Science–policy dimensions of research on climate change and conflict

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Abstract
A large body of research now indicates that climate likely matters for conflict. This climate–conflict scholarship, however, has involved divergent findings, sometimes strident disagreement, and resulting limits to the usability of the scholarship for policymakers and practitioners. This viewpoint essay draws from recent expert assessments of climate–conflict linkages to position the research field among climate change research and assessment more broadly. We explore potential insights from the climate realm. As is often the case for climate change research, science–society dynamics are inherent in scholarship on climate and conflict. They contribute to contestation about the state of knowledge, the best ways to characterize it, and its implications for societal choices and investments. Our critique is grounded in the literature evaluating policy-relevant climate change assessment across diverse disciplines, from sea-level-rise adaptation science to energy-system modeling. Through comparisons with such fields, this perspective article considers several implications for climate–conflict knowledge production. We examine, in particular, the necessity of integrating diverse lines of evidence to understand the risks of responding to societally relevant uncertainties and priorities, and of encouraging interactions among researchers, practitioners, and policymakers. The experiences of other climate change disciplines can provide inspiration for potential directions for climate, conflict, and security scholarship. They include risk framings in integrating underlying evidence, through to options for supporting the interactions among researchers and societies.

Keywords
climate change, conflict, science-policy interactions

Introduction
Research on the relationship between climate, conflict, and security has proliferated. This literature has spanned epistemologies and disciplines and evolved through time (Busby, 2018a, 2021; Gleditsch, 2021; von Uexkull & Buhaug, 2021). Across it, a large body of evidence now indicates that climate in both its variability and its change likely matters for violent conflict (Adger et al., 2014; Koubi, 2019; Mach et al., 2019). This scholarship, however, has been typified by divergent, seemingly contradictory findings and occasionally strident disagreement about how climate and conflict are linked (e.g. Buhaug, 2010; