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Reframing Climate-Induced Socio-Environmental Conflicts: A Systematic Review

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This article draws a comprehensive map of conflict climate change scholarship. It uses visualizations and descriptive statistics to trace the temporal, spatial, and topical evolution of the field of study via a bibliometric analysis of more than six hundred publications. It then proceeds to summarize findings, theoretical explanations, and methodological approaches. Overall, this systematic review shows a remarkable inconsistency of evidence among publications. As a way forward, this article recommends future research to use computational models, informed by a social-ecological perspective, to better explore the link between climate change and conflict.
Resumen: En este artículo se traza un mapa integral de la erudición conflictiva del cambio climático. Se utilizan visualizaciones y estadísticas descriptivas para rastrear la evolución temporal, espacial y temática del campo de estudio mediante un análisis bibliométrico de más de seiscientas publicaciones. Luego, continúa con un resumen de los hallazgos, las explicaciones teóricas y los enfoques metodológicos. En términos generales, esta revisión sistemática muestra una notable incoherencia de evidencias entre las publicaciones. En este artículo se recomiendan investigaciones a futuro para utilizar los modelos computacionales, informados con una perspectiva socioecológica, a fin de explorar mejor la conexión entre el cambio climático y los conflictos.
Extrait: Cet article offre une représentation complète des recherches portant sur les conflits liés au changement climatique. Il utilise des visualisations et des statistiques descriptives pour retracer l'évolution temporelle, spatiale et thématique de ce domaine d'étude via une analyse bibliométrique de plus de six cents publications. Il résume ensuite les constatations, explications théoriques et approches méthodologiques. Globalement, cette synthèse systématique montre une incohérence remarquable des preuves entre les publications. Pour aller de l'avant, cet article recommande que les recherches futures passent par des modèles informatiques éclairés par une perspective socio-écologique pour mieux explorer le lien entre le changement climatique et les conflits.

Keywords: climate change, conflict, Anthropocene, holocentrism, systematic review,
Palabras clave, cambio climático, conflicto, antropoceno, holocentrismo, revisión sistemática,
Mots clés, changement climatique, conflit, Anthropocène, holocentrisme, synthèse systématique

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Introduction

A significant improvement in our understanding of climate change has occurred during the past two decades. This progress has primarily been driven by the increasing accuracy of computational models, and by the work of synthesis carried out by the Intergovernmental Panel on Climate Change (IPCC). To date, most of the fundamental questions about the nature of climate change have been answered, and clear evidence has been gathered to prove that anthropogenic drivers are the "dominant cause" of global warming (IPCC 2014b, 3). Further work remains to be done to improve coupled climate system models and reduce their scientific uncertainties (McGuffie and Henderson-Sellers 2005, 52).

Despite the progress, uncertainties associated with socioeconomic processes remain a key bottleneck for the design of climate models. The anthropogenic causes of climate change indicate that the biotic and abiotic components of the ecosphere can no longer be studied in isolation. Without understanding social systems, and how much greenhouse gas (GHG) emissions they produce, it is simply not possible to understand how the climate system will evolve during the next century (Crutzen 2002, 23). Likewise, it is increasingly difficult to make sense of social systems without accounting for environmental factors and constraints. In other words, global warming forces us to adopt a socio-environmental perspective that blurs the lines between the traditional field of studies.

In recent years, a multitude of disciplines, ranging from humanities to public health, have studied climate change from different angles. To make sense of this heterogeneous body of literature, the IPCC has integrated the findings across disciplines and assessed their respective levels of scientific uncertainty. The degree of uncertainty in the findings produced by the literature on climate-induced socio-environmental conflicts has been noted as high. In the *Fifth Assessment Report*, the IPCC stated that "collectively the research does not conclude that there is a strong positive relationship between warming and armed conflict" (2014a, A:772).

Despite hundreds of published studies, there is still low confidence in the validity of the findings due to the lack of consistency of evidence and low degree of agreement. Several authors have established a correlation between global warming and increase of conflict onsets (e.g., Barnett 2003; Burke et al. 2009; Hsiang and Burke 2014), but many others have found confuting evidence (e.g., Nordås and Gleditsch 2007; Seter 2016; Hendrix 2018). Individually, each author appears to be right in its own terms; but taken together, it is difficult to assess what the scholarship is collectively saying due to lack of shared methodologies, theoretical frameworks, and datasets.[1]

This paper tries to organize and map this heterogeneous literature in a coherent body of knowledge. There are two main reasons why it is essential to bring clarity in this disaggregated body of scholarship. First, inter- and intra-state conflicts are in themselves a significant source of GHG emissions. To put things into perspective, global CO_2 emissions per military expenditures have ranged from 2 to 3 percent of total emissions from 1992 to 2011.[2] Organized violence simply requires extensive use of fossil fuels.[3] Conflicts have also led to higher GHG emissions via indirect effects caused by loss of lives and resource dilapidation. Overall, they increase vulnerabilities, reduce adaptive capacity, and pose barriers to adaptation. It is therefore important to understand whether conflict and climate change are linked in a

[1] The debate between Buhaug (2010b), Burke et al. (2010), Hsiang and Meng (2014), and O'Loughlin, Linke, and Witmer (2014) has shown that methodological preferences are difficult to reconcile and can yield to inconsistency of evidence.

[2] Data from Stockholm International Peace Research Institute (military expenditure percent of GDP) and World Bank (GDP constant 2010 US$ and CO_2 emissions in kt). The estimate was made assuming average emissions per unit of GDP from military expenditures. For an alternative estimate made with the same assumption, see Barnett (2009, 2).

[3] For example, the Department of Defense is the largest buyer of fossil fuel in the United States (Closson 2013, 311).

mutually reinforcing relationship, and how much this relationship will contribute to future emissions. It follows that having a clear understanding of socio-environmental conflicts will help to better estimate socioeconomic pathways and future GHG emissions, thus ultimately improving climate scenarios.

Second, in the wake of the post-modern critique, it is important to underline that climate change is also an issue of social justice. Inadequate research findings can have a direct negative impact on the livelihood of the most vulnerable. For example, climate change research has been used to depoliticize the causes of conflict and promote western agendas of military intervention under the pretense of environmental determinism (Raleigh, Linke, and O'Loughlin 2014, 76). To date, the debilitating relativism and methodological laissez-faire in this field of study have allowed deterministic assumptions and oversimplified correlations to thrive and continue influencing policymaking. It is, therefore, imperative to bring together the whole body of literature to re-evaluate individual findings in light of the collective wisdom and provide a strong argument to rebuke determinism.

This paper draws a comprehensive map of the conflict climate change scholarship and goes beyond the current impasse in the literature by highlighting a way forward for future studies. The first section of this study uses visualizations and descriptive statistics to trace the temporal, spatial, and topical evolution of the field of study via a bibliometric analysis of 643 publications. The second section narrows down the analysis to the most relevant documents and qualitatively analyzes them to extrapolate findings, theoretical explanations, and methodological approaches. Finally, the third section assesses the major limitations of existing literature and provides a novel critique based on ontological and epistemological grounds. Overall, the paper offers an extensive literature review that maps the structure of knowledge of the field, draws its boundaries, and defines avenues for future research on the conflict climate change nexus.

Framing the Field of Study

Over the past three decades, scholars working on the conflict climate change nexus have produced a large number of studies. This section gives form to this body of literature via a bibliometric analysis of 643 documents and their metadata, including 25,768 references, 2,239 keywords, and 1,209 authors. The data were used to trace the historical growth and geospatial dimension of the field of study, map its co-authorship networks, and visualize its thematic evolution. Overall, this section serves to highlight the structure of knowledge in the conflict climate change scholarship and identify relevant papers for the qualitative analysis that is presented in the following section.

The publication data were retrieved from Clarivate Analytics' Web of Science (WoS) and constitute a comprehensive dataset that includes publications related to climate change and conflict from various disciplines, ranging from international relations to public health.[4] The data were cleaned and pre-processed for statistical analysis using OpenRafine, an open-source data wrangling application, and Sci2, a modular toolset developed at the Cyberinfrastructure for Network Science Center of Indiana University (2019). The co-authorship and co-citation networks were handled with Sci2 and VOSviewer, a bibliometric tool developed at the Centre for

[4] The dataset includes publications on conflict and climate change, excluding documents on environmental security which are not expressly about climate change. The WoS search was conducted as follows: ((TI = (climate change OR global warming OR climat* OR temperature OR natural disaster* OR precipitation OR water OR land OR rain OR drought OR environment OR resource) AND TS = climate change) AND TI = (conflict* OR war OR strife OR violen* OR geopolitic* OR fight*)) AND LANGUAGE: (English) Indexes = SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan = 1900–2019.

Science and Technology Studies of Leiden University (van Eck and Waltman 2019). The final analyses and network visualizations were made using Gephi (2017).

The basic statistics and visualizations presented in this section indicate that the research field has been heavily influenced by positivist, environmental security scholarship. Environmental security scholars were among the first to study the intersections between climate and conflict, and their seminal work has remained highly influential in setting the research agenda and shaping its direction. The influence of environmental security can also be observed in more recent publications, as highlighted by the co-authorship and topical networks in the following sections.

Genealogy of Conflict Climate Change Research

By the 1990s, it had become clear to the broader public that emissions resulting from human activities were irreversibly changing the climate system and moving it toward a warmer state (IPCC 1990, XII). The Earth's climate was shifting, and so were ecosystems and societies (IPCC 1994, 5). As this new reality unraveled, practitioners and scholars started to wonder about the security implications of global warming. It soon became clear that climate change was an "environmental stressor" with far-reaching implications on human security (IPCC 1990, XII). The indirect impact of climate change on human health and security proved to be particularly worrisome. Whereas the academic community was to some extent familiar with the direct impact of climate, it lacked a frame of reference to make sense of how changes in ecosystems' provisions were going to unfold. The immediate reaction to these new security uncertainties and bleak climate predictions was alarmist and triggered a first wave of publications linking climate to national security and conflict outbreaks.

The period from the early 1990s to the late 2000s has been characterized by the influence of environmental security, neo-Malthusianism, and non-academic publications from IGOs, state agencies, and think tanks. The first scholars to try to provide a scientific assessment of the impact of climate change on national security came from the field of environmental security. Authors like Homer-Dixon (1991), Spillmann and Bächler (1995), and Gleick (1991) had been studying the link between environmental degradation and conflict for a few years, and climate change was in their view no different than any other form of environmental forcing. Their studies showed that competition for access and control of resources, mediated by demographic and socioeconomic factors, had been a cause of violent disputes and conflicts over the course of human history (Hauge and Ellingsen 1998, 302). Thus, if global warming was going to change the resource base, it was expected to lead to similar dynamics of competition and conflict.

