and carbon emissions; 4) health, vulnerability and adaptation; 5) policy and activism; 6) human rights and Indigenous people (Fig. 7). Early climate justice literature investigated questions related to nations' emissions and their responsibilities for taking action to mitigate climate change (see topic three, Fig. 7). Similarly, during the first five years, many scholars debated (paralleling the debates within international climate negotiations) on what basis global climate change mitigation agreements should be based. They asked questions about what constitutes an effective, equitable and fair way of determining how much countries should be expected to reduce their emissions under United Nations agreements. Various authors suggested different ethical justifications (e.g. historical responsibility, per capita emissions, development status, and human rights), depicted under topics two and six of Fig. 7.

Another strand within the early climate justice papers featured the topic of sustainability (see topic one and Figs. 7 and 8); this included a diverse array of papers including Indigenous environmental management, sustainable development, and also the sustainability of capacity-building (i.e. to assist developing countries to make low-carbon transitions). While few in number, early publications (1997–2006) were concerned primarily with topics three and one, which may reflect the commencement of the United Nations Millennium Development Goals a few years earlier (in 2000) but also could reflect several UNFCCC Conference of the Parties (COP) decisions. The first decision of COP7, for instance, stated that "addressing the many challenges of climate change will make a contribution to achieving sustainable development" (United Nations Framework Convention on Climate Change, 2001). While there was a slight decline in sustainability-focused climate justice publications from 2006 onwards, the number of papers exploring the intersections of sustainability, development, and climate justice remained relatively consistent over the next 15 years under review. In turn, several of the most cited authors (Leach et al. 2010 and Pretty et al., 2010) wrote about sustainability and climate justice, highlighting how the topic influenced the development of climate justice studies.

Up until 2005, there were relatively few publications that explored the justice dimensions of climate change adaptation. However,

