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ADVANCED REVIEW

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Public participation, engagement, and climate change adaptation: A review of the research literature

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Abstract

There is a clear need for a state-of-the-art review of how public participation in climate change adaptation is being considered in research across academic communities: The Rio Declaration developed in 1992 at the UN Conference on Environment and Development (UNCED) included explicit goals of citizen participation and engagement in climate actions (Principle 10). Nation states were given special responsibility to facilitate these by ensuring access to information and opportunities to participate in decision-making processes. Since then the need for public participation has featured prominently in calls to climate action. Using text analysis to produce a corpus of abstracts drawn from Web of Science, a review of literature incorporating public participation and citizen engagement in climate change adaptation since 1992 reveals lexical, temporal, and spatial distribution dynamics of research on the topic. An exponential rise in research effort since the year 2000 is demonstrated, with the focus of research action on three substantial themes—risk, flood risk, and risk assessment, perception, and communication. These are critically reviewed and three substantive issues are considered: the paradox of participation, the challenge of governance transformation, and the need to incorporate psycho-social and behavioral adaptation to climate change in policy processes. Gaps in current research include a lack of common understanding of public participation for climate adaptation across disciplines; incomplete articulation of processes involving public participation and citizen engagement; and a paucity of empirical research examining how understanding and usage of influential concepts of risk, vulnerability and adaptive capacity varies among different disciplines and stakeholders. Finally, a provisional research agenda for attending to these gaps is described.

This article is categorized under:

Vulnerability and Adaptation to Climate Change > Institutions for Adaptation
Policy and Governance > Governing Climate Change in Communities, Cities, and Regions

KEYWORDS

citizen engagement, climate change adaptation, public engagement, public participation

1 | INTRODUCTION

The importance of public participation in responding to climate change has featured in key international statements since the Rio Declaration developed in 1992 at the United Nations Conference on Environment and Development (UNCED) included explicit goals for citizen participation and engagement in climate actions (Principle 10). Its significance was reiterated more than 28 years later in the Intergovernmental Panel on Climate Change (IPCC) Special Report on the impacts of global warming of 1.5°C above pre-industrial levels, which specifically identified public participation in adaptation planning as a means to enhance capacity to cope with climate change risks (IPCC, 2018). Similarly, issues related to public participation in climate action have long been a concern for researchers (Few, Brown, & Tompkins, 2007), although a paucity of empirical work in relation to public participation in adaptation planning is often lamented (Burton & Mustelin, 2013; Sarzynski, 2015; Wamsler, 2017; Whitmarsh, O'Neill, & Lorenzoni, 2013). Increased pressure from civil society and a widening of public activism around climate change—exemplified by the impact of Greta Thunberg and her Fridays for Future school strikes, as well as the emergence of the Extinction Rebellion movement—means that attention to matters of public participation in climate change adaptation at this time is particularly apposite. A quantitative analysis, combined with a critical review of published research collated through Web of Science, as presented in this article, provides an important entry point to reflect on and review research examining public participation in adapting to climate change. This article is therefore aimed at researchers interested in understanding how public participation for climate adaptation has been and is being considered across a multiplicity of disciplines.

Before setting out the parameters of the review it is useful to clarify first what is meant by public participation and its allied terms. While there is no singular universal definition, public participation is primarily viewed as an umbrella term incorporating various forms of interaction with people, from informing and listening through dialogue, debate, and analysis, to implementing jointly agreed solutions. Research in land-use planning forms the foundation for much contemporary attention to such participation in public policy (Arnstein, 1969; Nelkin & Pollak, 1979; Smith, Nell, & Prystupa, 1997; Wiedemann & Femers, 1993). This work identifies varying levels of participation, particularly in terms of the intensity of engagement with publics and the degree of control over decision-making that is afforded to publics through that participation. Rowe and Frewer (2000, 2005, pp. 253–254) in contrast focus on the dynamics of information flows between a sponsoring entity and participating publics. Participation is seen as necessitating a bidirectional flow of information, whereas communication is characterized by a unidirectional flow of information between sponsoring entity and the public, with public consultation being the unidirectional flow of information from public to sponsoring entity.

Ultimately, and importantly for this review, there are multiple synonyms for public participation and different understandings of those terms across geographical contexts, academic disciplines, and professions. This makes conducting a review challenging but nonetheless important both in terms of fostering greater cross-fertilization of ideas among researchers from different disciplines and developing robust dialogue with participating sponsors such as local authorities and local or national governments about their understandings of and goals for participation around climate adaptation. In light of this and the growing recognition that adaptation to climate change will only become more pressing over time, this advanced review provides a critical appraisal of the literature specifically focusing on the explicit articulation of public participation and engagement in relation to climate change adaptation from the landmark year for climate change policy 1992 up to 2018.

The review comprises four sections: First, a detailed account of the methodology used in the scientometric analysis is presented, discussing the advantages and limitations of the chosen approach. The second section presents the results of the scientometric analysis, which characterizes a corpus of abstracts of peer-reviewed publications drawn from the Web of Science Database, based on key terms and phrases related to engagement and participation in the context of climate change adaptation, and detailing the justification for the choice of risk as the key theme of the review, as well as presenting temporal and spatial distributions of papers, the territorial distribution of authorship, and lexical dynamics. This is followed by a thematic analysis which offers a critical review of numerically significant themes and those directly relevant to the research questions from the corpus, particularly focusing on public participation and climate action in relation to the concept of risk, and sub-themes arising from this: Risk perception and communication and flood risk. In the final section of the article, gaps in current research are mapped and a prospective agenda for attending to matters of engagement and participation around climate adaptation strategies is outlined. Due to the volume of peer-reviewed material to examine this review does not include gray literature such as policy statements and plans, although conducting a systematic study of this material in the future would usefully complement this review.

2 | METHODOLOGY

The analysis of the articles was carried out in three phases (Figure 1). In Phase I, the Web of Science database was examined for all articles with titles or abstracts containing the phrase "climate change adaptation". As established in Section 1, there are different terms used to capture the ways people are engaged in climate change adaptation. In the absence of an accepted and comprehensive lexicon for public participation, we then conducted a search of the climate change adaptation literature between 1992 and 2018 using three configurations: "citizen engagement", "public participation", and "public engagement." This resulted in a set of 484 publications (Annex 3). Further searches were conducted for two other terms, citizen involvement and city–citizen interactions, which identified three further papers. Given the small number of additional papers, these were not included in the final analyses. There is however scope for more nuanced work identifying and examining additional terms which may be used in particular locations or situations to describe participation, as we shall discuss in the critical reflection section. It is acknowledged that the Web of Science Database does not capture all research outputs, although in 2019 it claimed to include 1.7 billion cited references from over 159 million records. These are derived from 21,100 peer-reviewed scholarly journals in over 250 sciences, social sciences, arts and humanities disciplines, with conference proceedings, and book data also available.[1]

In Phase II, the abstracts of the publications in Annex 1 were imported into a Pandas (McKinney, 2010) DataFrame for textual analysis. Using the Scikit-Learn Python library (Pedregosa et al., 2011), these were used to produce a cleaned version (hereinafter a "corpus") of single-word terms (keywords), bigrams, and trigrams by cleaning, stemming, and lemmatizing (reducing inflected words to their root forms). This operation used a "bag of words" approach (Joulin, Grave, Bojanowski, & Mikolov, 2016) combined with feature extraction (Guyon, Gunn, Nikravesh, & Zadeh, 2008; Lewis, 1992) to produce the final terms and frequencies.