During the first wave of publications on environmental security, a few alternative theories and perspectives emerged (Hardt and Scheffran 2019). The most relevant, at least by weight of citations and bibliometric impact, was the one offered by Homer-Dixon that centered on the role of resource scarcity. Homer-Dixon contended that there are three kinds of scarcity: supply, demand, and access induced. The three forms of scarcity interplay with each other and can potentially be aggravated by "resource capture" and "ecological marginalization" (Homer-Dixon 1994, 40). In turn, he argued, scarcity decreases economic development and weakens the state, while grievances and opportunity cost calculations trigger resource competition and outbreaks of violence (Homer-Dixon 1999, 197–99).

The work of Homer-Dixon provides a good illustration of the core argument of the first wave of environmental security, where the *resource base* is the key independent variable, and *greed* or *grievance* are the underlying mechanisms linking environmental changes to conflict outbreaks. Undeniably, Homer-Dixon's work on the "Project on Environment, Population and Security" at the University of Toronto had a neo-Malthusian flavor. Yet, he should be given credit for being one of the

few authors of his time who tried to go beyond Malthus.[5] Albeit influenced by the neo-Malthusian dyad of population growth and environmental constraints, Homer-Dixon rejected any form of determinism and recognized that scarcity is fundamentally a distributive problem. He was not a Cornucopian, but he argued that if a country had sufficient "ingenuity" (i.e., the ability to generate new technologies and reform institutions), it would have been able to adapt to the challenges imposed by scarcity.[6]

Some writers in the first wave of publications identified alternative conflict mechanisms to the one proposed by the Toronto Group. For instance, Collier and Hoeffler (1998, 571) argued that resource abundance, in the context of a developing country, increases the amount of "lootable income" and the risk of conflict outbreaks (De Soysa 2002, 398). Gurr (1985) and Irving (1989) counterargued that relative deprivation is a more significant variable than resource abundance or scarcity. As Theisen (2017, 211) later noted, changes in resources "relative to a reference scenario" can aggravate grievances regardless of the absolute number of resources available. Finally, a few authors contested the focus on natural resources. Hauge and Ellingsen (1998) and Gleditsch (1998) argued that institutional variables, such as regime type, are a better predictor of climate-induced conflict. Similarly, Flanigan and Fogelman (1970) suggested that economic variables, such as development or international trade, are more significant than the resource base.

Stepping away from the narrow-scoped debate on resources, the Environment and Conflicts Project (ENCOP) at ETH Zürich decided to focus on the security implications of socio-ecological changes. In the 1994 proceedings of the International Conference at Monte Verità, Spillmann and Bächler differentiated between three types of environmental changes: not anthropogenic, planned-anthropogenic, and unplanned-anthropogenic. The first, they argued, could potentially cause neo-Malthusian conflicts over control of resources when the survival of a population was at stake. The second could create conflicts over grievances between groups benefiting from environmental changes versus deprived groups. And the third, unplanned-anthropogenic changes, could lead to a situation of tragedy of the commons where shared accountability of ecological damages prevents retribution and leads to "political disintegration" (Spillmann and Bächler 1995, 7).

Overall, the first wave of academic publications looked at climate change through the lenses of pre-existing theoretical frameworks and missed to distinguish global warming from other forms of environmental forcings. With resources as the intermediate variable and greed or grievance as the causal mechanisms, the literature held tight to its strong neo-Malthusian roots. Outside of academia, the debate appeared even more monopolized by deterministic assumptions on the effects of climate on society. Public opinion in the 1990s had been heavily influenced by the environmentalist debate of the previous decade on the limits of growth, as well as by the threats posed by the ozone hole and a possible nuclear winter (Dalby 2014, 6; Allan 2017, 811). The collective imagination of the decade was well captured in a 1994 article published on *The Atlantic* by Kaplan (1994), in which the social fabric of western countries is said to be undermined by a mix of scarcity, over-population, climate refugees, diseases, failed states, and clash of civilizations. In other words, a hotpot of post–Cold War security threats pushed to the boiling point by global warming.

Several non-academic reports published in the following years portrayed similar cataclysmic scenarios. Among the most dramatic, a 2003 (US) Department of Defense report from Schwartz and Randall (2003, 2) imagined that, due to a reduction of "global and local carrying capacities," states had two options: fight for resources,

[5] In recent literature reviews, Homer-Dixon is often labeled as a Malthusian. See, for example, Verhoeven (2011, 681).

[6] To be noted that, accordingly to Homer-Dixon (1999, 43), ingenuity requires resources.

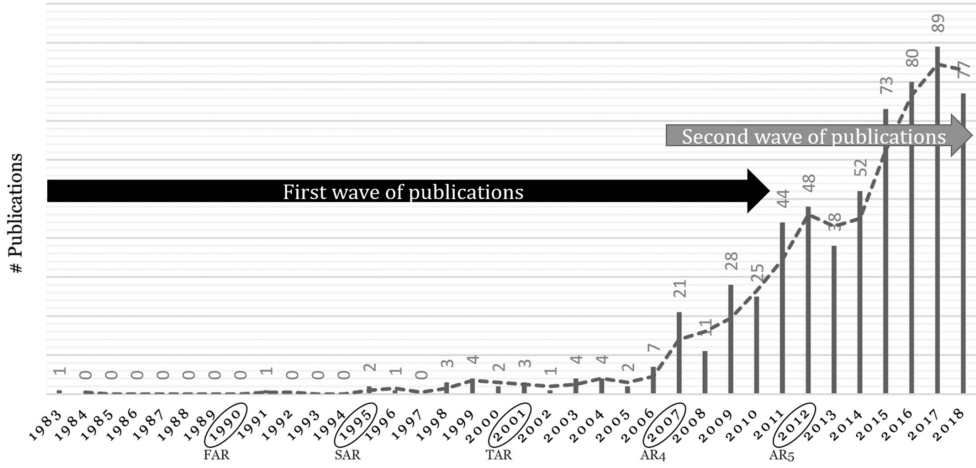

Figure 1. Number of publications per year.[7]

or protect the ones they have by building "virtual fortresses" around them. In the same vein, a CSIS report in 2007 remarked that developing countries are a potential liability for global security since they do not have the capacity to deal with global warming and are likely to spur mass migrations, crime, and infectious diseases (Campbell et al. 2007, 5–10). An in-depth review of non-peer-reviewed publications is beyond the scope of this essay, especially as several authors have already provided a good account of this literature (see Barnett 2009; Hartmann 2010; Livingstone 2015). It suffices here to remark that, as pointed out by Selby et al. (2017, 233), the public perception and discourse on the climate–conflict nexus "has been well ahead of, and often at variance with, the available scientific evidence."

In 2001 and then in 2007 again, non-peer-reviewed publications on climate-induced conflict were featured prominently in the Third (TAR) and Fourth (AR4) Assessment Reports of the IPCC. Both reports mention possible conflict outbreaks over water resources caused by climate change. However, as observed by Gleditsch and Nordås (2014, 84), these claims were made using speculative sources and omitting relevant "academic empirical work." The academic community promptly criticized both reports. However, at the same time, it also acknowledged that it had failed to provide the IPCC with a rigorous quantification of the effect size of climate change on conflict onsets. Too many studies had been, to this point, anecdotal and case study specific. For this reason, after the AR4, researchers embarked on a "new quantitative research program" to establish a "'reliable baseline knowledge on the links between climate and conflict' equivalent to that within other areas of climate change research" (Selby 2014, 830).

After the publication of AR4 in 2007, the field of study experienced rapid growth in the number of publications, as shown in figure 1. This growth was driven by new quantitative studies, mostly large-*N* panel studies, correlating proxy variables of climate (e.g., precipitations, temperatures, draughts) with conflict onsets. This second wave of publications, which is analyzed in depth in the second section of this essay, was heavily influenced by pre-2007 studies. Figure 2 shows the citation network of the most cited papers and indicates how publications built on each other. Figure 3 shows a co-citation network of the top-cited references in the conflict climate change literature. About half of the top-60 are first wave publications, while the other half is mostly composed of post-2007 positivist studies that, as shown in figure 2, follow the path of early environmental security publications. As it can

[7] Publication data on conflict climate change nexus, see note no. 4.

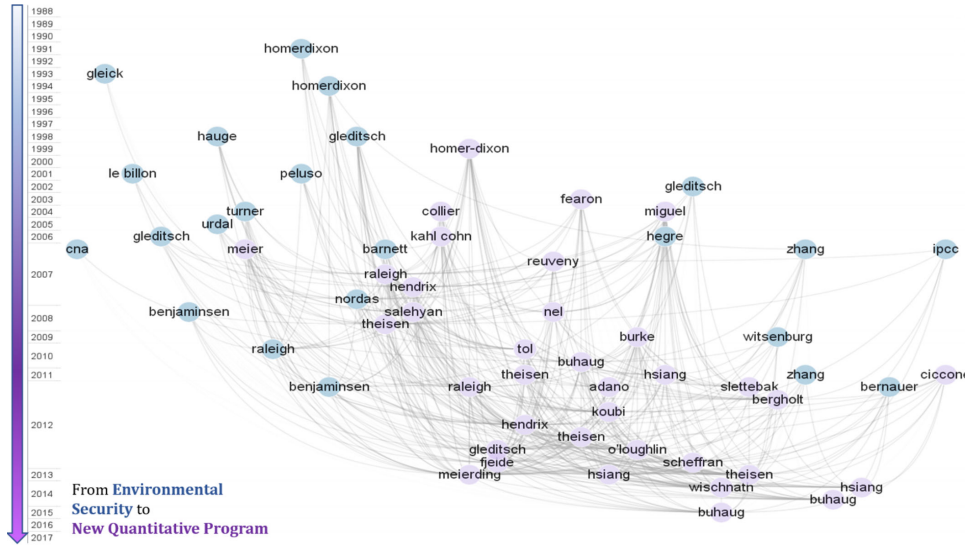

Figure 2. Citation network.[8]