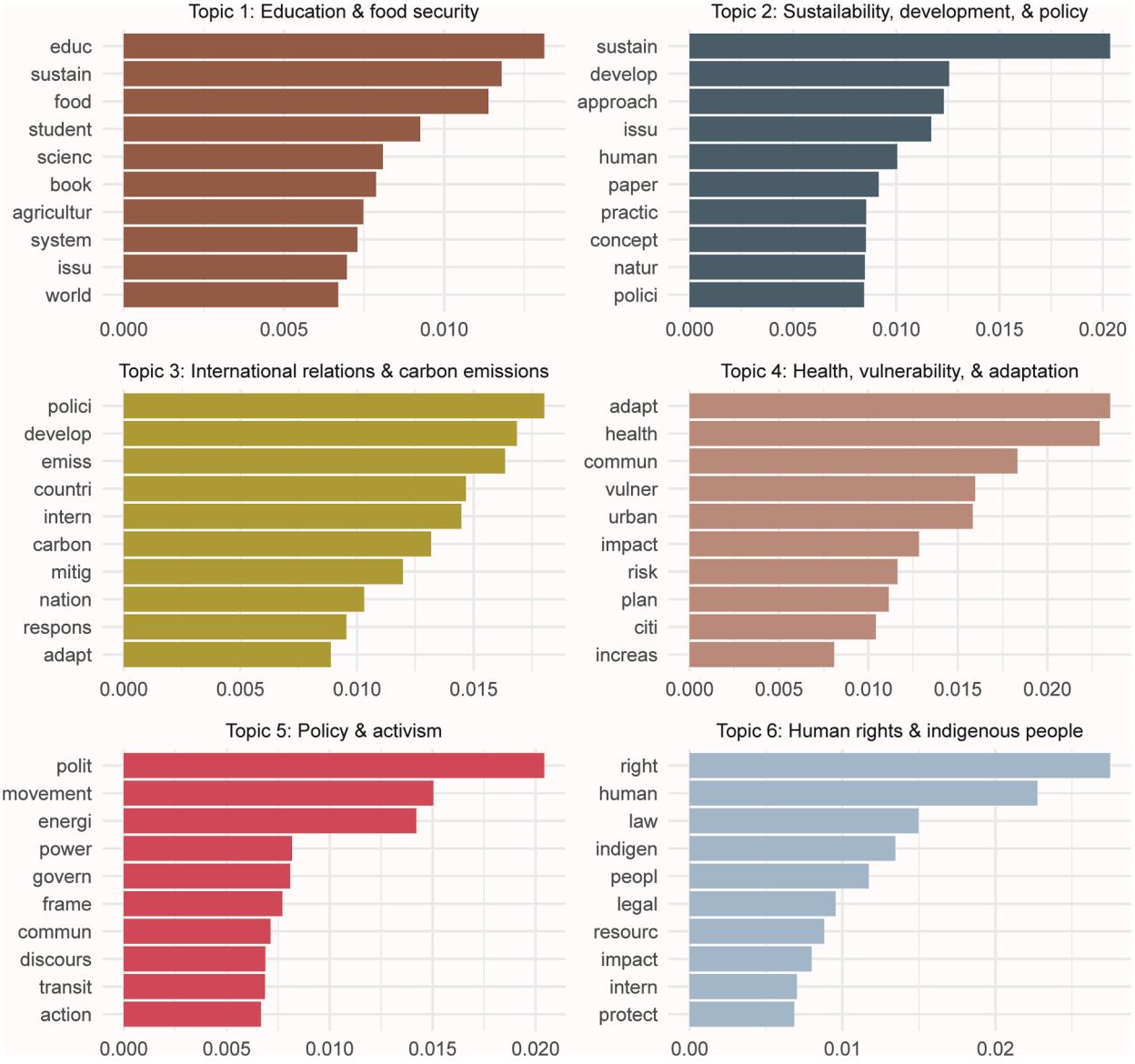

Fig. 7. Six topics (corpus) identified through topic modelling within the published papers, with the keywords appearing most frequently within each topic.

since 2006 onwards, there has been a significant increase in the number of papers examining what climate adaptation justice or just adaptation is (or could be), as shown in topic four in Fig. 8, as well as the works of some of the most cited authors (Eakin and Luers, 2006; Eriksen, 2011) and the most productive authors (Paavola, 2008; Tschakert, 2012; Tschakert et al., 2021).

Another small but growing topic of inquiry that emerged over the last decade or so focuses specifically on population health; this includes the physical and psychological health impacts of climate change and the vulnerability of communities and individuals to worsening health conditions. For instance, some of the most cited authors we previously mentioned (Kabisch, 2020; Nicholas and Breakey, 2017) explore in various ways the climate justice dimensions and dilemmas that governments and practitioners (planners and medical professionals) are (or will) face when planning for and responding to the health impacts of climate change. A plethora of recent scholarship highlights the critical need for public health policy-makers and medical practitioners to understand how existing population health disparities intersect with climate change to create heightened vulnerability amongst certain groups (Chalupka et al., 2020; Gutschow et al., 2021). These authors concur that healthcare providers need to broaden their knowledge of the structural determinants of health (including institutional racism and environmental racism) and the impacts of climate change at a local level (Carmichael, 2019; Curtis and Oven, 2012; Gutschow et al., 2021); they also provide a variety of suggestions for how healthcare providers can actively promote resilience and health, advocate for vulnerable communities and their patients' needs, and address institutional injustices within existing medical institutions and practices (Boeckmann and Zeeb, 2016; Chalupka and Anderko, 2019;