In Phase III, two kinds of textual analysis were carried out: First, the keywords, bigrams, and trigrams were ranked by frequency, to determine the 20 most-frequently occurring entries (Figures 2 and 3). In a second step, a complementary term-frequency/inverse-document-frequency (tf-idf) approach (See Aizawa, 2003; Ramos, 2003; Trstenjak, Mikac, & Donko, 2014) was used to rank the relative importance of keywords within the corpus. In addition to the textual analysis, publication dates were normalized to include only the year of publication, allowing a simple regression model to be fitted to the data. The feature extraction and tf-idf approaches have the advantage of speed and simplicity, though they are limited in the sense that they cannot identify synonyms (Berger & Lafferty, 1999), and rely on a preprocessing step (lemmatization, see Annex 1; Table 1) to give high-quality results. However, given that a close reading of the publications for the purposes of analysis and discussion forms an integral part of this review, this limitation was considered to be acceptable. Furthermore, while the regression model only includes a single term, it is nonetheless effective in demonstrating that scholarly attention in the area of public participation in climate change adaptation is expanding rapidly. The interactive Jupyter notebook used to carry out these analyses is available online.[2]

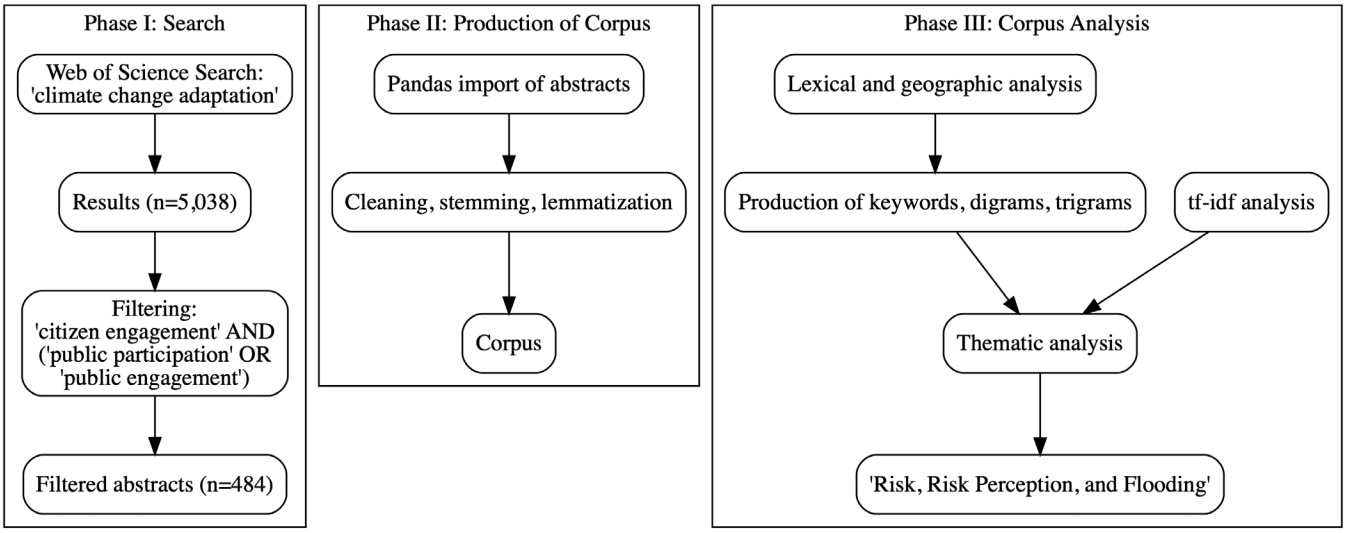

FIGURE 1 Analysis methodology, comprising three phases: Search, corpus production, and corpus analysis

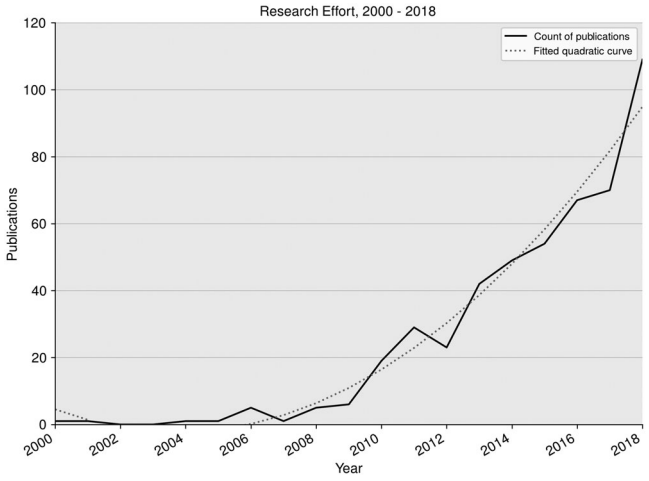

FIGURE 2 Number of publications per year. The fitted quadratic curve has an R^2 of 0.966

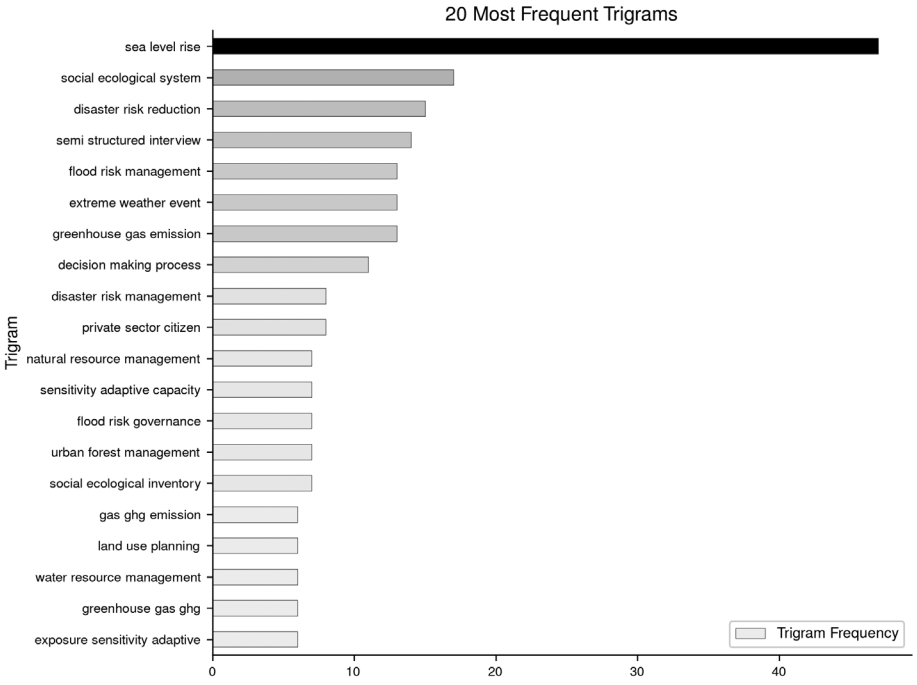

FIGURE 3 Most frequently occurring trigrams in the corpus

Finally, a thematic analysis of the most relevant themes in terms of their numerical significance, as identified in Phase III, was carried out. It should be noted that while the themes of the papers in this sub-sample overlap, they are considered separately for clarity in this review.

3 | RESULTS

3.1 | Lexical and geographic analysis

Though the parameters of the literature search were set to include publications from 1992 onwards, the conjunction of "public engagement," "public participation," or "citizen engagement," and "climate change adaptation" does not appear until the year 2000. This may be explained by changes in standard terminology; for example, activities related to Local Agenda 21 were much to the fore throughout the 1990s and early 2000s (Barrutia, Echebarria, Paredes, Hartmann, & Apaolaza, 2015). Furthermore, as Massey and Huitema (2013) explanation, adaptation did not become a key focus of public policy until the publication of the IPCC report titled *Impacts*, *Adaptation*, *and Vulnerability* in 2001

TABLE 1 Top five tf-idf scores

Keyword	tf-idf score
Water	0.16
Risk	0.154
Community	0.143
Policy	0.137
Local	0.12

(McCarthy, Canziani, Leary, Dokken, & White, 2001). We found that between 2000 and 2018, research effort at the intersection of participation, engagement and climate change adaptation has increased (Figure 2).