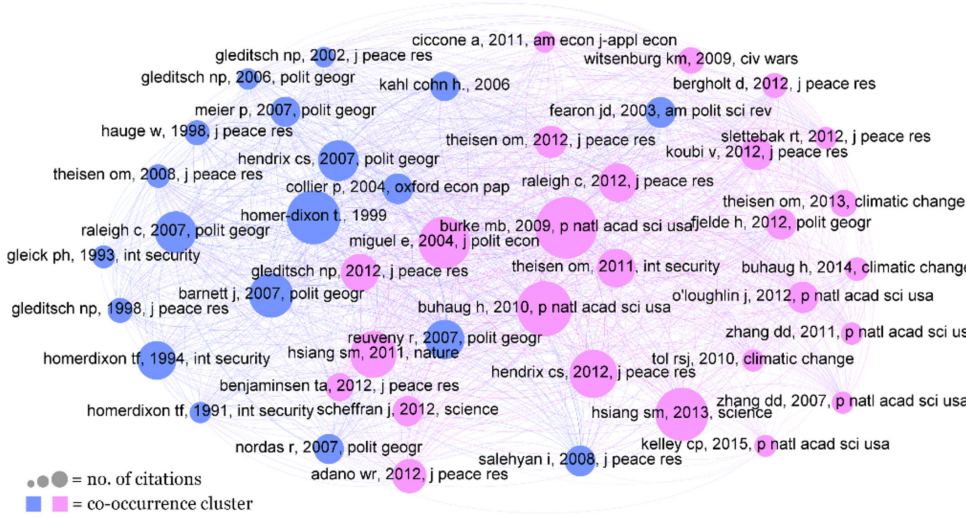

Figure 3. Co-citation network of cited references.[9]

be inferred from both figures, early environmental security scholars are featured prominently as progenitors of the field of study and continue to be highly cited by recent publications as well. Having traced the origins of the field of study, the next sections address the most recent developments by introducing principal authors, publications, and topics in the literature.

[8] Publication data on conflict climate change, see note no. 4. The image displays the top 59 documents based on citation score. The data were preprocessed with Sci2. The network analysis and the visualization were made with Citnetexplorer.

[9] Publication data on conflict climate change, see note no. 4. The image shows the references cited by the documents in the dataset that have at least 21 citations (60 references out of 25.768). The data were preprocessed with Sci2, and the co-occurrence network was extracted with VOSviewer. The visualization and the network analysis were made with Gephi.

Authors and Collaboration Networks

This section identifies different epistemological communities via an analysis of the co-authorship network. The network, shown in figure 4, was constructed using publication data of 1,120 authors and 643 documents. To analyze the growth of collaborations over time, the dataset was sliced into four consecutive periods (a, b, c, d). In a cumulative fashion, each period carries on the data of the previous. The nodes represent authors. They are colored relative to their clustering coefficient and are sized proportionally to the natural logarithm of their degrees. The edges linking nodes represent co-authorships and are sized based on the number of collaborations. The modularity analysis was made for each network using Gephi, and the layout was made using the Fruchterman–Reingold (1991) algorithm. Figure 4 reveals that there has been a steady increase in the number of authors and collaborations over time. What stands out in this figure is the increase of modularity, indicating a growth of collaborations within existing clusters of authors, and a relative reduction of co-authorship among clusters.

The 1998–2018 network is analyzed in detail in figure 4 to highlight the most relevant clusters in the field. The network was filtered to exclude nodes with citations below 40 and a degree lower than 1. Nodes are sized relative to the number of citations and colored based on the cluster id. Since the WOS dataset is broad and multidisciplinary in scope, the data had to be cleaned manually to remove clusters of authors that are not strictly pertinent to the topic. Statistics at the individual level are shown in figure 5, which lists the top authors per number of citations and their clustering association. From these two figures, it is possible to notice that there are three main co-authorship networks with a significant number of citations and collaborations. For the sake of this review, the three clusters will be identified according to their most-cited authors: Hsiang, Buhaug, and HF Lee. To be noted, all the three clusters are representative of the post-2007 wave of positivist publications and include several large-*N* studies that are analyzed in section two of this essay. The three clusters stand on similar epistemological grounds but hold different methodological approaches and theoretical understandings, which have led to diverging findings.

The co-authorship network of HF Lee is the most radical in terms of determinism and reductionism. This cluster is characterized for favoring large-*N* studies with long temporal scales. For example, Lee et al. (2013, 8) analyzed climate and conflict in Europe using data on the North Atlantic Oscillation from 1400 to 1995, and Zhang et al. (2006, 2007a) have studied the link between temperatures and conflict in China from 1000 to 1911 using palaeoclimatological records. Overall, the findings of this cluster have established that lower temperatures are correlated to an increase in conflict outbreaks. The explanation provided for this correlation is strictly neo-Malthusian: colder periods cause lower agricultural production, and therefore socioeconomic collapse (which is assumed to lead to rebellions or mass migrations) (Z. Zhang et al. 2010).

There are, however, two main problems with this body of literature. The first problem is methodological. The studies use linear regressions without adequately controlling for socioeconomic variables (Gartzke 2012, 179). Moreover, they use climate proxy data at low resolutions, mostly country-level, to analyze conflict outbreaks at the community level. The simplistic (and drastically reductionist) methodology means that, even if the correlation is not spurious, it is not going to be very useful to determine causality. To make an example, we could well argue that summer causes war because, historically, most wars have occurred during summer. However, as any reader would notice, in this assertion lies a clear case of inductive

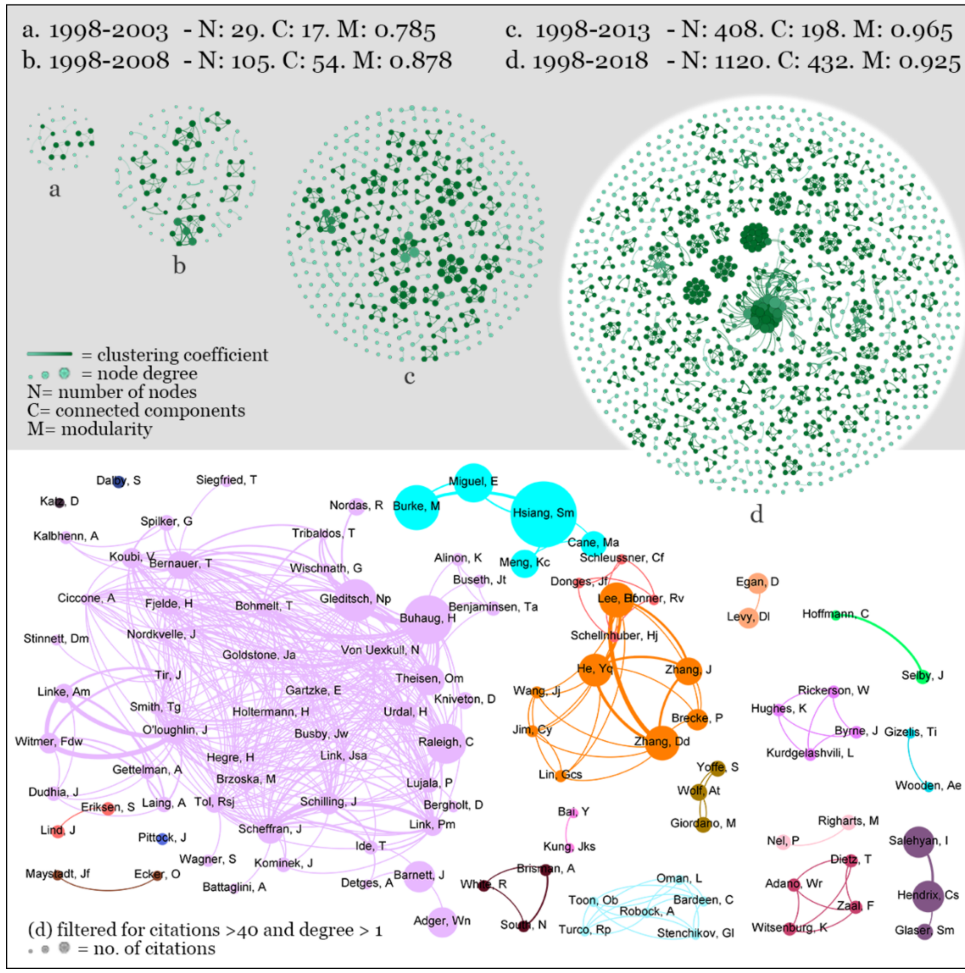

Figure 4. Co-authorship network: growth and clustering.[10]

fallacy. The same logic and faulty generalizations between climate and conflict outbreaks can be found in the scholarship of this cluster.

The second problem is that the causal relationship in the HF Lee cluster is inferred, not from data, but from a theoretical perspective. The authors in this cluster are strongly embedded in neo-Malthusianism and present the link between resources, population, and security as an indisputable fact. Yet, this truth is based on dated and pseudo-scientific sources. Zhang et al. (2007a, 403), as Livingstone (2015) points out, have used the work of Ellsworth Huntington as evidence of a "scholarly tradition" linking climate variability to violence. Huntington was, in the words of Fleming, a "failed academic" turned prolific writer who has published several essays in the early twentieth century based on nineteenth-century ideas of climate determinism, ethnoclimatology, and social Darwinism (Carey 2012, 238; Fleming 1998, 96–106).

[10] Publication data on conflict climate change, see note no. 4. The first half of the image displays the growth of the co-authorship network. Nodes represent authors and are sized based on the node degree. Edges represent co-publications and are sized based on the number of shared publications. Color represent clustering coefficient. The second half of the image shows the co-authorship network from 1998 to 2018, filtered for citations > 40 and node degree > 1. The data were preprocessed with Sci2 and cleaned by hand to remove papers not strictly pertinent to conflict and climate change. The network analysis and the visualization were made with Gephi. The clustering of the (d) network was made with the Leiden algorithm and the layout of the sliced networks was made with the Reingold algorithm.