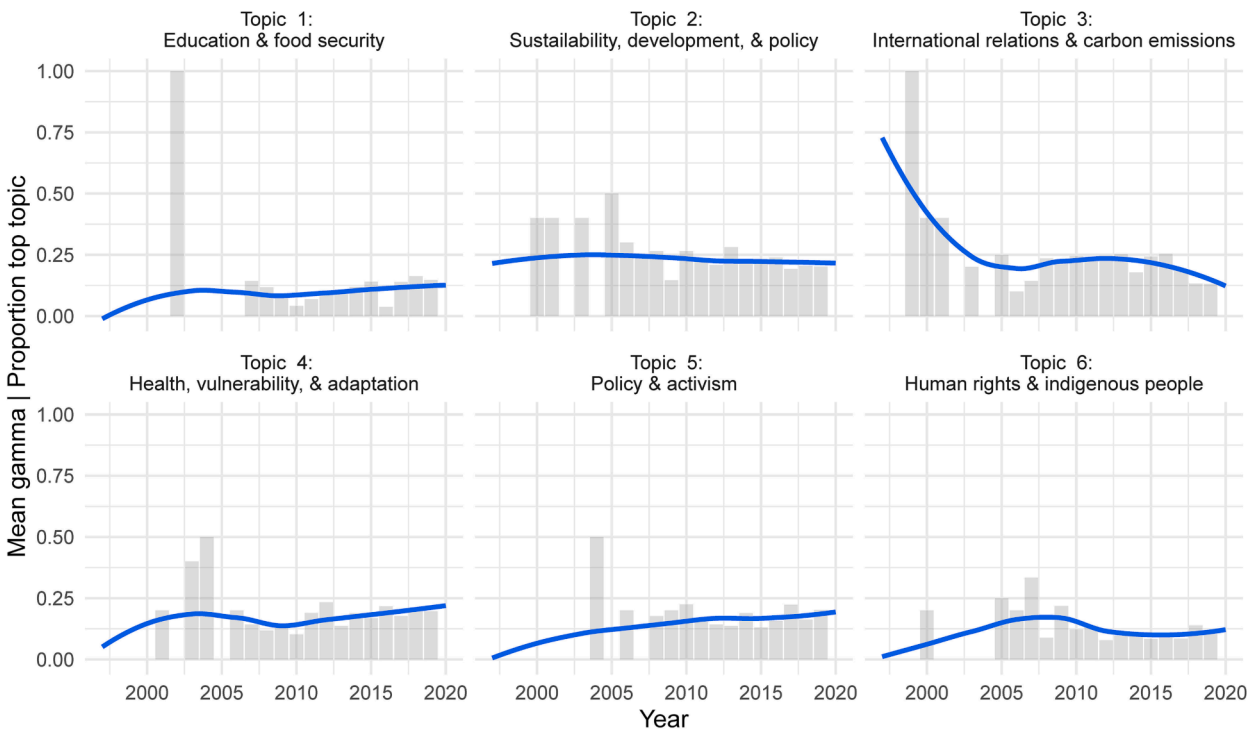

Fig. 8. The frequency with which the six topics appeared in the literature over the last two decades. *The graphs show what proportion (out of 1) of the literature featured the topic six topics each year from 1998 to 2020. The blue line depicts the mean gamma for each topic (thereby showing if the topic was being written and published more or less over time). Grey bars indicate the proportion of documents belonging to each topic for a given year.*

Divakaran, 2016). The health and wellbeing of children and youth are essential areas of study within this topic (Chalupka et al., 2020; Sheffield, 2011), which closely relates to topic one (politics and education).

Since 2005, a growing number of researchers have begun to explore if and how children and youth are being educated about climate change inside and outside classroom settings and the representation of young people as both climate victims and actors (Basu, 2019; Howard-Jones, 2021; Oberman, 2021). A slow but steady increase in publications in this area (shown in topic one of Fig. 7), which includes the emergence of a distinct critical pedagogy of climate change education (Oberman, 2021; Sandhaus, 2018) as well as School Strikers' actions to enact their learnings and their politics of climate justice (Martiskainen et al., 2020; Thomas, 2019; White et al., 2021). Given the ongoing developments in both climate change education and youth climate activism around the world in the 2020s, it is likely that we will continue to see further increases in the number of publications on this topic in the immediate future.

3.4. What have been the research themes amongst the most cited papers?

The most cited papers (see Fig. 3) explore the justice implications of climate change impacts, vulnerability and adaptation (topic four), mitigation (topics three), and sustainable development in the context of rural livelihoods and agriculture (topics one and two) (Bulkeley, 2003; Eriksen et al., 2011; Thomas and Twyman, 2005). It should be noted that other topics (six: human rights, five: climate politics, and one: education) are not explored in any great depth in the highly cited papers, even though other (less cited) publications do explore those topics (Ackerly, 2018; Baxi, 2016; Grady-Benson and Sarathy, 2016; Hens, 2014). Across the topics covered by the most cited papers, we identify three common themes: 1) a critical, reflexive approach to climate action, 2) attention to sub-national and local scales, and 3) interrelationships between different aspects of climate justice.

The papers advocate a critical, 'reflexive' approach to climate mitigation, adaptation, and sustainable development that is cognizant of the unequal power relationships, uncertainties and potential unintended consequences implicated in governing and responding to climate change (Eakin and Luers, 2006; Eriksen et al., 2011; Goodman et al., 2012; Kabisch et al., 2016). For instance, the articles examining various aspects of adaptation and vulnerability (topic 4) call for recognition that some nations and sub-national social groups are more severely impacted by climate change than others because of socio-political factors and inequalities that enhance vulnerability, and hence should be prioritised in adaptation decision-making processes (Eakin and Luers, 2006; Eriksen et al., 2011; Paavola and Adger, 2006). Likewise, in challenging assumptions that climate policies and sustainability movements are necessarily politically neutral and beneficial (Eriksen et al., 2011), the papers advocate deeper consideration of what climate justice entails and how it can be achieved. Often using case studies, the papers highlight how strategies for climate adaptation and mitigation often prioritise the values and agendas of the Global North, privileged social groupings, and current generations and can exclude or even contribute to further harm amongst less powerful groupings like nations of the Global South, women, those of lower socio-economic

class, people of colour and so on (Eakin and Luers, 2006; Eriksen et al., 2011; Goodman et al., 2012; Paavola and Adger, 2006; Pretty et al., 2010; Thomas and Twyman, 2005; Walker, 2012). Reflexivity is an essential tool for achieving equitable vulnerability reduction, both now and in the future, and increasing such reflexive deeper approaches could assist in designing inclusive, forward-looking, flexible, and appropriate strategies for the context.