It is clear from the analysis that the overall frequency of publications is increasing year-on-year, beginning in 2005, showing a quadratic increase in attention to matters of participation and climate change adaptation, with publications more than doubling between 2017 and 2018.

The analysis of the corpus's trigrams (a group of three consecutive words) presented in Figure 3 shows that "sea-level rise" occurs most frequently (47 times); almost three times more frequently than any other term. This is a strong indication that there is a preoccupation with this particular climate impact in recent scholarship. Though the "sea-level rise" trigram (see Figure 3) appears far more frequently than any other, four of the 20 most frequently-occurring trigrams include the term "risk", which rises to six occurrences within the top 40, with "social–ecological system", a key concept in the system model of risk discussed later, also occurring frequently.

The single-keyword analysis (Figure 4) is confirmed by the tf-idf analysis, a technique that ranks the relative importance of a word within a corpus (Table 1): Water, risk, community, and policy are all highly-ranked. Based on these results, "Risk" was chosen as the central theme of the thematic analysis which follows.

Figure 5 shows the geographic distribution of research effort. Though there are some difficulties with this data—Clarivate analytics calculates this in relation to the institutional affiliation of the authors alone and not the geographical focus of the research—it provides a means of illustrating where relevant research is being undertaken. It is clear that US-based researchers contribute the highest number (83) of publications that consider public participation and engagement with climate change adaptation, followed by the UK and Australia. While it is not appropriate to use population size as a proxy for expected research effort it is nonetheless worth noting that The Netherlands, with a population of just over 17 million, contributes a research effort just slightly less than half of the US, with a population of 327 million—over 19 times as large. It should further be noted that researchers based in BRIC countries (Brazil, Russia, India, and China) are beginning to make substantial contributions to this field of research, with most (90%) of the publications from these nations appearing since 2015.

Figure 6 presents the disciplinary affiliation of the journal articles in the corpus. This indicates the range of academic perspectives that are contributing to debates at the nexus of climate change adaptation and public participation. While the subject classification for journals is automatically generated by the Clarivate metrics without any explanation of the metrics used for doing so and while it is possible to assign a paper to multiple subject categories, the graphic is instructive in its visualization of the balance of research effort across broad disciplinary boundaries. Despite the very human nature of public participation, the natural sciences (e.g., Meteorology and Atmospheric Science and Environmental Sciences Ecology) are the most productive in terms of the total number of papers published that include attention to public participation and climate change adaptation. Nonetheless, a considerable proportion of the total research effort is allocated to business and economics, with Geography, as a bridging discipline between the natural and social sciences, also a notable contributor to the field.

3.2 | Thematic analysis: Risk, risk perception, and flooding in climate adaptation

This section offers a critical review of numerically significant themes from the corpus. The results of the quantitative text analysis are presented, and used to contextualize the choice of themes and specific papers pertaining to these, which are discussed in more depth. We focus specifically on the theme of risk, and particularly on perceptions of flooding risk as a key theme identified in the scientometric analysis. Other themes, such as adapting to increasing and high temperatures which may result in droughts, changing patterns of disease and viable forms of agriculture, as well as adaptation to other forms of extreme weather events such as tornados, hurricanes, are less prominent in the corpus.

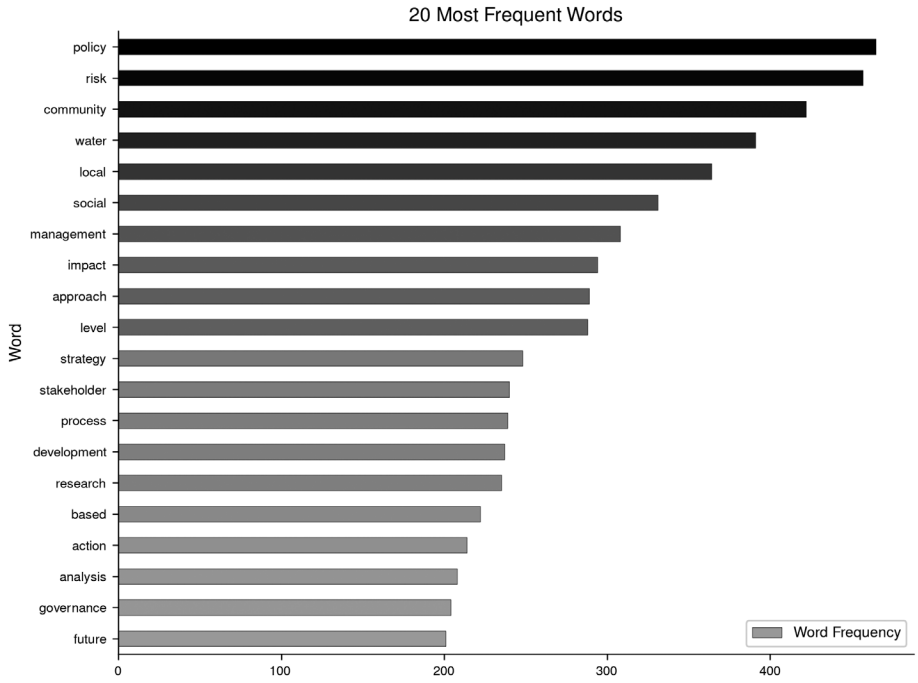

FIGURE 4 Most frequently occurring words in the corpus

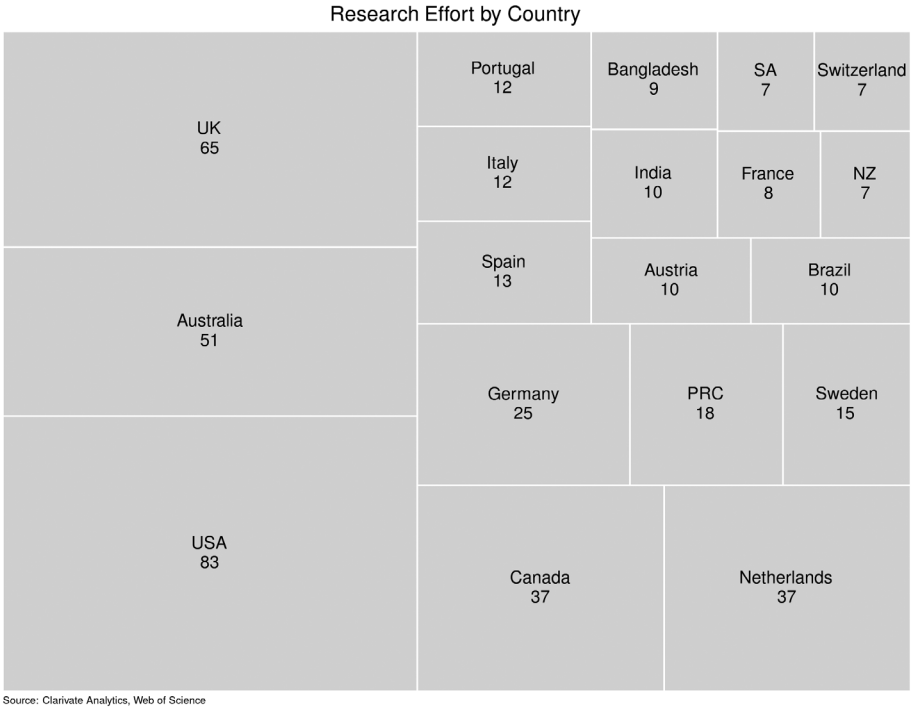

FIGURE 5 Clarivate Web of Science metrics of research effort grouped by geographic area of author affiliation for climate change adaptation and public participation

It is not possible within this paper to consider these additional themes, though they would benefit from dedicated attention in the future.