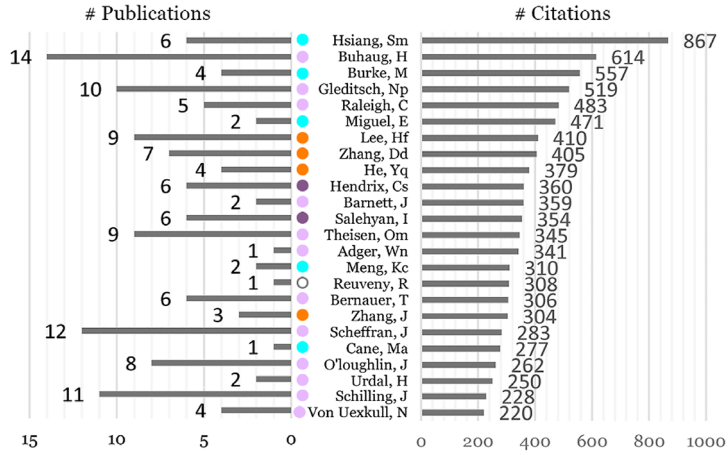

Figure 5. Top authors per no. of citations.[11]

It is puzzling, to say the least, to see Huntington's name being cited in contemporary work as a reliable source. Adding another example, Lee et al. (2013, 8) and Zhang (2007, 19,218) have cited Maslow's hierarchy of needs in support of their causal inference that resource scarcity can potentially lead to conflict, without, however, recognizing that the validity of the Maslow's work is highly contested in academic circles. In sum, methodological problems and underlying biases hinder the validity of the studies produced by this cluster of authors, who seem to be hiding climate determinism behind the façade of methodological reductionism.

Moving on to other clusters, we find the group of Hsiang, highlighted in cyan, and Buhaug, marked in light violet in figure 4. The two groups have published large-*N* studies, review articles, and critiques of each other's work. The groups diverge primarily on methodological preferences and have engaged in a lively debate over the course of the years. The debate started in 2010 when Buhaug (2010a) failed to replicate a 2009 paper from Burke et al. (2009, 20,670), which assessed that "temperature variables are strongly related to conflict incidence" in sub-Saharan Africa. When Buhaug (2010a, 16,477) changed the model specifications and the measures for precipitation, temperature, and civil war, he concluded that armed conflict is only weakly correlated to climate variability and is better explained "by generic structural and contextual conditions" of African countries. A few months later, Burke et al. (2010, E185) replied with a letter on proceedings of the National Academy of Sciences of the United States of America and accused Buhaug of having altered the replication study via the addition of control variables and parameter changes. In his defense, Buhaug (2010b, E186) rejected the accusations and provided additional econometric evidence that temperature is statistically insignificant on conflict incidence in the cases selected by the original paper. Moreover, he remarked that the findings of Burke et al. were in contradiction with the general trend of declining conflict and increasing temperatures in Africa.

The methodological debate between the two groups of authors has had a significant impact on the overall research field. In 2014, Hsiang and Meng (2014, 2100) published an article titled "Reconciling disagreement over climate–conflict results in Africa" where they argued that Buhaug's original paper, when corrected for statistical errors, did not confute the evidence of Burke et al. (2009). In a following article, O'Loughlin, Linke, and Witmer (2014, 2054) provided a different perspective and argued that the real problem with the original Burke et al. paper did not

[11] Publication data on conflict climate change, see note no. 4. The color next to the authors represents their co-authorship cluster in Figure 4.

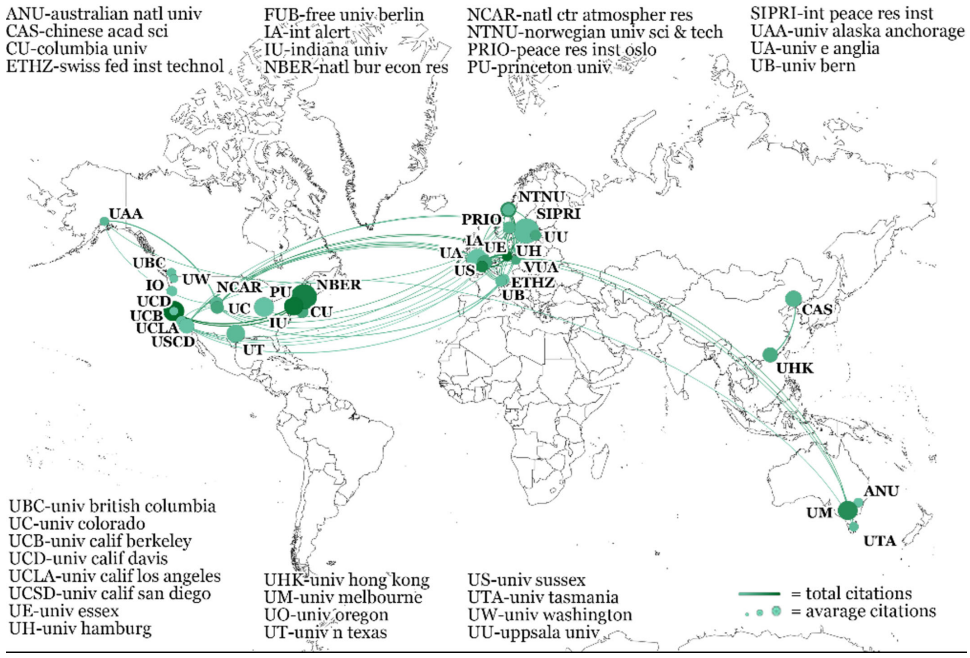

Figure 6. Geospatial distribution of collaborations among institutions.[12]

lie in the methodology, but rather in the data, which were too "coarse" to provide actual statistical insights on how conflict emerges at the subnational level. The data problem has been a persistent issue in the literature. However, in recent years, as Ide observed (2017, 3), it has been alleviated by the use of higher definition datasets that use artificial grid cells or regional data sampled in shorter temporal spans.

In the Burke versus Buhaug (and coauthors) debate, it is difficult to say who stands on the right side. From a bibliometric perspective, both clusters have had a high impact on the literature and continue to be prominently featured by new publications. However, by shared strength in the number of authors and citations received, the Buhaug cluster is the one that has gained more momentum over the years. Overall, it appears that the distinguishing element between the two authors lies in their relative confidence in traditional statistical methods. Within Hsiang's cluster, all authors agree on method and findings—that is, climate change is linked to an increase of intra-state conflict.[13] Conversely, in Buhaug's cluster, there is a plurality of voices and research approaches. Collectively, the studies of this research group have found significant, weak, and non-significant correlations between climate–conflict variables.[14] These mixed results have inspired caution and healthy skepticism, which, in recent years, have led to the co-publication of several review articles, including a recent review by Mach et al. (2019) that provides an extensive assessment of the current state of knowledge.

[12] Publication data on conflict and climate change, see note no. 4. The figure displays the co-authorship network among institutions. Only institutions with citations > 40 and publications > 4 are shown in the image to avoid cluttering. Nodes are sized based on the average number of citations per publication and colored relative to the total (cumulative) number of citations. Edges represent co-authorship and are sized based on the number of shared publications. The data were preprocessed with OpenRefine and cleaned 'by hand' to remove papers not strictly pertinent to conflict-climate change. Institutions were geotagged using the Google Maps API. Missing coordinates were added by hand. The network analysis and the visualization were made with Gephi using the GeoLayout algorithm.

[13] Climate change has been measured using various proxy variables across their studies, including temperature, precipitation, climate variability, and El Niño-Southern Oscillation. See M. B. Burke et al. (2009), Hsiang and Burke (2014), and Hsiang, Meng, and Cane (2011).

[14] See table 1.

Before concluding, this section provides a map of the geospatial distribution of collaborations among institutions. The field of study is often accused by post-modern scholars for being too Eurocentric and supportive of "Northern stereotypes, ideologies and policy agendas" (Selby 2014, 830). Some researchers, like Hartmann (2010, 239) and Bettini (2013), have argued that the portrayal of vulnerable populations as a potential security threat has created a sense of crisis that legitimizes Western intervention, higher defense expenditure, and stricter immigration controls (Ide 2017). In the same vein, Barnett (2009) has pointed out that the literature naturalizes and depoliticizes the causes of conflict with the consequence of providing policy solutions that do not address the root problems. Critiques of this kind are (and must be) based on the corpus produced by the research field and not based on the provenience of the authors. Nonetheless, it is interesting to remark that the most relevant institutions working on climate change and conflict are predominantly located in northern Europe and America, as can be seen in figure 6. Is this proof of a Western bias? Not necessarily. As can be seen in these pages, post-modern and alternative scholarship has flourished in Northern Europe and Australia, whereas determinist and Malthusian scholarship has been featured prominently in a non-Western nation: China (see the cluster of HF Lee, figure 4, in UHK and CAS, figure 7).

Topics in the Conflict Climate Change Literature

This final section of the bibliometric analysis focuses on the evolution of topics in an attempt to identify general trends and research areas within the field of study. Figure 7a shows the co-occurrence network of keywords with fifteen or more occurrences (41 out of 2,239). Nodes and edges are sized according to occurrences and co-occurrences. Figure 7b lists the temporal evolution of twenty selected keywords using their normalized frequency (occurrences divided by the number of publications in the same year).

In the image, it is possible to spot four clusters and a series of keywords that reference topics that have already been introduced in the previous sections. Environmental security keywords are featured prominently, as to be expected, in the co-occurrence network. The orange and cyan clusters are particularly indicative of the pre-2007 wave of publications. Keywords such as scarcity, environmental degradation, migration, and Africa are indicative of the topical and geographic focus of the 1990s (see Homer-Dixon and Bächler). Meanwhile, words such as water, shared rivers, and drought are representative of the early 2000s literature on the water–security nexus (see clusters of Gizelis or Yoffe in figure 4).

The purple and green clusters are mostly composed of post-2007 research. Keywords in the purple cluster are primarily drawn from quantitative literature linking climate-induced socioeconomic changes to conflict outbreaks. Here, it is possible to find keywords that represent climate proxies (e.g., variability, temperature, rainfall, weather, natural disasters), intermediate variables (e.g., economic shocks, growth) and dependent variables (e.g., war, civil conflict). In addition, there is again a keyword signaling the geographic focus of the literature on Africa, more precisely sub-Saharan Africa. Finally, the green cluster, which includes terms such as institutions, governance, adaptation, management, and resilience—is an assemblage of different quantitative and qualitative scholarship.