The papers, particularly those exploring topic two (sustainability) and topic four (adaptation and vulnerability), identify the sub-national and local scale necessary for pursuing climate justice. Firstly, local governments and grassroots movements such as local food networks may facilitate democratic, inclusive, context-appropriate adaptation, mitigation, and sustainable development (Bulkeley, 2003; Goodman et al., 2012; Kabisch et al., 2016). Secondly, attending to the sub-national and local scale reveals significant diversity within populations that are instructive for designing and amending climate strategies in line with justice (Walker, 2012). For instance, there is evidence that the benefits of adaptation and mitigation policy are unequally distributed in both the Global North and South (Eriksen et al., 2011; Kabisch et al., 2016; Walker, 2012). Poorer and/or female farmers may be excluded from livelihood diversification and agricultural extension policies that help wealthier male farmers adapt to climate variability (Pretty et al., 2010; Thomas and Twyman, 2005), whilst employees of carbon-intensive industries may suffer job losses and financial insecurity as national governments encourage transitions towards a low-emissions economy to slow future climate change (Walker, 2012). As the literature shows, considering local social dynamics is an integral element of reflexive, justice-oriented solutions to climate change that avert harm and pursue wellbeing for all (Eriksen et al., 2011; Paavola and Adger, 2006).

Finally, the papers demonstrate that different dimensions of justice (particularly distributional and procedural justice) are interrelated to climate adaptation and mitigation (Eakin and Luers, 2006; Pretty et al., 2010; Walker, 2012). Distributional justice is used to analyse the unequal distribution of climate vulnerabilities and to think through how responsibilities for emissions reductions are and should be distributed amongst society (Walker, 2012b). Procedural justice can be applied to analyse representation and inclusion in climate change decision-making and to understand whose values, knowledges, or priorities are centred (Thomas and Twyman, 2005; Walker, 2012). Often, distributional injustices can be (at least partly) addressed through enhancing procedural justice (Eriksen et al., 2011; Goodman et al., 2012; Pretty et al., 2010; Thomas and Twyman, 2005). For instance, Kabisch et al. (2016) note that nature-based solutions to climate change may unwittingly decrease the wellbeing of some lower-income urban residents who face increased rent prices as neighbourhoods become more liveable and attractive (a distributional injustice). Including a wide range of local residents in decision-making processes (procedural justice) is crucial for averting potential distributional harms and enhancing wellbeing across urban populations (Kabisch et al., 2016). However, inclusion can be tokenistic and cannot guarantee distributional justice (Thomas and Twyman, 2005). Some groups (including future generations) cannot participate in decision-making, creating potential distributional harms since their needs cannot be known (Walker, 2012).

Analysis of the papers that scored highest for a given topic sees a different set of themes emerge. For topic one – sustainability – the papers converge around several key themes, including the importance of different cosmologies in understanding environmental changes (Adamson, 2011); the evolution of the environment movement and the need for environmental activists to work towards environmental justice and social justice (Karber, 2015; Ziser, 2017); and lastly the role of environmentally conscious art and literature for educating and inspiring actions (Adamson, 2011; Fancy, 2021). The papers underscore the evolving nature of public awareness of environmental issues, the importance of cultural narratives, and the pressing need for multi-faceted environmental activism.

For topic 2 – human rights and international negotiations – the papers are broadly concerned with the need for transformative changes to address climate change and the need for ethical and responsible leadership (be it by governments, religious institutions, or corporations) (Deneulin, 2013; MacUt, 2019). There is agreement amongst scholars that humanity is facing rapid global changes and unprecedented environmental challenges, and the papers underscore the need for multi-faceted, ethical, and transformative solutions. At the same time, the proposed pathways to transformational change varied – from religious bodies (MacUt, 2019) to relational ethics and capabilities (Antadze, 2019; Deneulin, 2013; Fazey, 2018) – the underlying message is consistent: the complexities of climate change demand innovative thinking, just actions, and a collective global effort.

The highest-ranked papers under topic three examine equity and fairness within international and national climate mitigation policies. Scholars explore how to balance the efficiency of climate mitigation measures with the sustainable development needs of Global South countries, particularly in terms of financial transfers and carbon pricing (Alcaraz, 2018; Bauer, 2020). The papers also highlight the role of public perceptions in shaping national climate policy directives and evaluating production-based and consumption-based emissions reduction policies (Schleich, 2016; Steininger, 2014).

Papers under topic four are chiefly centred on understanding the nature of biophysical and social vulnerabilities to the impacts of climate change, most notably extreme weather events and, to a lesser extent, adaptation actions (Jesdale et al., 2013, 2013; Larson, 2021; Mitchell, 2018; Osiecki, 2021). Recurrent themes include the disproportionate exposure of socially and economically marginalised groups, notably racial and ethnic minorities and/or low socio-economic households (Chu and Michael, 2019; Jesdale et al., 2013), to the adverse impacts of extreme weather events (such as flooding and heatwaves). For instance, studies from cities in the USA identify how predominately Black or Latinx neighbourhoods possess fewer green spaces and less tree coverage than predominately White neighbourhoods (Jesdale et al., 2013; Mitchell, 2018). During heatwave events, Black and Latinx neighbourhoods are subjected to higher temperatures than White neighbourhoods; added socio-economic inequities mean that Black and Latinx households are less likely to possess air-conditioning units, which further exacerbates their vulnerability to extreme heat. In summary, reviewed papers illuminate how social inequities underpin climate vulnerability and emphasise the need for adaptation actions and policy initiatives to address these disparities.