In this section, additional context is added by reference to papers outside the corpus, to expand upon and more usefully discuss the concepts under review. An analysis of single-word (keyword) frequency in the corpus, illustrated in Figure 4, shows that the words "risk," "policy," "community," and "local" occur most frequently (457, 465, 422, and 364 occurrences, respectively) in the abstracts. Of these four terms, "risk," "community," and "local" are worthy of further consideration: The search keywords which produced the corpus did not specify these terms, yet it is clear from the number of articles focusing on these themes that they are a key focus of research when considering climate change

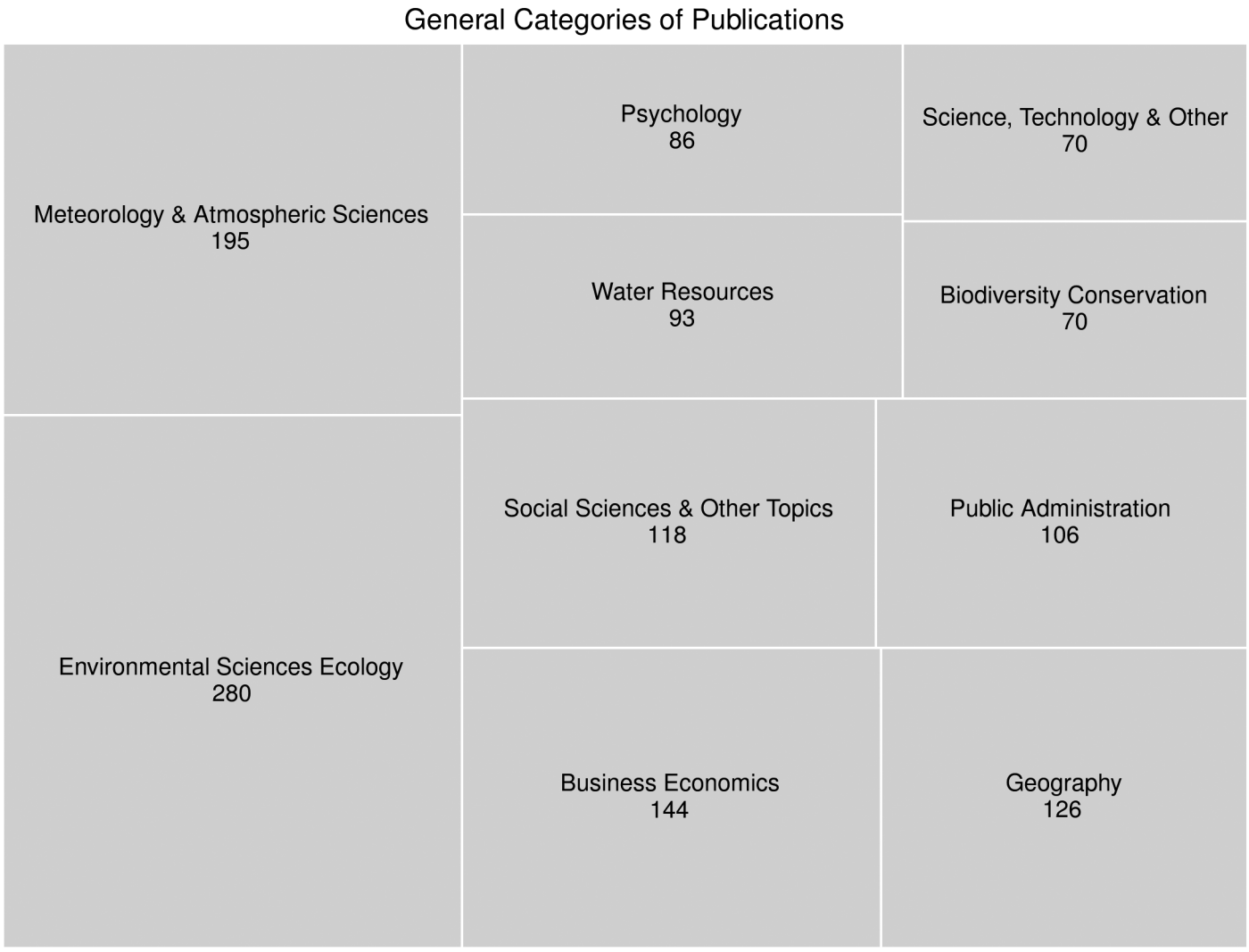

FIGURE 6 Clarivate Web of Science subject categories for climate change adaptation and public participation

adaptation and public participation. While "policy" was identified as a significant term, a close reading of the abstracts did not identify it as thematically significant, and it was excluded from further analysis. However, as mentioned previously, it would be useful to conduct a detailed review of gray and policy literature to explore more carefully how such documents address the intersection of policy with public participation and climate change adaptation.

The links between the leading trigram "sea-level rise" and the most frequently used words are clear. Sea level rise is experienced in places (e.g., at the local scale) by people living in areas (e.g., in communities) that are likely to be affected by it (e.g., being at risk). However, the conflation of citizen engagement and participation, localities, and adaptation raises interesting scalar questions given that much (though not all: See Bierbaum et al., 2013) adaptation planning to date has been conducted at national or international scales through initiatives such as National Adaptation Plans of Action (NAPAs; Woodruff & Regan, 2019), with local adaptation planning an emerging space of activity (Cloutier et al., 2015; Ford et al., 2016; Woodruff & Stults, 2016).

While the topics of risk, perceptions of risk and flood risk frequently overlap rather than being mutually exclusive, in order to provide a useful heuristic for this review we consider papers under these sub-headings separately based on their major focus, based on a close reading of their abstracts. More than a third of all publications in the corpus (33% or 160 publications) mention risk in some context, with another 12.6% (61) mentioning vulnerability. Before examining this corpus in detail it is useful to clarify the relationship between concepts of risk, vulnerability, and adaptation as it is often unclear (Brooks, 2003). This lack of clarity is due in large part to their use in different disciplines; natural hazard research tends to use the term "risk," whereas "vulnerability" (E. Downing et al., 2001) is

more commonly used by social science and climate change researchers. Among social scientists and climate scientists, the term "vulnerability" is often employed differently, with social scientists using it more broadly to refer to a set of socioeconomic factors determining people's ability to cope with stress or change (Allen, 2003). Climate scientists meanwhile tend to use it to characterize the likelihood of the occurrence and impacts of weather and climate-related events. These differences may be more usefully distinguished as *social vulnerability* and *biophysical vulnerability* (Brooks, 2003, p. 3). The relationship between these concepts is illustrated by Figure 7, from the IPCC 2014 WG II AR5 summary for policymakers, demonstrating that "risk of climate-related impacts results from the interaction of climate-related hazards (including hazardous events and trends) with the vulnerability and exposure of human and natural systems" (Field et al., 2014, p. 3).

In terms of the focus of this review, the complex landscape of risk and vulnerability research engages with public participation in different ways. For example, Smit and Wandel (2006) and Adger's (2006) work is contingent upon the conception of a community as a "social–ecological system", or just a "system" more generally. This is necessary to describe relationships and interactions within it in a concise manner, but it raises questions as to whether this systematic view excludes other kinds of more situated knowledge and relationships. Adger et al. (2009) see adaptation activities as societally endogenous and "inherently local and necessarily based on contextual knowledge" (p. 346), and suggest "[t]hat an adaptable society is characterized by awareness of diverse values, appreciation and understanding of specific and variable vulnerabilities to impacts, and acceptance of some loss through change" (Adger et al., 2009, p. 350). The ability to adapt is then affected, at last to some extent, by the availability of technologies and capabilities but also, and importantly "by the ethics of the treatment of vulnerable people and places within societal decision-making structures." (Adger et al., 2009, p. 350).