Lack of control variables and over-reductionism has been a long-standing problem among quantitative studies in the field. For this reason, researchers have been increasingly using socioeconomic and institutional variables to control for the effects of climate change. For instance, Linke et al. (2018) have used formal and informal institutions to better control for the conditional and contextual effects of draught on violence in Kenya. Likewise, in an earlier article, Adano et al. (2012, 77) have assessed the significance of institutions vis-à-vis climate variables and reached the conclusion that local institutions in Kenya were effectively mediating resource

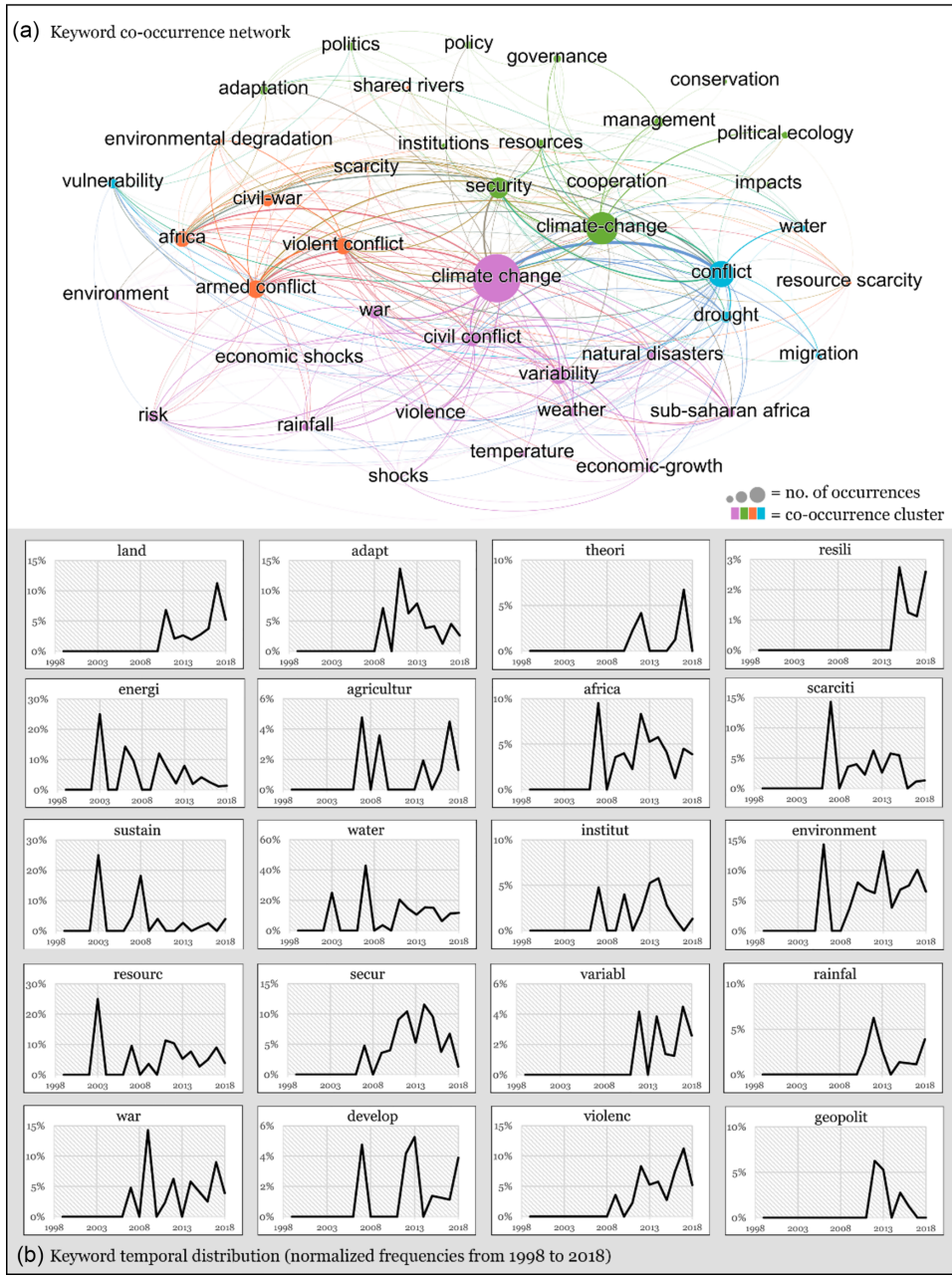

Figure 7. Keywords: co-occurrence network and temporal evolution.[15]

conflicts. Similar results were reached by studies on the water-security nexus, which, when controlling for water treaties, have found institutions to have a significant effect in conflict prevention (Dinar et al. 2015; De Bruyne and Fischhendler 2013; Gizelis and Wooden 2010; Tir and Stinnett 2012).

[15] Publication data on conflict and climate change, see note no. 4. Figure 7a displays the co-occurrence network of the keywords used by the publications. Only keywords with more than 15 occurrences are shown (41 out of 2239). Nodes are sized based on the number of occurrences and colored based on the co-occurrence cluster. Edges are sized relative to the number of shared co-occurrences. Data were preprocessed with Sci2. The co-occurrence network was extracted using VosViewer, and the visualization was made with Gephi. Figure 7b shows the histogram of selected

Governance, resilience, management, and adaptation have also been used as proxy variables to better measure the effects of climate on conflict. The general idea is that these variables are helpful to contextualize the impact of climate change on a local population and its likelihood of resorting to violence. For instance, lower resilience and adaptation are expected to increase vulnerability and exposure to climate hazards,[16] while more robust governance and democratic institutions are associated with better conflict resolution mechanisms (Koubi 2019, 18.6). It is now rare to find newly published quantitative studies not controlling for some of these variables. Yet, as Ide (2017) points out, there is still a fundamental problem with construct validity, that is, the discrepancy between the construct of interest and the actual variable which is being measured.[17]

Among all keywords, it is worth focusing on "adaptation." Despite being, as this paper argues, a key process in the conflict climate change nexus, adaptation has been poorly and seldomly studied. In general, adaptation has been presented as a variable that favors conflict prevention.[18] If adaptation reduces vulnerability, as Burke et al. (2015, 607) and many others argue, then it is also expected to reduce the impact of climate on known drivers of conflict. In a sense, adaptation is paradoxically conceptualized as a process to maintain society static and shield it from the effects of climate. In a similar vein, adaptation has also been discussed in the context of conflict resolution and peacebuilding. Between 2010 and 2014 (see "adapt" graph in figure 8b), several authors have published on the topic of conflict-sensitive adaptation to climate change. The general idea supported by this group of researchers is that adaptation policies can contribute to prevent potential conflicts as well as "defuse" existing ones (Tänzler, Maas, and Carius 2010, 742) by "mitigating risks for human security that arise from adverse climate change impacts or maladaptation" (Tänzler, Ziegenhagen, and Mohns 2013, 40).

There is, however, a recognized conflict potential also in adaptation policies (Mach et al. 2019, 196). As Paavola and Adger (2002, 6) notice, adaptation policies involve questions of distributive and procedural justice. If political processes and social issues are not taken into account, adaptation policies can worsen or create new grievances (Yanda and Bronkhorst 2011, 3). For example, some authors have highlighted the fact that adaptation/mitigation policies can unintentionally change power structures in a population, creating new opportunities for confrontation as well as cooperation (see Carey, French, and O'Brien 2012; Eriksen and Lind 2009). According to Babcicky (2013, 482), adaptation can also be a trigger for resource conflicts, for example, when policies in one country reduce the number of resources available in another. Finally, migration has also been framed as an adaptive strategy which, when not controlled, can trigger conflict by increasing resource competition or creating various forms of social conflict (Black et al. 2011; Burrows and Kinney 2016; Reuveny 2007; Scheffran, Marmer, and Sow 2012; van Baalen and Mobjörk 2018). Taken all together, it seems, however, that the literature on the conflict potential of adaptation has remained mostly theoretical, grounded on anecdotal evidence, and based on existing causal inferences (greed and grievances).

Lack of developments in this area can be attributed to the overwhelming influence of positivist, environmental security scholarship. As Selby (2014, 846–50) noted, positivist literature is inattentive of the conflict potential of adaptation because it is too focused on using historical evidence to test its hypotheses, thus ignoring the possibility of new forms of conflict emerging from climate change.

keywords from 1998 to 2018 with their normalized frequency. The words were truncated and merged to avoid duplicates using, respectively, Sci2 and OpenRafine.

[16] Vulnerability is a measure of exposure, sensitivity, and adaptive capacity. (Scheffran, Brzoska, et al. 2012; Barnett and Adger 2007).

[17] For example, numerous studies use economic variables, such as access to international commodity markets, to proxy adaptive capacity (Barnett & Adger, 2007, 649; Ide, 2017, 4).

[18] An exception to this inference has been discussed by Hicks and Maldonado (2019), who argued that there is no evidence at the macro-level that adaptation reduces the likelihood of conflict outbreaks.

Moreover, it can be argued that most quantitative studies rely on the *ceteris paribus* clause and, therefore, assume that social responses to future climate impact will remain constant over time (Hermans and Ide 2019, 42). In other words, they ignore adaptation for statistical reasons. Issues related to methodological tractability are a well-known problem that only recently (a few) scholars have been trying to address. For instance, Hagre et al. (2016) have adopted a *mutatis mutandis* approach to statistical analysis in which society is expected to change in the future according to shared socioeconomic pathways (SSPs).

The use of SSPs among large-*N* studies has been welcomed as a step forward in the right direction (Theisen 2017, 218). Nonetheless, it should be noted that when using SSPs, society is not modeled as adaptive, but rather as variably static. SSPs allow to improve future predictions, but they are not useful in understanding how adaptation interplays with climate and conflict. A better approach to understand causation seems to be offered by qualitative studies. For instance, two recent case studies on Bangladesh have described how adaptation policies have led to communal conflicts due to processes of enclosure, exclusion, encroachment, and entrenchment (Sultana and Thompson 2017; Sovacool 2018). Qualitative studies of this kind are useful to trace how adaptation can lead to conflict, but as Scheffran et al. (2012a, 4) argue, they ultimately have problems supporting "their claims beyond case-specific data." For this reason, as explained by Ide (2017, 10), future research should attempt to "refine existing methods" and "explore new (combinations of) methods for investigating climate–conflict links." Particularly promising in this regard, as BenDor and Scheffran (2019) point out, could be the use of computer simulations on conflict, cooperation, and adaptation via agent-based modeling (ABM).

Disaggregated Evidence and Theoretical Explanations

This section reviews evidence linking climate change to conflict onsets. The documents analyzed in the previous section were screened and then examined individually to extrapolate their conclusions, theoretical explanations, and methodological approaches. In order to be selected, documents had to meet two criteria: (a) formally test whether climate change increases the risk of conflict onsets; and (b) describe method and data to allow for replication. The WoS dataset, as previously explained, provides a comprehensive list of publications but also contains a few omissions. For example, articles that are not well indexed or only recently published might not be featured in the dataset. For this reason, the WoS dataset was crosschecked with the bibliographies of five other review articles to prevent oversights (Scheffran, Brzoska, et al. 2012c; Selby 2014; Sakaguchi, Varughese, and Auld 2017; Burke, Hsiang, and Miguel 2015; Buhaug, Gleditsch, and Theisen 2008).