Papers under topic five focus on climate justice activism and explore the intersections between climate justice and social justice (Grosse and Mark, 2020; James and Mack, 2020; Pye, 2010). Papers emphasise the importance of climate activists showing solidarity or allyship with marginalised communities in the Global South and Global North (including Indigenous peoples, ethnic minorities, and

refugees) and adopting anti-racist, anti-colonialist, and/or decolonial stances (Grosse and Mark, 2020; James and Mack, 2020; Thomas Black et al., 2016). Taken together, the papers stress the critical need for the climate movement to acknowledge and take action to address the various forms of oppression and privilege operating around the world as well as within various climate NGOs and seek to build local and transnational collaborations that promote the voices and aspirations of historically marginalised peoples.

The reviewed papers predominately revolve around the legal dimensions of climate justice, such as how climate change threatens the long-term existence of certain places/communities/nation-states, such as Indigenous communities in the Arctic and Small Island Developing States or SIDs) (Robert, 2009; Stoddart, 2016). Studies explore the role of the courts in determining who is responsible for taking climate actions and examine specific climate litigation cases wherein institutions or individuals attempt to use the legal processes to force governments and/or corporations to reduce their emissions (de Charles, 2007; Setzer and Vanhala, 2019). Other studies examine how climate change is damaging the human rights of vulnerable communities (such as those in the Arctic and SIDS) and advocate for actions to help those most negatively affected by climate change, be it through legal actions (Robert, 2009) or training counsellors to be climate justice advocates and educators (Hilert, 2021).

4. Discussion and concluding remarks

In this bibliometric review of climate justice literature, we catalogued 1683 Scopus-indexed documents spanning 1997 to July 2021. While not exhaustive in capturing every research nuance, this quantitative mapping offers insights into evolving trends in climate justice scholarship. It aligns with a broader academic narrative, evident in the progression of knowledge generation over the last two decades. Our findings demonstrate the exponential increase in climate justice studies published over the previous two decades and provide a baseline for future growth in the field of climate justice. The observed growth trajectory aligns with findings from other reviews in the discipline (Alves and Mariano, 2018). A salient observation is that researchers are beginning to move beyond theoretical constructs of climate justice and delve into real-world studies of climate injustices, examining the impact of hegemonic systems on policy and actions and efforts to minimise or address these injustices (Ahmed and Eklund, 2021). Yet, there remains a need for scholars, practitioners, and decision-makers to prioritise the experiences and knowledge of the individuals and communities most negatively impacted by climate change.

A concerning feature noted in our review is the predominance of authors from institutions based in the Global North, even when discussions revolve around Global South issues. Regrettably, Scopus limitations prevented an exploration into the representation of BIPOC (Black, Indigenous, People of Colour) authors in the Global North. Nonetheless, the underrepresentation of these groups, notably in academia and institutions like the Intergovernmental Panel on Climate Change (IPCC), has been substantiated elsewhere (Eaves, 2021; Ford et al., 2016). The implications of this imbalance resonate with historical criticisms, where researchers from dominant groups often misrepresent or undervalue the experiences of marginalised populations, perpetuating existing power dynamics (McIntosh, 2017; Smith, 2013). Despite its transformative and emancipatory aims, the field of climate justice runs the risk of creating or reinforcing injustices when climate projects and policies are not designed in partnership with affected communities through co-production and co-design.

Critically, the omission of 'subaltern voices', especially in the context of climate change impacts on post-colonial communities in the Global South and marginalised communities (particularly BIPOC), highlights the persistence of colonial paradigms in much of the climate justice discourse (Rice et al., 2023; Sultana, 2018; Torres et al., 2020). Such a bias (evidence of coloniality) can further undermine the rights, experiences, and knowledge of those most affected by climate change.