3.3 | Risk assessment, risk perception, and risk communication

The topics of risk perception and communication are deeply interlinked, as explicitly noted by Pidgeon (2012), who points out that uncertainty about impacts can result in what he terms "uncertainty transfer": A corresponding and counter-intuitive uncertainty concerning causes. A similarly counter-intuitive phenomenon is described by Domingues, Santos, de Jesus, and Ferreira (2018) in their case study of a vulnerable island barrier system, showing that while risk perception among surveyed inhabitants was high, their belief in the danger of hazards was low, and distant in time, and that authorities' efforts to increase their perception and decrease their psychological distance may in fact have had the opposite effect, due to what the authors believe is an understudied aspect of the psychological coping mechanisms which are at play. However, the work of Lawrence, Quade, and Becker (2014) with coastal communities in New Zealand demonstrates that previous experience of flooding heightens risk perception, and increased preparedness, as well as leading to a greater willingness to communicate with local government about adaptation. As Buys, Miller, and van Megen (2012) emphasize in their study of perceptions of climate change in rural Australia, a detailed understanding of the differing perceptions of climate change is crucial in order to effectively shape both national and local-level responses to climate change.

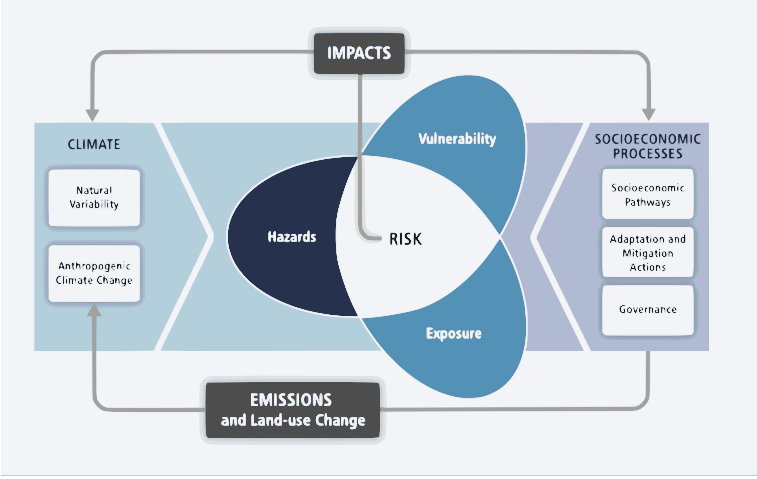

FIGURE 7 Illustration of the core concepts of the WGII AR5: "Changes in both the climate system (left) and socioeconomic processes including adaptation and mitigation (right) are drivers of hazards, exposure, and vulnerability" (Field et al., 2014, p. 3)

Johnson et al. (2012) have called for a more sophisticated approach to communicating risk, using Fischhoff's (1995) model of risk communication to demonstrate that to date, most climate change communication has stressed persuasion, rather than social movement mobilization or deliberation. They point out that while social movement mobilization has its own set of weaknesses, it can nevertheless complement persuasive communication strategies. Such mobilization can be activated by focusing on developing power and influence over decision making, subverting mainstream assumptions, and engaging people in collective action, such that "[d]eliberation, unlike the other two approaches does not define the solution or even, necessarily, the problem in advance, and thus offers the chance for people of contending viewpoints to jointly develop concepts and action agendas hitherto unimagined" (B. B. Johnson, 2012, p. 973).

Another possible method of mitigating the difficulties described is that of risk assessment, more specifically, community risk assessment (CRA). CRA is a participatory method used to assess hazards, risks, and capacities in support of community-based disaster risk reduction (DRR). Van Aalst, Cannon, and Burton (2008) review its evolution, noting that an explicitly participatory form of CRA may be useful in the integration of climate change risks arising at the global scale in a bottom-up, place-based approach to risk assessment. Bell, Turner, Meinke, and Holbrook (2015) study of health adaptation responses to climate change, has shown that an applied, complexity-oriented understanding of the impact of climate change is necessary in order to understand how they can affect both local communities and local services, compromising human health. Their development of an electronic tool demonstrates that CRA can be used to capture and make sense of these complexities, resulting in a more effective ordering of priorities for health sector adaptation, and thus more effective planning.

The use of electronic or geospatial media is by no means a panacea, however. As Lieske, Wade, and Roness (2014) work demonstrates, "geovisually-enhanced" communication strategies for flood risk are not guaranteed to be more effective than standard strategies, but they may enhance willingness to become politically active around the issue of climate change. As both Lawrence et al. (2014) and Lieske et al. (2014) suggest, these techniques could help to disrupt the perception that governments alone are responsible for providing protection from flooding and move toward a more inclusive and multi-scalar dialogue between national and local governments and citizens about the changing nature of flood risk. Carayannis and Campbell have attempted to widen this systematic interaction by conceptualizing a "quintuple helix," which frames interactions between governments, citizens, industry, and academia in the context of the environment (Carayannis & Campbell, 2010). Whether it is possible to re-orient society towards increased risk consciousness on a large scale, however, remains an open question.

3.4 | Participation, adaptation, and flood risk

As with the overall corpus of research at the intersection of climate change adaptation, citizen engagement, and participation, attention to matters of flood risk within this corpus has increased dramatically since 2011, accounting for more than half (77) of the 160 risk-related publications. These papers are largely authored by researchers based in, and focusing on, western high-income countries, with UK-based researchers producing over a third of all papers. Looking at papers that focus specifically on public participation and flood risk this pattern largely persists, although The Netherlands appears as another key locus of research. Collaborative and comparative research endeavors are also prominent in this field. For example, Williams, Costa, Celliers, and Sutherland (2018) bring together researchers based in Germany and South Africa to examine risks for water management in Durban, while Garschagen, Surtiari, and Harb (2018) explores the flood risk reduction strategies being employed in the high flood risk city of Jakarta, Indonesia. Both Eakin, Eriksen, Eikeland, and Oyen (2011) and Henriksen et al. (2018) undertake comparative work, with the former examining the implications of public management for adaptive capacity in Mexico and Norway and the latter using selected Nordic and other European examples to explore the potential for public participation across flood disaster risk reduction cycles.

The bulk of papers in this sub-corpus examine and assess existing approaches to climate change adaptation, with fewer (4) reporting on novel interventions developed by the researchers or in collaboration with other actors. The latter, more experimental, approach appears in papers focusing on citizen engagement in relation to developing action research for improving adaptive capacity (Picketts, Curry, Dery, & Cohen, 2013), using dialogic communication methods (Cone et al., 2013) or designing and testing other co-production approaches (H. Mees, Crabbe, & Driessen, 2017). Co-production is used to describe a process of including multiple actors in the formation of knowledge, recognizing that addressing complex problems such as climate change adaptation requires attention to scientific information, local needs, knowledge, and values in decision making (Djenontin & Meadow, 2018). Essentially, co-production

techniques attempt to bring together science, society, and policy as a means to improve problem-solving (Jasanoff & Wynne, 1998; Latour, 1998).