In addition to the above-mentioned selection criteria, this review has excluded papers that use (c) outbreaks of interpersonal violence as the dependent variable and (d) environmental/climatic variables not related to climate change as the independent variable. Most review articles assemble a multitude of papers that, at times, share little in common. For instance, in a review of Burke et al. (2015), eighteen reviewed papers out of fifty-six include forms of interpersonal violence as a dependent variable, ranging from domestic violence to road rage. Interpersonal violence and organized violence might, at times, be intertwined, but they are, by all means, two distinct phenomena that should be studied in their own regards. Assembling them will only skew the final assessment of the review.

A more subtle problem is related to criteria (d). As Meierding (2016) noted, many authors seem to be engaging in "weather conflict" research rather than in "climate conflict" research. Most publications from environmental security bundle together anthropogenic and non-anthropogenic climate processes, often including environmental variables that are not related to climate change. Going back to Burke et al. (2015), we find over one-fifth of reviewed articles being affected by this problem. If the geophysical processes of climate are man-made,

their impact on society involves questions of attribution, justice, and security that are absent in non-anthropogenic climate processes. For this reason, it is advised to exclude papers on environmental security that are not directly related to global warming.

The overall findings of this section are difficult to interpret. On the one hand, this paper provides plenty of evidence in support of a nexus, but, on the other, it also provides refuting and conflicting evidence. Moreover, an evaluation of the state of knowledge in the literature is hindered by the lack of shared methodologies, theories, and epistemological standards across studies. Overall, it appears that the field of study has reached a stalemate in terms of knowledge production. New large-*N* studies and case studies continue to be published, but our theoretical understanding of the causes of conflict is not gaining depth. At the same time, it appears that older theoretical explanations on the causes of conflict are becoming increasingly inadequate in explaining the host of contradicting evidence. For this reason, this section invokes caution in reading existing evidence and reaffirms, as the IPCC has already stated, that there is no indication of a "strong positive relationship between warming and armed conflict" (2014a, A:772).

Evidence of a Nexus

This section analyzes in detail fifty-eight prominent studies that correlate climate variables with conflict onsets. In order to provide a coherent synthesis of this body of literature, the studies were listed in table 1 and then summarized in figure 8. Table 1 lists the independent and dependent variables, the link between them, and the period and area analyzed by each study. The table was structured according to the same format of the tables found in the review articles of Scheffran et al. (2012, 3–4) and Selby (2014, 823). It should be pointed out that extrapolating the findings from their original source has required, in some cases, some degree of interpretation. For these reasons, the results listed in table 1 should be taken with a grain of salt and regarded only as indicative.

The majority of documents in table 1 use cross-sectional/panel data from a range of different countries. Regarding the area analyzed, Africa is the most studied region counting 24 studies, followed by Asia with 11, and Europe with five. Only twenty studies use panel data on a global scale. Regarding the granularity of data, most studies use aggregate data sampled at the country-level on a yearly basis. In contrast, palaeoclimatological studies use decades as a time unit (Tol and Wagner 2010; D. D. Zhang, Zhang, et al. 2007; D. D. Zhang et al. 2006). It also appears that recent publications are increasingly adopting finer datasets using months and sub-national data points to account for the "short-lived and local nature" of conflict (Almer, Laurent-Lucchetti, and Oechslin 2017, 193). Regarding methodology, most studies in table 1 use logit, probit, and Tobit models, with recent publications often relying on mixed approaches that use multiple statistical models (Wischnath and Buhaug 2014; Almer, Laurent-Lucchetti, and Oechslin 2017).

When looking at the dependent variable, intra-state conflict has been studied by thirty-three papers, non-state conflict by seventeen papers, and inter-state conflict by four papers. Concerning the independent variable, the most used proxy for climate change is precipitation (including drought), with twenty-three studies; followed by temperature and climate-induced disasters. Regarding correlations, a significant link between climate and conflict has been found by forty-one studies and has not been found by fourteen studies. Figure 8 provides a visualization of table 1 showing which climate variables are linked to what kind of conflict. As can be seen, certain links between climate variables and types of conflict remain overlooked by the literature.

Table 1. Selected quantitative studies

Source	Date	Period analyzed	Area analyzed		IV	Link	DV	*
			Country	Region				
Adano et al. (2012)	2012	1950–2010	KEN	Africa	+P	Y	+NSC/+IV	a,c
Almer, Laurent-Lucchetti, and Oechslin (2017)	2017	1990–2011		Africa	+D	Y	+INTRA/+NSC	
Burke et al. (2009)	2009	1981–2002		Africa	+T	Y	+INTRA	a,b,c,d
Detges (2016)	2016	1990–2010		Africa	+D/−P	Y	+INTRA	c
Fjelde and von Uexkull (2012)	2012	1990–2008		Africa	−P	Y	+NSC	b,c,d
Hendrix and Glaser (2007)	2007	1981–2002		Africa	CV	Y	INTRA	a,b,c,e
Hendrix and Salehyan (2012)	2012	1990–2008		Africa	^P	Y	INTRA/NSC	a,b,c,d
Maystadt and Ecker (2014)	2014	1997–2009	SOM	Africa	D	Y	+INTRA/+NSC	b,d
Miguel, Satyanath, and Sergenti (2004)	2004	1979–1999		Africa	^P	Y	+INTRA	a,d,e
Nordkvelle, Rustad, and Salmivalli (2017)	2017	1989–2013		Africa	+D/DIS	Y	+NSC	
O'Loughlin et al. (2012)	2012	1990–2009		Africa	+T	Y	^INTRA	b,c,d
Papaioannou (2016)	2016	1912–1945	NGA	Africa	^P	Y	INTRA/NSC/IV	c
Raleigh and Kniveton (2012)	2012	1997–2009		Africa	^P	Y	+INTRA/NSC	a,b,c
Raleigh, Choi, and Kniveton (2015)	2015	1997–2010		Africa	−P/D	Y	+INTRA/NSC	c
Rowhani et al. (2011)	2011	2000–2006		Africa	+V	Y	+INTRA	a
Theisen (2012)	2012	1989–2004	KEN	Africa	+P	Y	+INTRA/NSC	a
Benjaminsen et al. (2012)	2012	1992–2009	MLI	Africa	−W	N	^C	a
Buhaug (2010a)	2010	1981–2002		Africa	+T/^P	N	^INTRA	a,b,c,d
Buhaug and Theisen (2012)	2012	1960–2004		Africa	^P/+D	N	^INTRA	a
Couttenier and Soubeyran (2013)	2014	1957–2005		Africa	+D	N	+INTRA	d
Kevane and Gray (2008)	2008	1980–2000	SDN	Africa	−P	N	+INTRA	b
Meier, Bond, and Bond (2007)	2007	2004–2005		Africa	P	N	+NSC	b,c,e
Theisen, Holtermann, and Buhaug (2011)	2011	1960–2004		Africa	D	N	INTRA	b,d
von Uexkull et al. (2016)	2016	1989–2014		Africa–Asia	D	Y	^INTRA	
Bai and Kung (2011)	2011	220b.c.–839	CHN	Asia	+D/−P	Y	+C	a,d
Bhavnani and Lacina (2015)	2015	1982–2000	IND	Asia	^P	Y	+NSC/+IV	c
Caruso, Petrarca, and Ricciuti (2016)	2016	1993–2003	IDN	Asia	+T	Y	+INTRA	c
Sarsons (2015)	2015	1950–1995	IND	Asia	+P	Y	−NSC	c
D. D. Zhang et al. (2006)	2006	1000–1911	CHN	Asia	−T	Y	+C	d
D. D. Zhang, Zhang et al. (2007)	2007	1000–1911	CHN	Asia	−T	Y	+C	a,b
Z. Zhang et al. (2010)	2010	10–1990	CHN	Asia	−T	Y	+C	a

Table 1. Continued

Source	Date	Period analyzed	Area analyzed		IV	Link	DV	*
			Country	Region				
Bernauer and Siegfried (2012)	2012	1991–2045	KYR-UZB	Asia	CC	N	+INTER	
Wischnath and Buhaug (2014)	2014	1950–2008		Asia	CV	N	INTRA	b,c
Buntgen et al. (2011)	2011	500b.c.–011		Europe	^^T/^P/CV	Y	^C	b
H. F. Lee et al. (2013)	2013	1400–1995		Europe	NAO	Y	+C	b,d
D. D. Zhang et al. (2011)	2011	1500–1800		Europe	−T	Y	+C	a
Tol and Wagner (2010)	2010	1000–2000		Europe	−T	~	+C	a,b,c,d
D. D. Zhang, Brecke, et al. (2007)	2007	1400–1900		Europe–Asia	−T	Y	+C	b,c
Devlin and Hendrix (2014)	2014	1950–2002		Global	^P	Y	^^C	c
Gartzke (2012)	2012	1816–200		Global	+T	Y	−INTER	a,b
Ghimire and Ferreira (2016)	2016	1985–2009		Global	+DIS	Y	INTER	c
Gizelis and Wooden (2010)	2010	1981–2000		Global	^W	Y	INTRA	a
Hsiang, Meng, and Cane (2011)	2011	1950–2004		Global	EL	Y	INTRA	a,b,c,d
Landis (2014)	2014	1948–2011		Global	+T/−P	Y	+INTRA/+NSC	c
Nardulli, Peyton, and Bajjalieh (2015)	2015	1981–2004		Global	DIS	Y	C	c
Nel and Righarts (2008)	2008	1950–2002		Global	DIS	Y	+INTRA	a,b,c
Salehyan and Hendrix (2014)	2014	1970–2006		Global	+P	Y	+NSC	c,d
Schleussner et al. (2016)	2016	1980–2010		Global	DIS	Y	INTRA	c
Slettebak (2012)	2012	1950–2008		Global	DIS/D	Y	−INTRA	a,b,c
Theisen (2008)	2008	1979–2001		Global	L	Y	INTRA	a,e
Tir and Stinnett (2012)	2012	1950–2002		Global	−W	Y	INTER	c
Bergholt and Lujala (2012)	2012	1980–2007		Global	+DIS	N	+INTRA	a,b,c
Böhmelt et al. (2014)	2014	1997–2009		Global	CV	N	^INTRA/^NST	c
Dell, Jones, and Olken (2012)	2012	1950–2003		Global	^T	N	^C	c,d
Klomp and Bulte (2013)	2013	1960–2008		Global	^P/^T	N	+INTRA	b
Koubi et al. (2012)	2012	1980–2004		Global	^P/^T	N	+INTRA	a,b,c
Raleigh and Urdal (2007)	2007	1990–2004		Global	^L/^W	~	+INTRA/NSC	a,b,c,e
Urdal (2005)	2005	1950–2000		Global	L	~	INTER	a,e

Notes: Independent variable (IV): CC = climate change; CV = climate variability; P = precipitation; T = temperature; D = draught; DIS = climate-induced disasters; V = vegetation; L = land, W = freshwater; SLR = sea-level rise; EL = ENSO; NAO = North Atlantic Oscillation.
Link: Y = leads to; N = does not lead to; ~ = is not clear if it leads to.
Dependent variable (DV): C = conflict; INTER = inter-state conflict; INTRA = intra-state conflict; NSC = non-state conflict; IV = interpersonal violence.
Symbols: + = increase; − = decrease; ^ = variation (increase or decrease).
*Additional sources: a = Scheffran, Brzoska, et al. (2012); b = Selby (2014); c = Sakaguchi, Varughese, and Auld (2017); d = Burke, Hsiang, and Miguel (2015); e = Buhaug, Gleditsch, and Theisen (2008).