Although the climate justice movement has its roots in BIPOC-led environmental justice activism, the roles of BIPOC communities, activists, and researchers in pioneering climate justice are often overlooked (Schlosberg and Collins, 2014). The lack of representation, both in media coverage and academic discussion, paints an incomplete picture (one which is often whitewashed), which further challenges efforts towards genuine climate justice (Cultural Survival, 2022; Grosse and Mark, 2020; Méndez-Barrientos et al., 2022). Thus, there are multiple issues tied to the under- or mis-representation of BIPOC peoples and Global South peoples within the existing climate justice scholarship. Indeed, recognitional climate justice is not confined to the examination of who is recognised within climate policies, it also relates to whether research reflects researchers, scholarship, and aims that connect to the particularities and contexts of societies and social groups. As Zimm et al. observe (2024, p. 24) "[j]ust as demographic processes ideally reflect the heterogeneity of the public, science should ideally cultivate diversity". There can also be epistemic benefits, "in the sense that diverse backgrounds can lead to people to recognize different issues in research".

Expanding on Nixon's (2011) concept of "slow violence", we note the slow violence of climate change. Historical and contemporary structures and dynamics of globalisation, capitalism and colonialism interact and overlap to compound the injustices marginalised populations face (Chu and Michael, 2019; Sultana, 2022). Understanding these climate injustices necessitates a holistic view, encompassing both scalar and situational perspectives. Nevertheless, the politics of global climate governance remains fraught, with developed nations often sidestepping their historical and ongoing contributions to global emissions (Okereke and Coventry, 2016). The Common But Differentiated Responsbilities (CBDR) in the UNFCCC Convention remain a crucial factor causing disagreement across most decisions.

Furthermore, existing scholarship accentuates the politics of knowledge and power struggles embedded within climate research, governance and policy-making, highlighting climate-related norms' contentious nature (Parsons, 2015; Wilkens and Datchoua-Tirvaudey, 2022; Winter, 2019). Some evidence suggests the coloniality of knowledge, shaping academic knowledge production as well as international and domestic climate policy development, is serving to marginalise or distort the knowledges and experiences of those most affected by climate change (Wilkens and Datchoua-Tirvaudey, 2022, p. 126). Recently, Wilkens and Datchoua-Tirvaudey (2022) studied how international climate agreements and climate governance structures are guilty of representing colonial structures

and neglecting the experiences of those most affected by climate change. Along similar lines, Wijsman and Feagan (2019, p. 72) point out how climate decision-making processes and actions frequently involve the following:

> "*exclusion of women and indigenous people, as well as other socially marginalised groups, from being recognised as legitimate knowers [of climate change is] problematic because it limits the kind of knowledge thought relevant, and risks keeping the realities that only socially marginalised groups experience hidden within the dominant social order*".

Furthermore, existing research accentuates the politics and power struggles embedded within climate discourse (Milanez et al., 2022; Wilkens and Datchoua-Tirvaudey, 2022). Consequently, robust climate justice frameworks require unpacking the assumptions that influence knowledge creation and policy decisions, often steeped in Western paradigms and overlooking power dynamics integral to racism, colonialism, and gender (Parsons et al., 2019).

Recent scholarship demonstrates that climate injustices are spatially and historically produced and tied to colonialism, racism, and globalisation (García-López, 2018; Sultana, 2018). These injustices are disproportionately impacting women and gender minorities (Ahmed, 2016), racialised communities and nation-states in the Global South (Nightingale, 2017; Smith, 2016) and IBPOC in the Global North (Fayazi et al., 2020; Nursey-Bray and Palmer, 2018), with gender hegemony intersecting with power dynamics to make sure groups more or less vulnerable to climate risks. Yet, explorations of gender and racialised dimensions of climate (in)justices remain a small subset of the climate justice scholarship. A few publications (James and Mack, 2020), all under topic five, explore the ethics of allyship or solidarity within climate justice movements (such as Extinction Rebellion) and advocate for climate activism to be more strongly aligned with other social-ecological struggles (immigration justice, racial justice, Indigenous environmental justice).

However, our analysis of the ten most cited papers and the five most highly ranked papers under each topic reveals that most climate justice papers do not adopt intersectional, anti-colonial or decolonial lenses, and the voices of under-represented groups are marginalised. As the work of Sultana (2022) and others (Ahmed, 2016; Ahmed and Eklund, 2021) shows in the context of climate adaptation, climate change contributes to heightened intersectional gendered vulnerability, inequality and marginalisation in certain countries. However, our knowledge of how power dynamics, subjectivities, and oppression intersect in different contexts and shape

Fig. 9. Intersectional Climate Justice Conceptual Framework (Created by Lead Author).

climate mitigation and adaptation justice remains piecemeal. Since the compounding impacts of social-ecological changes interact with gendered (which intersect Indigeneity, race, class, sexuality, migrant status and so on) relations in different contexts in different ways, more research is needed that examines the historical and contextual axes of differentiation, marginalisation, discrimination and oppression. Thus, there is considerable potential for climate justice scholars to advance the field by drawing on critical social theories (intersectional feminist, anti-colonial, anti-racist, decolonial) and, in doing so, to advance intersectional climate justice-centred praxis as proposed by Rice et al. (2023).