A small number of publications (2) report on the design and implementation of creative mechanisms to engage citizens, such as gaming. The "serious games" (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012) strategy adopted by Pontee and Morris (2011) is an example of this experimental approach to research that develops novel responses to pre-identified problems. Pontee and Morris (2011) begin their research from the pragmatic and ideological position that it will become increasingly important for stakeholders to become more fully engaged with consultation processes around flood governance and that more creative and imaginative ways of engaging will be required to do this. On one hand, this position is relatively uncontroversial as it is well-established that mainstream methods of citizen engagement have failed to produce significant levels of participation in climate adaptation planning (Lane, 2005). However, research focused on public participation in planning, and environmental planning more broadly has indicated that it is not just the method of engagement that affects whether people engage or not. Other factors such as a lack of trust in processes and a fear of co-option or manipulation can also affect people's willingness to engage (Davies, 2001a, 2001b, 2005). Indeed, attending to the power and politics of participation has been flagged as an important element of any assessment of, or intervention in, planning for more than 50 years (Arnstein, 1969; Cardullo & Kitchin, 2018).

It is interesting to note that Pontee and Morris (2011, p. 25) explicitly state that the game is "not intended to be used as an expert system for choosing management policies to other stretches of coast", justifying this based on the simplifications that had to be made for the process to sit within the parameters of the game's architecture. However, nothing is said about what elements of the decision-making process have been excluded or simplified, and in particular, whether these elements of complexity are related to technical matters, scientific processes or social, political, and economic maneuvers (or indeed all of the above). Also, the paper focuses on the development of the tool rather than its implementation and no papers on implementation or evaluation of the tool have been published to date. Elsewhere, however, work is emerging (see Connolly et al., 2012; Flood, Cradock-Henry, Blackett, & Edwards, 2018) which begins to demonstrate how serious games may support and enhance social learning in communities as a way of addressing the adaptation deficit which arises in the gaps between scientific knowledge and public understanding. They attempt to delineate where and how impact is being achieved through serious games, assessing which particular combinations of cognitive (e.g., knowledge and thinking), normative (e.g., norms and approaches), and relational (e.g., how people connect and network building) learning are being achieved. They find that influencing behavior and catalyzing learning for adaptation requires high levels of trust between researchers, practitioners, and community participants, experienced facilitators and robust processes for debriefing and evaluation postengagement. Whether and how such games might bring broader benefits beyond learning, for example, in relation to enhancing trust (Roth & Winnubst, 2014) and legitimacy (M. Alexander, Doorn, & Priest, 2018; H. L. P. Mees, Driessen, & Runhaar, 2014) or action, is still to be determined. Considering matters of visualization also appear in the work of Neset, Opach, Lion, Lilja, and Johansson (2016), who reviewed the use of geovisual tools to support participation in climate adaptation, while Sheppard et al make the case for community engagement and planning using scenarios and visualization (Sheppard et al., 2011).

In contrast to the experimental work of Pontee and Morris (2011), the bulk of papers in this sub-corpus examine existing interventions implemented to address the complex challenges of climate change adaptation to flooding. For example, Nye, Tapsell, and Twigger-Ross (2011) explore the emergence of a sociotechnical approach to flood and coastal risk management in the UK which explicitly seeks to expand community engagement and explore personal or community-level responsibility for flood risk planning, awareness, and resilience. These emergent sociotechnical approaches sit alongside more centrally managed structural and technical measures that have dominated responses to flood risk to date. Nye et al. (2011) focus on the drivers of a perceived "social turn" in flood risk management and they ask whether this marks a broader trend towards a more "civic model" (Owens, 2000) of environmental policy and planning that they call "flood risk citizenship." The civic model delineated by Owens (2000) suggests that deliberation, in this case with respect to adaptation to flood risk driven by climate change, does not rely on experts to set out the issues at stake; rather the issues are negotiated through discussions among all participants. Adopting a civic model in this way suggests a process which is far removed from asking participants to select prescribed responses to predefined challenges in order to establish passive compliance or what is often termed social acceptance (Fournis & Fortin, 2017), instead focusing on redistributing expertise and opening up possibilities for participatory modeling (Landström et al., 2011). However, rather than exploring possibilities for reorienting control within flood risk management, many papers in this sub-corpus focus on understanding how people perceive risks in relation to climate forced flooding (K. S. Alexander, Ryan, & Measham, 2012), or how science is communicated when engaging with at-risk coastal communities (Cone et al., 2013). Research concludes that risks are, unsurprisingly, perceived more strongly by those who experience

them directly, leading to increased salience of climate change, pronounced emotional responses and an elevated sense of personal vulnerability.

Another thematic focus within the flood risk literature is the process of risk response, often through the development of local adaptation strategies (Manning, Lawrence, King, & Chapman, 2015; Picketts et al., 2013) and the different perceptions of risk they embody. Yet, despite the prominence of economic arguments in framing decisions about flood risk management (Zhou, Halsnaes, & Arnbjerg-Nielsen, 2012), only a few papers in the corpus (3) directly address the role of insurance schemes in shaping those responses (Kammerbauer & Wamsler, 2017a, 2017b; Seifert-Dahnn, 2018; Crick et al., 2018). There are also relatively few papers (7) in this sub-corpus which focus on low-income communities and nation states, despite recognition that it is frequently these communities and countries which are already being worst-hit by early climatic changes, with dire predictions for future impacts and little capacity to adapt (Adger, Huq, Brown, Conway, & Hulme, 2003; Cinner, 2011). These matters are not ignored by researchers, rather that they are typically framed within international development discourses and disaster risk management literature rather than explicitly focusing on climate adaptation and citizen participation and engagement (Garschagen et al., 2018). However, the uneven distribution of research in this sub-corpus suggests that there are other processes at play, perhaps in relation to the availability of funding, which should be further explored both in relation to the focus of climate change research and in terms of the disciplines which benefit from climate change research funding (Overland & Sovacool, 2020). Within the papers which do address low-income contexts and countries, there are clear areas of commonality. Vedeld, Coly, Ndour, and Hellevik (2016) in their study of climate adaptation in Saint Louis, Senegal, for example, examined the multi-level governing structures which shape adaptation strategies in the city. In terms of citizen engagement, they established that some level of participation is encouraged by public officials in adaptation planning at city and regional scales. However, they also found a lack of support, particularly technical and financial support, for these activities from national structures and uneven investment in participation among low-income and vulnerable settlements. As the municipality of Saint Louis had no statutory mandate to govern in the areas of adaptation and disaster risk management this limited the capability of diverse citizens to partner effectively with government in co-producing effective resilience to climate change in the area and beyond. Similarly Mulligan, Harper, Kipkemboi, Ngobi, and Collins (2017) in their study of community-responsive adaptation to flooding in Kibera, Kenya found that household-level engagement with adaptation practices was disincentivized by insecure housing tenure and a lack of effective community engagement. Isunju and Kemp (2016) meanwhile adopted a more targeted approach, examining flooding in the Nakivubo wetland region of Kampala, Uganda. Combining findings from aerial photos and satellite imagery, focus group discussions, and stakeholder interviews, their findings resonate with those of Vedeld et al. (2016), that a stronger multi-faceted governance approach is needed which co-ordinates stakeholders and engages wetland-dependent communities in co-designing responses to flooding challenges. Nonetheless, as with papers focused on higher-income contexts, there are general conclusions that community-responsive adaptation to flooding is required (Ramm, Graham, White, & Watson, 2017).

The challenges of social inequality and marginalization in post-disaster recovery situations is not restricted to low-income nations, with the research conducted in Germany by Kammerbauer and Wamsler (2017a) warning that recovery efforts may reinforce inequalities and sometimes even create new cleavages. Concurring with the findings of Hegger, Mees, Driessen, and Runhaar (2017), they call for more attention to the interplay and power constellations between state, market, and civil society actors. Indeed, it is common for publications in this sub-corpus to flag uneven power relations in planning for climate adaptation. However, rarely do the publications focus explicitly on how to address these power imbalances with a focus instead on increasing levels of participation using deliberative methods. Of course, simply providing opportunities for participation does not mean that underlying patterns of power and influence are dissolved or even reoriented (H. Mees et al., 2017; Mees, Alexander, Gralepois, Matczak, & Mees, 2018).