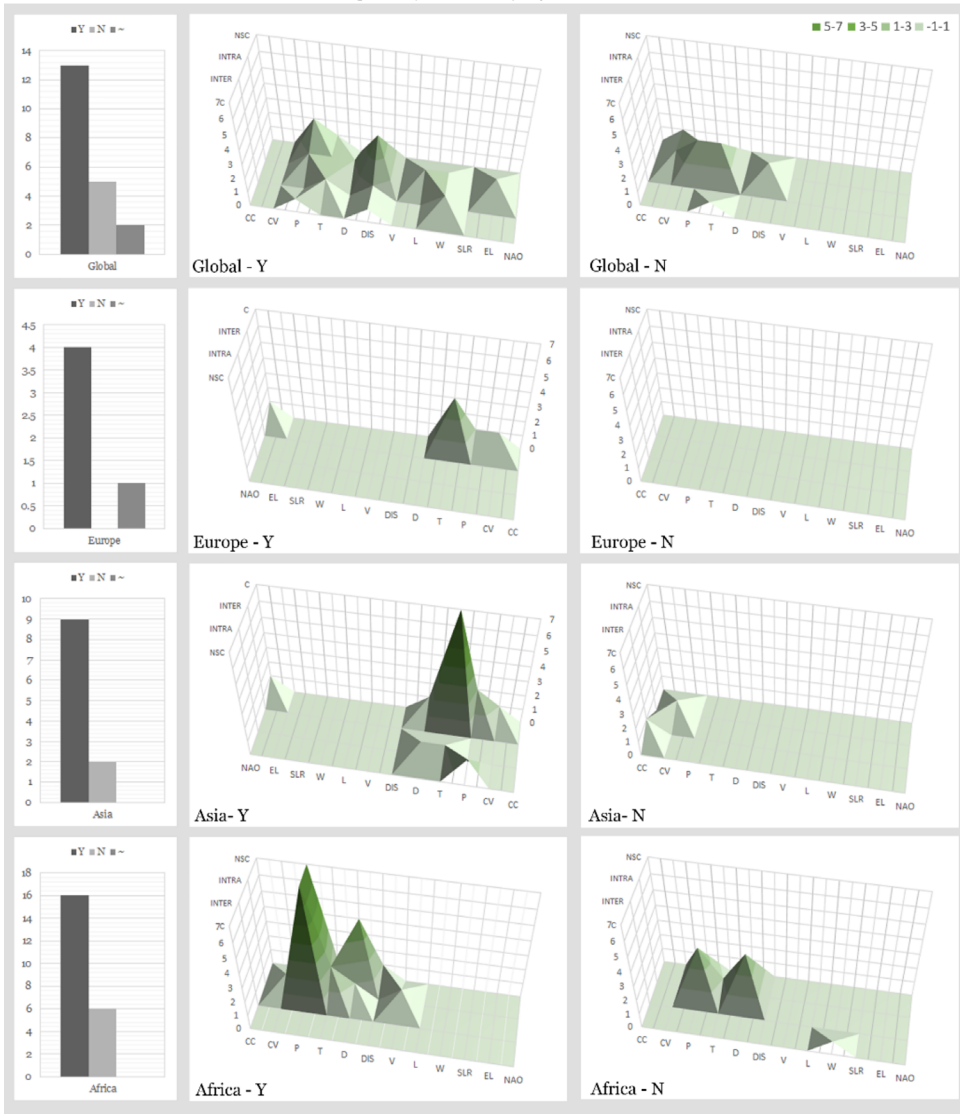

Figure 8. Summary of table 1.[19]

Table 1 and figure 8 also reveal that the findings are not consistent among regions, temporal scales, and causal links. For instance, in the context of Africa and inter-state conflict, drought has been found not statistically significant by Theisen et al. (2011), but significant by Maystadt and Ecker (2014). Reduction of precipitation has been linked to inter-state conflict by Detges (2016) in areas with weak water infrastructure and by Raleigh, Choi, and Kniveton (2015) via an indirect impact on food prices. Conversely, more precipitation has been found to be significantly linked to conflict outbreaks by Adano et al. (2012) in the case of livestock raiding and by Theisen (2012) in the context of pastoralist societies.

Regarding temperatures, palaeoclimatological studies have found that lower temperatures are linked to conflict increases in Europe and Asia (D. D. Zhang, Zhang

[19] Data, table 1. "~" were not included in the surface graphs.

et al. 2007; Tol and Wagner 2010), whereas studies analyzing recent periods have established that higher temperatures are instead correlated to inter-state and non-state conflict (Burke et al. 2009; Landis 2014). Natural disasters have also been linked to intra-state conflict by Nel and Righarts (2008) in the case of low- and middle-income countries, but Bergholt and Lujala (2012) have found no historical evidence in their dataset. Listing all the conflicting evidence is beyond the scope of this review and would be redundant to do so since figure 8 and table 1 already provide an effective summary to the reader. It is instead more interesting to move to the next section and explain what causal mechanisms have been identified so far by the literature and what the collective assessment on the state of knowledge in the field is.

Causal Mechanisms

Studies on the climate–conflict nexus have succeeded in establishing a series of correlations, albeit inconsistent, but failed to isolate causal factors and to provide sufficient theoretical explanations.[20] It is a well-known fact that conflict is a multi-dimensional and multi-causal[21] social behavior, but the widespread "positivist–rationalist bias" (Ide 2016, 2) of quantitative literature has often stirred scholars to seek for a simple "Newtonian" causality in the climate–conflict relationship (Haldén 2012, 12). This reductionist turn is particularly evident in the post-2007 wave of publications, which has focused on measuring the effect size of climate change on conflict rather than understanding its causes.[22] Indeed, most papers do not even make causal claims for the correlations that they find or, when they do so, they rely on explanations borrowed from environmental security or rational choice theory.

The majority of contemporary studies establish causal links using interacting and mediating variables (see figure 9). As pointed out by Adano et al. (2012, 65), direct causal chains that do not control for mediating variables are now rare in the scholarship and "dismissed as physical determinism." Nonetheless, studies accounting only for mediating factors (see figure 9a) are somehow still tolerated despite their radical form of reductionism (Meierding 2013, 58). This group of studies includes research on the effects of climate on human behavior (e.g., temperatures and aggressivity)[23] and traditional neo-Malthusian research that assumes a structural relationship between environment, economic growth, and population (Sakaguchi, Varughese, and Auld 2017, 631).

Studies that look at intermediate factors (Figure 9b) use a two-stage approach to "model the indirect effects of climate change on conflict via an intermediate variable," which is often drawn from environmental security or economic literature (Meierding 2013, 186). The indirect causal pathways found in the literature are summarized in table 2. As shown, the impact of climate change, which is always regarded as exogenous, is seen interacting with economic growth, state capacity, resource base, policies, and migration movements. In turn, these intermediate variables, mediated by local and contextual factors, act as conflict drivers via grievances, opportunity-costs calculations, or tactical opportunities.

Whereas the first wave of literature has focused on the resource base as an intermediate factor, the post-2007 literature has been centered on the economic effects of climate change. The underlying assumption is that economic shocks and slow economic growth affect conflict onsets. For example, it has been argued that

[20] There have been a few attempts at constructing a theoretical framework: see Scheffran, Brzoska et al. (2012); Scheffran, Link, and Schilling (2012).

[21] See Homer-Dixon (1999, 106), Hsiang, Burke, and Miguel (2013, 341), Selby (2014, 839), and Theisen et al. (2011, 91).

[22] An exception is represented by several qualitative studies based on local-regional case studies, many conducted in the research group Climate Change and Security (CLISEC) at the University of Hamburg.

[23] This body of literature is not analyzed in this literature review, see section "Evidence of a Nexus."

Table 2. Summary of causal mechanisms and explanations

Climate change →	Interacting with →	Mediated by →	Leads to conflict because of
Geophysical processes; Climate impacts	Resource base; Economy/trade/ markets; Human displacement; State capacity/governance	Socioeconomic factors; Environmental/ geographic factors; Institutional/political factors; Exposure/vulnerability; Culture/ethnicity; etc.	Greed; Grievances; Tactical opportunities

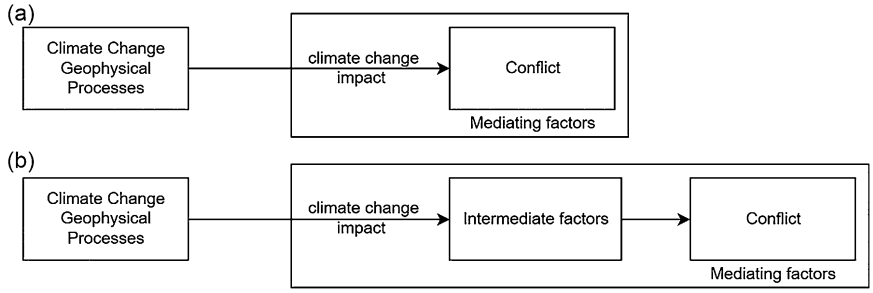

Figure 9. Summary of causal links.

a reduction of taxable income reduces state capacity and governance, which in turn increases the opportunity cost of not participating in an insurgency. Moreover, poor governance and economic downturns have been said to create grievances by exacerbating economic inequalities and suppressing welfare (Koubi 2019, 5; Hendrix and Salehyan 2012, 38; Buhaug, Gleditsch, and Theisen 2008, 24–25). It should be pointed out, however, that the effects of climate change on the economy are highly contested and context-specific (Dell, Jones, and Olken 2012, 92). The same goes for the other intermediate variables.