Emerging scholarship is starting to recognise the pressing need to integrate critical social theories within climate justice studies. For instance, Winter's (2023) and Whyte's (2020) draw on Indigenous philosophical traditions and decolonial theorising to explore Indigenous peoples' different understandings of what constitutes climate justice. Likewise, Rice et al.'s recent book (2023) on urban climate justice employs an intersectional and anti-racist praxis to understand how varying power structures and dynamics intersect to perpetuate injustices in cities worldwide. Furthermore, while contemporary climate justice scholarship is expansive, it often lacks a comprehensive spatial, temporal, and ontological focus. As such, there is ample scope for research that transcends human-centric perspectives and considers future generations and more-than-human entities (Winter, 2023). Such research (intersectional, decolonial, anti-racist, multi-species) offers the potential to allow us to develop more effective, tailored, and equitable processes and solutions (which is to say, more just responses to climate change). Sultana (2022, p. 122) argues that "*there is no singular or ideal climate justice for all, no singular arrival point, but a becoming, of doing more and better, unlearning to relearn and continually taking stock of various collectivities for equitable and transformative praxis*".

Theories of climate justice are nonetheless helpful to understanding the justice implications of climate policies, planning, and on-the-ground actions (be it pertaining to mitigation, adaptation, or loss and damage). The development of climate justice-centred understandings of climate mitigation and adaptation, as our bibliometric review highlights, is associated with deployment of a wide array of different justice theories surrounding issues of fairness, equality, and equity of impacts, processes, and outcomes. Based on our review, we propose a conceptual framework for intersectional climate justice research and policy discussions that encompasses five dimensions of justice – distributive; procedural; recognitional; corrective; and temporal – to expand the study of climate justice. The framework (see Fig. 9) summarises the climate justice theorising of the papers we reviewed, as well as identifying entry points for climate justice research and policy discussions (see Table 3).

The journey to unravel the intricacies of climate justice is both essential and complex. Our bibliometric review offers a snapshot of the prevailing academic landscape but underscores the remaining critical gaps. From addressing the coloniality in knowledge production to the real-world experiences of marginalised communities, there is a pressing need for comprehensive, intersectional, and decolonised research. This approach, which acknowledges the legacy of past injustices and the challenges of contemporary climate dynamics, is essential to forging a path towards genuine global climate justice.

For future research, several distinct themes could take the field forward. First, research focusing on future generations and more-than-human entities is needed, given that our decisions have long-lasting impacts on humans and other species. This research could explore time scales of decisions, forecast impacts and societal changes, and even examine dimensions of imagination and visions of the future, focusing on younger people and marginalised groups. Can there be a shared imagination for climate justice? What role do future visions play in how climate justice is imagined, thought of, and enacted upon? What does an anti-racial, decolonised society look like that promotes intersectionalist decision-making, and what does this mean for climate mitigation, adaptation and loss and damage? What would a world led by women and youth look like?

Second, a clear theme is the integration of climate justice and climate activism with broader struggles for justice. What can we learn from other societal processes, groups and movements that have enacted social change? What do immigration justice, racial justice, and Indigenous environmental justice show us about the potential to move towards more equal decision-making processes? How does "true inclusion" emerge or is enacted in these struggles, and what would that look like in climate mitigation and adaptation processes on local and global scales?

Third, some of this research also calls for rethinking climate adaptation "success" and "effectiveness": if not all groups are on equal footing in a neighbourhood and disparities and injustices continue to exist despite adaptation efforts, then we cannot call that community/neighbourhood/city a well-adapted place. A more holistic approach to adaptation then considers structural and underlying vulnerabilities and increases our standards of climate-just adaptation. What are the standards and principles of climate justice that build on and guide these efforts? Another future critical research for climate justice is loss and damage, where climate justice questions mainly take centre stage.

Finally, the Global Goal on Adaptation (GGA), as decided at COP28, specifically mentions participatory and fully transparent, gender-responsive, human rights approaches while also singling out "intergenerational equity and social justice" and extending its focus to "children, youth and persons with disabilities". This calls again for more targeted research into what a climate just GGA is and how these critical approaches and stakeholder groups participate in, are included, and represent a way forward for a more just and informed adaptation across all scales. The GGA also moves adaptation away from only local-scale small case studies and opens up new possibilities for climate justice research to consider global, transboundary, and broader scales at which climate adaptation occurs.

CRediT authorship contribution statement

Meg Parsons: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Quinn Asena:** Writing – original draft, Visualization, Software, Methodology, Formal analysis, Data curation. **Danielle Johnson:** Writing – original draft, Investigation. **Johanna Nalau:** Writing – review & editing, Conceptualization.

Table 3
Entry points for understanding climate justice. The table highlights key questions to guide climate justice research and policy discussions. It is inspired by the work of Zimm et al., (2024,p. 23).