4 | CRITICAL REFLECTION AND PROSPECTIVE RESEARCH AGENDA

The previous sections of this article have identified a suite of trends in existing research which addresses the nexus of public participation and engagement with climate change adaptation, and focused on a detailed analysis of the dominant themes of risk and flooding. This section addresses matters of engagement and participation more generally. Taken together, the trends and themes identified raise a number of issues that demand more careful consideration and critical reflection. Some of these issues related to the nature, interpretation, and application of the key terms participation and engagement which are used liberally and often loosely across the corpus. Other issues, such as the nature of

knowledge and expertise are evoked or mentioned in passing under the umbrella of governance, but they rarely form the key focus of publications. Further issues, such as matters of climate anxiety (Doherty, 2015), are conspicuous in their absence or are, at best, addressed only superficially in the corpus. Considering these issues more carefully gives greater clarity to unresolved matters at the heart of climate change adaptation and provides the basis for a prospective agenda for future research. As noted previously, there is considerable scope for the examination of more varied terms for describing participation. For example, city–citizen commoning (Wamsler & Raggers, 2018), city–citizen interaction (Wamsler, 2016), and citizen involvement (Brink et al., 2016) are all directly related to the theme of this review but are poorly represented in search results.

4.1 | The wicked problem of participation and engagement

What is clear from the corpus is the extent to which matters of participation and engagement are evoked in a generic and normative manner. There is universal agreement among the papers examined, for example, that greater levels of engagement and participation are needed to improve the efficacy of climate change adaptation. What constitutes appropriate participation, delineating the reasons why it is crucial in a particular context and establishing a clear means for designing it appropriately and evaluating whether it has been successful (or not) are, however, rarely set out explicitly or in detail.

As noted earlier, examining different types of participation and the associated balance of power and influence that those varieties of participation embody has long preoccupied scholars, from Sherry Arnstein's ladder of participation in the late 1960s (Arnstein, 1969), through the expansion of participatory processes stimulated by Local Agenda 21 and sustainability more broadly in the 1990s (Davies, 2002) to contemporary attention to climate action (Corner, Markowitz, & Pidgeon, 2014; Whitmarsh et al., 2013). Permeating this body of work is what Sprain (Sprain, 2017) calls the paradox of participation. Participation occurs in spaces which are not neutral and which can be exclusive and hierarchical rather than inclusive and accommodating (Cooke & Kothari, 2001). Similar to the development field which experienced its participatory turn at the turn of the millennium, all papers in this review assume that participation if undertaken correctly, is an intrinsically good thing. Yet participatory approaches, when viewed as add-ons to fundamentally inequitable structures, could potentially quell dissenting voices and gloss over conflicts between participants. Participatory processes in particular places are rarely apolitical and they are inevitably mediated by uneven patterns of power between those involved (Isunju & Kemp, 2016; Vedeld et al., 2016). Power that can be, for example, political, economic, gender-based, and cultural in composition. While many papers in the corpus acknowledge this in their conclusions (Hegger et al., 2017; Kammerbauer & Wamsler, 2017b) they rarely provide the means to navigate these conditions. Ultimately, participation in climate change adaptation must be demonstrably fair and just from both a procedural—That is, the justness of the institutional processes and procedures through which decisions are made, see (Young, 2011)—and distributional perspective, that is, justice that is concerned with "moral preferences over the distribution of social and economic benefits and burdens among a group of individuals" (Walker, 2010, p. 7).

Despite ongoing concerns regarding public participation in climate adaptation, great strides have been taken in terms of widening engagement with, and participation in, planning around climate change. It is clear that civil society and private sector groups, for example, now contribute to national and global climate discussions that were once dominated by scientists and technical experts (Schroeder & Lovell, 2012). However, the corpus of papers examined in this review also suggests that formal participation by unorganized publics around climate adaptation remains stubbornly limited despite increased research into communicating climate change (Moser, 2010; Nisbet, 2009). Here it is useful to consider the considerable research which disrupts assumptions of a neat linear path between information, awareness, and action (Ayers, 2011; Collins & Ison, 2009; Davies, Fahy, & Rau, 2014), such that information alone will not be sufficient to lead directly or unproblematically to adaptive changes in social practices. Participation in relation to climate change adaptation will need long-term collaboration between different groups and ongoing resources and contributions. It is often messy, cumbersome, and slow, creating tensions with other drivers of public governance relating to bureaucratic efficiency and value for money. However, such processes allow for considered debate and ultimately are, as a result, more likely to lead to robust and defensible decisions.

At the same time that formal public participation in climate adaptation is struggling to gain traction there has been a rise in incidence, and coverage, of climate strikes, protests, and marches internationally which provides visible indications of support for progressive climate action (both mitigation and adaptation), particularly among young people (Davies & Hügel, 2019; Warren, 2019). Exploring the confluence of conditions that generated this phenomenon and

interrogating the means to reconcile these calls for action with practical mechanisms for implementing climate change adaptation should be a priority for research. Such grassroots action in relation to climate change is not new (Whitmarsh et al., 2013), but a gap between such activities and public policies for climate action has persisted. As such research needs to dig beneath simple calls to incorporate new actors into adaptation planning and implementation processes and approach questions relating to a reconfiguration of governance structures and systems.

4.2 | Governance and the redistribution of expertise

The challenges related to participation for climate change adaptation are set within broader frameworks of governance. For all the rhetorical commitment to increasing public participation for climate change adaptation, the lack of practical developments suggests systemic barriers exist which are cumulatively impeding participation being embedded further. This was alluded to in the corpus in relation to fundamental matters of trust and legitimacy and relates to wider debates about decision making. Certainly, it cannot be assumed that the "civic model" of decision making that Owens (2000) describes, for example, is necessarily the goal of all governments or scientists. Yet, as Sprain (2017) argues, reducing participation to a narrow technical-functionalist methodology focused on small technical fixes risks obscuring ambivalences, conflicts, and difficult choices that will not disappear and may lead to more structural resistance in the future. Instead, participatory processes need to acknowledge and accommodate these paradoxes of participation. If politicians and scientists are serious about involving unorganized publics in co-producing knowledge for climate change adaption, for example, then they need to admit them as experts on their own terms; as experts of their own lived experiences. Effectively, there will need to be some redistribution of expertise in decision-making structures.

Landström et al. (2011) explored this issue in relation to the potential of computer simulation modeling around flood risk, suggesting that modelers need to reposition themselves with respect to their modeling practices, bringing in participants as competency groups aimed at harnessing public controversy over flood management. This suggests moving away from a primary rationalist driver for public engagement (to create trust and minimize conflict) and accepting and even encouraging discussions about the very assumptions which underpin decision making processes. Certainly, this will be necessary in order to have open and frank dialogue about what public participation is trying to achieve. Conflict under these conditions is not a failure of governance, rather it is its lifeblood and an opportunity for deeper engagement; a generative force (Callon, Lascoumes, & Barthe, 2009). As a result, enhancing public participation in climate adaptation requires not just changes on the part of the public, but also the part of incumbent actors of the decision-making processes. This is not only possible, but also potentially beneficial. Landström et al. (2011), for example, found that once the scientists involved in the computer modeling experiment were willing and able to accept a redistribution of expertise they encountered a new sense of "moral imagination" (Coeckelbergh, 2006) in flood risk management that became embedded in their day-to-day activities, rather than being a bolt-on activity to their scientific practice.