Overall, despite the plethora of specific mechanisms and pathways identified in the literature, it appears that outbreaks of violence are always explained with three kinds of mechanisms: greed, grievances, and tactical opportunities. The greed explanation is often grounded in rational choice theory and it is built on some disputable assumptions: such as population homogeneity and utility-optimizing behavior (Mueller 2003; Collier and Hoeffler 1998). It assumes that, if given an opportunity, every citizen will eventually resort to violence when the benefits of insurgency outweigh the costs. The grievance explanation is also problematic since, as De Soysa (2002) argues, grievances are omnipresent but rarely a sufficient cause of violent outbreaks. Moreover, grievances are often determined by the use of violence, rather than being a cause of violence (De Soysa 2002).

In conclusion, it appears that scholars have taken note of the impact of climate on previously observed drivers of conflict but missed to ask the question of whether climate change also introduces new forms of conflict (see Meierding 2016). More specifically, the role of cognition and adaptation has remained largely understudied. As discussed in the previous section, the *process of adaptation to climate change* can be in itself a cause of conflict independent from socio-environmental stressors. For example, climate conflicts could arise from individual and collective choices of adaptation to climate change that are mutually exclusive across scales and not

Table 3. Causal mechanisms linked to adaptation and cognition

Climate change →	Interacting with →	Mediated by →	Leads to conflict because of
Geophysical processes; Climate impacts	Cognition of climate change; Adaptation strategies; Climate change policies	Social and environmental uncertainties	Incompatible adaptive pathways; Strategic opportunities to secure/improve adaptive pathways; Maladaptation

reconcilable due to lack of coordination and/or high levels of social and environmental uncertainty.

It is well understood that policies and strategies for adaptation have to be coordinated across scales in order to prevent forms of social conflict. For instance, adaptive pathways at the international level need to account for local forms of adaptation and vice versa. Likewise, choices regarding adaptation to climate change in the present, such as allocation of resources to specific age groups, have to be coordinated with the necessities of future generations. Nonetheless, coordination of adaptive pathways might not be sufficient in preventing conflict outbreaks due to *social and environmental uncertainties*.

Individuals adapting to climate change determine their livelihood options and allocate resources based on deliberative assessments (e.g., risk and adaptation appraisals), affective predispositions (e.g., fear conditioning), and social factors (e.g., dispositional contagion) (Hailegiorgis, Crooks, and Cioffi-Revilla 2018; Grothmann and Patt 2005; Epstein 2014). High social uncertainty (i.e., variance of views on climate change) translates into low confidence that people will act according to common strategies of adaptation. High environmental uncertainty (i.e., knowledge of climate processes and their local impact) equals high chances of choosing wrong adaptive strategies and skewing the expected distribution of benefits. Overall, when socio-environmental uncertainties are high, the adaptive choices of individuals are more likely to lead to maladaptation and be informed by affective factors. It is in this context of high uncertainties that violence can emerge, either as an integral part of an adaptive strategy or as a consequence of a breakdown of cooperation.

In sum, it could be hypothesized that the causes of conflict are to be found not only in the geophysical impact of climate change or in the environmental stressors that it poses, but also in the social processes that are used to cope with it (e.g., adaptation or mitigation). This implies that the intersubjective knowledge of climate change, which informs attitudes and behavioral choices, is as relevant as the geophysical impact of climate in determining the likelihood of conflict onsets. As a consequence, research on the conflict climate change nexus should take into greater account the cognitive dimension of climate change and consider causal mechanisms as the one outlined in table 3 rather than focusing solely on the material consequences of climate change on the economy and resource base of a society. As Meierding (2016) pointed out, violence is only one of the many possible social responses to climate change. However, even seemingly non-violent responses (i.e., migration or carbon tax) can ultimately lead to structural or kinetic violence under premises of high social and environmental uncertainties.

While future research in IR should investigate the conflict potential of adaptation and mitigation to climate change, policy makers should also question a strictly materialistic view of peacekeeping and conflict prevention policies. It might well be the case that institutional arrangements that reduce social and environmental uncertainties while promoting cooperation across scales are positively related to a reduction in socio-environmental conflicts. So, again, rather than focusing on

reducing or mitigating the material impact of climate change to prevent conflict onsets, it might be better to mobilize social capital to promote knowledge acquisition and information sharing.

Final Remarks and Recommendations for Further Research

This study has shown that the conflict climate change scholarship has failed to integrate its empirical evidence into a coherent, heterogeneous body of knowledge. Despite hundreds of published studies, there is still low confidence in the validity of the findings due to lack of consistency of evidence and low degree of agreement (IPCC 2014a, A:772). Low consistency has often been attributed to lack of shared methodologies, theoretical frameworks, and datasets.[24] However, as this paper suggests, the problems run deeper than that. The current impasse in the field of study is not a consequence of methodological preferences, but rather of ontological and epistemological standings.

To better illustrate this point, let us look back at the history of climatology: what we see is that, during the nineteenth and early twentieth century, climate had been understood as stable in time, geographically defined and exogenous to society (Heymann 2010, 582). This conceptualization was indeed substantiated by early empirical observations made during a geological era, the Holocene, characterized by relative stability and regularities. Yet, as we moved into the Anthropocene, it became clear that the climate system was not fitting with the mechanistic explanations provided by classical climatology. Eventually, new data collected in the higher atmosphere gave rise to dynamic meteorology and led to the development of modern climatology, which conceptualizes climate as a dynamic, global, and non-linear process.

Despite the paradigm shift that occurred in climatology, much of the social science research on socio-environmental conflicts has remained stuck in a nineteenth-century conceptualization of climate. In part because of methodological inertia and in part because of issues of mathematical tractability, the Holocentric view of climate—that is, the ontological belief that climate is a stable and local phenomenon that occurs in an environment exogenous to society—has remained widespread. Just as climatologists have quantified the increase of seawater for a given increase of temperature, many social scientists have tried to quantify the increase of conflict outbreaks for a given climate hazard. Yet, whereas climate science has moved toward computational models,[25] much of social science has kept using the methodological toolkit of nineteenth-century scientists and opted for reductionist methodologies that oversimplify social realities.

To this date, climate models are largely inaccurate at predicting the local micro-level changes in climate, and weather forecasting models systematically fail to give accurate predictions above twelve days (McGuffie and Henderson-Sellers 2005, 11/66). Nevertheless, many positivist social scientists still believe they can run a regression and make an accurate long-term prediction of human behavior. Their justification often lies in the *ceteris paribus* clause, which, however, appears to be epistemologically unsubstantiated (Buhaug 2015, 271). In a complex adaptive system, things are never held equal. Societies learn, adapt, and co-evolve in

[24] See footnote 1.

[25] In 1946, a group of scientists led by John von Neumann ran the first weather model on a computer (Heymann 2010, 590). Nine years later, Norman Phillips, a member of von Neumann's team, ran another weather model on a longer timescale, thus creating the first climate simulation (McGuffie and Henderson-Sellers 2005, 63). This model, which used a computer with only 5 kilobytes of memory, was based on a stylized and approximate representation of the climate system but served to prove the point that it was possible to simulate climate on longer temporal scales (McGuffie and Henderson-Sellers 2005, 63). In the following decades, the complexity of models increased exponentially as well as their ability to precisely simulate future scenarios. A reconstruction of the history of climate change science is beyond the scope of this research. Readers who wish to learn more can read McGuffie and Henderson-Sellers (2005).

unexpected ways, and consequentially their behavior cannot be reduced to some deterministic causality found within the system's experience. Reductionism might have worked in the Holocene, but it is not going to help in the Anthropocene.

If we keep looking at a nonlinear word through a "linear vision," as noted by Richards (2000, 2), we "miss a lot" or, worst, we risk superimposing reductionist explanations upon complex multi-causal phenomena. IR and conflict studies should therefore reframe social-ecological systems (SES) as complex adaptive systems (Ostrom 2009) and socio-environmental conflicts as emergent behaviors of coupled biotic and abiotic systems (Scartozzi 2018). Only through a social-ecological perspective it will be possible to move the research program into the Anthropocene and see climate as a variable, global process that is intertwined with society through feedback loops and co-evolutionary dynamics.

As this essay shows, the positivist research program has reached its natural end with the Anthropocene. It has succeeded in providing evidence that climate and conflict are correlated, but it has failed to provide a theoretical understanding. From a Lakatosian perspective, it can be said that the research program has become "degenerative" and lost its explanatory and predictive power at the moment when its theoretical growth fell behind its empirical growth (Lakatos 1978, 1:112). Indeed, what is urgently needed at this point are not additional narrow scope empirical validations, but rather a qualitative understanding of the mechanisms and feedbacks that couple conflict with climate change (Rigg and Reyes Mason 2018).

Ostrom, as well as scholars from various disciplines ranging from system-ecology to political science, has identified computer simulations made via ABM as a possible tool to discern the complexity of SES and identify the key mechanisms that generate the behavior of interest (Janssen and Ostrom 2006; Balbi and Giupponi 2009; Harrison 2006). Within the conflict climate change scholarship, agent-based models have been recently referenced by Hermans and Ide (2019, 43) as a promising method to investigate the climate–conflict links "given their ability to depict individual behavior" and go beyond structural factors. BenDor and Scheffran (2019, xxvi) have also used complexity theory and ABM as tools for "understanding the dynamics of conflicts that emerge from the incompatible actions, values, behavioral modes." Overall, ABM and computational models are particularly promising as they go beyond the limitations of equation-based models (Meierding 2016) and allow to simulate complex adaptive behaviors among heterogeneous agents.

Further investigation and experimentation using computational models and mixed methodologies are strongly recommended, if not needed, to make sense of the disaggregated evidence and understand causation. Parallel to this effort, it is important for the scholarship to engage in epistemological debates and periodically re-evaluate the state of knowledge via meta-analyses and systematic reviews. As recently done by Mach et al. (2019), review articles should also break down existing co-authorship clusters and have broad and inclusive authorship to avoid the pitfalls of polarization and relativism highlighted in this paper.

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