Temporal and Intergenerational Justice	Procedural Justice	Recognitional Justice	Corrective Justice	Distributive Justice
Temporal justice focuses on: • Emphasises the health and well-being rights of current and future generations. • Acknowledging diverse cultural understandings of differ – linear in Western contexts versus cyclical or spiral in many Indigenous cultures. • Temporal justice involves transition justice, focusing on sequencing mitigation efforts for long-term equitable outcomes, and the continuous need for adaptation to climate change impacts, underscoring the absence of an endpoint in adapting to or compensating for loss and damage. • It also explores strategies for ensuring the health and well-being of humans and more-than-humans in future generations through carefully sequenced adaptation policies and actions.	**Procedural justice focuses on** • Inclusive decision-making in climate governance and planning processes, ensuring representation of diverse identities and addressing the under-representation of certain groups due to structural barriers like racism, language barriers, ableism, Casteism, gender injustices, and homophobia. • Prioritising the inclusion of historically marginalised groups in all decision-making levels, acknowledging that varying identities and forms of oppression. Key groups include women and gender diverse, Indigenous peoples, African American and Afro-Latin/Caribbean peoples, refugees, disabled peoples, LGBTQ+ communities, and socio-economically disadvantaged groups. • Importance of representing communities impacted by climate change, environmental degradation, and biodiversity loss in policymaking.	**Recognition of:** • Diverse identities, knowledge, worldviews, values, and experiences. • The interplay between identities, power structures, oppression, and participation. • The importance of Indigenous and local knowledge, including the rights of non-humans, in driving equitable and effective climate actions. • The value of unpaid care work and other invisible labour. • The need for research to reflect the diversity of societies and social groups. • Implementation of climate policies in a manner sensitive to the affected communities' livelihoods, beliefs, and values.	**Corrective justice focuses on:** • Addressing past wrongs through apologies, reparations, and financial compensation, focusing on historical responsibility. • It overlaps with distributive justice, emphasising the responsibility of Global North countries for past emissions and involves actions to compensate Global South countries for climate harms and the loss of development opportunities from transition. • It includes providing climate finance based on historical responsibility and polluter pays principle, aiding the most impacted countries. • Corrective justice also demands examining existing injustices within countries and addressing the disproportionate impact on vulnerable communities due to historical injustices.	**Distributive justice involves:** • Fair allocation of environmental benefits and burdens, focusing on current and future needs, especially for marginalised and vulnerable groups disproportionately affected by climate and environmental risks. • It is concerned with equitable access to environmental goods and the redistribution of resources to reduce environmental harms and climate risks while enhancing social and/or ecological well-being. • This justice framework uses metrics and indicators like health, well-being and energy use to assess and guide the redistribution of resources and efforts to reduce vulnerabilities and addresses both economic and non-economic losses from climate change.
Key questions to be considered: • How do time preferences influence climate policy? • How can policies be sequenced over time to enable just futures? • What provisions are made for future generations? • How are responsibilities for climate change and climate action distributed across generations? • How are current actions going to affect future generations? • How is climate finance structured to support long-term sustainability?	**Key questions to be considered:** • Who is involved in climate change policies and decision-making? • How are decision-making processes designed? • How are different forms of knowledge and different knowledge systems evaluated and utilised in forming climate policies and actions? • Who is being left out of the research and policy-making pertaining to climate change? • What barriers exist to participation of marginalised groups?	**Key questions to be considered:** • What forms of knowledge are valued within decision-making processes, climate policies, and actions? • How are different identifies and values considered? • How do the impacts of climate change threaten identities, values, and modes of living of different social groups? • How are different social and cultural values and ways of life considered in the design and implementation of climate solutions? • How do climate policies address the intersectional	**Key questions to be considered:** • How are responsibility and liability for climate change determined? • What criteria are used to assign responsibility for greenhouse gas emissions and their consequences? • What forms of compensation are adequate? • How are the rights and needs of vulnerable populations' prioritised in corrective justice mechanisms? • What legal frameworks support corrective justice? • How can loss and damage be addressed? • What challenges and opportunities exist for	**Key questions to be considered:** • How are the impacts of climate change distributed? • Who bears the burdens of mitigation efforts? • How are the benefits of climate actions allocated? • What are the mechanisms for climate finance? • How is compensation for loss and damage addressed?

(*continued on next page*)

Table 3 (*continued*)

Temporal and Intergenerational Justice	Procedural Justice	Recognitional Justice	Corrective Justice	Distributive Justice
		impacts of climate change, considering factors such as gender, race, ethnicity, and socioeconomic status?	seeking legal redress for climate-related harms through the judiciary? • How is the principle of common but differentiated responsibilities applied in this context?	

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Meg Parsons (MP) is co-Editor-in-Chief for Climate Risk Management. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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