Within the protected niche of scientific experiments, such reconfiguration is feasible, if still challenging. Yet conventional governance institutions are notorious for being poorly equipped to facilitate, even tolerate, such innovative strategies (Termeer, Dewulf, & Biesbroek, 2017), particularly in the complex multiscalar policy world of climate change. Here there is considerable research already being conducted on ideas of experimental governance for climate change (Bulkeley & Castán Broto, 2012; Gordon, 2018; Laakso, Berg, & Annala, 2017), including notions of expanding climate justice at the urban scale (Bulkeley, Edwards, & Fuller, 2014), that could usefully be extended beyond their current urban loci and connected explicitly to debates about public participation and engagement with adaptation to climate change more broadly. In particular, the ways in which interventions around climate change adaptation intersect with already existing forms of inequality demands much more nuanced research endeavors.

4.3 | Expanding adaptation

There is far greater focus in the corpus on public participation and engagement with material and physical adaptation of environments in response to climate change than to matters of psycho-social and behavioral adaptation (Bonnheim, 2010; Reser, Bradley, & Ellul, 2012). This might be because changing the everyday behavior of publics to reduce carbon emissions has tended to be categorized as mitigation rather than adaption, despite the fact that significant adaptations to social practices are required to facilitate such changes (Davies et al., 2014). The corpus examined in this review touches on this arena predominantly through attention to individuals' perception of risk from climate

changes and any tensions between those perceptions and scientific calculations of the same risks. It remains the case that studies tend to focus on providing information—perhaps in new ways or in new formats—about risk from climate change to better align public perceptions with scientific judgments. Yet the issue of individuals' anxiety around climate change as a factor impeding citizen engagement with adaptation is emerging as a legitimate arena of study, particularly within behavioral science (Aronsson & Schöb, 2018; Kubo, Tsuge, Abe, & Yamano, 2019; Nai, Schemeil, & Marie, 2017). This is important not only because an individual's perception of climate change impacts may influence their support for adaptation actions (Singh, Zwickle, Bruskotter, & Wilson, 2017), but also because it can impact their psychological health, potentially creating a new arena of eco-anxiety.

In addition, and beyond perception of climate risk, there are rising concerns that experiencing climate change-related events and their aftermath, such as floods or sea-level rise, may trigger post-traumatic stress disorder, depression, and even violence (Moon, 2016). This work recognizes that people respond to such events in different ways, influenced by personal cognition, affect and motivation, and suggests that incorporating a psychological perspective could help improve the efficacy of adaptation interventions and any residual climate impacts. Indeed, Truelove, Carrico, and Thabrew (2015), in their analysis of farmers' adaptive responses to drought in Sri Lanka, found that a sense of efficacy was an important predictor of behavioral intentions. While it is not yet clear if there are unique responses needed for psychological adaptation to climate change, sentiment analysis research by Cody, Reagan, Mitchell, Dodds, and Danforth (2015) found that active responses, such as climate rallies, can contribute to an increase in happiness, at least in the short term. Importantly, and as recognized by (Gifford, 2011), psychological, social, and structural adaptation will be required to fully meet the challenges of climate change. In this regard, it would be useful to further explore the cultural and emotional dimensions of adapting to climate change, drawing on recent research which has elevated matters of empathy, identity, and place-attachment as important determinants of positive engagement in the broader arena of environmental change and sustainability (Brown et al., 2019).

5 | CONCLUSION

This review has examined the corpus of research captured in a bibliographic database which combines attention to public participation and citizen engagement with climate change adaptation, and suggests an expansion of the research agenda to include the following issues:

1 How public participation in climate change adaptation is addressed in gray literature and policy documents;
2 Patterns of public participation in relation to adaptation with respect to drought, changing patterns of disease and agricultural viability and also other extreme weather events beyond flooding;
3 The nature of public participation for climate change adaptation in local adaptation policies and community practices;
4 The extent, form, and findings of evaluation efforts with respect to the impacts of extending public participation in climate change adaptation;
5 The geographical distribution of both funding for research and the locus of research efforts into climate change adaptation;
6 Examination of the tensions and complementarities between formal public participation interventions and emerging social movements around climate change;
7 Expanded consideration of the cultural and emotional aspects that emerge with respect to climate change adaptation.

As noted in the critical reflection, additional terms that refer to aspects of public participation may be relevant but remain invisible unless they can be identified. Such identification requires detailed work to be conducted with diverse communities of scholars across different geographical and disciplinary territories. The current search engines remain a "black box" in terms of search algorithms and metrics, with limited provision for identifying "related" papers from searches. The coverage of research by search engines remains incomplete, and disciplinary traditions and divergent scientific practices across the natural and social sciences and humanities means that cross-fertilization of ideas, concepts, and vocabularies remains limited, even where researchers are working in related areas.

The relatively recent appearance of research at this nexus of public participation in climate change, from 2000 onwards, is marked by a number of key features, but most particularly an exponential rise in research effort since

that date and a predominance of research action focused on areas of risk and its assessment, communication, and perception in relation to flooding. While the landscape of research is still predominantly shaped by researchers based in high-income countries, the emergence of published activity from other locations including China, India, Brazil, Bangladesh, and South Africa is notable, as is the growth in collaborative and comparative work across both territorial and disciplinary arenas. Research is still dominated, at least in terms of the number of publications, by environmental, meteorological, and atmospheric sciences, with business, economics, geography, and other social science disciplines also making their mark in the field. Here, we concur with Overland and Sovacool (2020), that research funding to social sciences needs to be expanded to meet the complex challenges related to climate change. In addition, and to optimize learning about climate change adaptation and public participation, it will be necessary to ensure that diverse research outputs from all disciplines are available to all researchers. At present systems like Web of Science tend to underrepresent research outputs from social science, arts, and humanities research. Identifying means of better capturing and communicating these diverse outputs (Moser, 2010) to make them accessible to natural and environmental scientists, engineers, and technologists as well as policy makers, needs to be established if interdisciplinary research on public participation and climate adaptation is to flourish.

Critical attention to the thematic areas of risk and the perception, communication, and awareness of risk, particularly in relation to floods, also revealed some important areas for further research. At a fundamental level, there remains work to be done with respect to developing common understanding across disciplines, and between science and policy, of how processes involving public participation and citizen engagement are articulated, as well as ensuring broad comprehension of how influential concepts of risk, vulnerability, and adaptive capacity are used and used differently by different disciplines and stakeholders. This is necessary to aid interdisciplinary interactions which are increasingly recognized as essential to address the wicked challenge of climate change—as set out in the "global stocktake" referred to by Article 14 of the Paris Agreement (Global Stocktake, 2015; The Paris Agreement, 2015)—and also to address tensions between abstract theories of participation and the operationalization of public participation interventions in particular places.

It will become even more pressing to ensure research is translatable given the rise of experimental research in "real world" settings, where researchers in collaboration with other stakeholders, sometimes including publics, conduct novel adaptation exercises within particular locations (Davies et al., 2014; Voytenko, McCormick, Evans, & Schliwa, 2016). Further attention to the benefits and limitations of creating these living laboratories for examining participation and engagement in climate change adaptation could help bridge the current gaps between theory and practice. Certainly, while isolating public participation in climate change adaptation has heuristic benefits for a review of scientific research it will ultimately, as noted by the IPCC (2018) need to be married with climate change mitigation and, importantly, action toward wider sustainable development goals.

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CONFLICT OF INTEREST

The authors have declared no conflicts of interest for this article.

AUTHOR CONTRIBUTIONS

Stephan Hügel: Conceptualization; data curation; formal analysis; investigation; methodology; validation; visualization; writing-original draft; writing-review and editing. **Anna Davies:** Conceptualization; writing-original draft; writing-review and editing.

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ENDNOTES

[1] https://clarivate.com/webofsciencegroup/solutions/web-of-science-core-collection/

[2] DOI: https://doi.org/10.5281/zenodo.2790803

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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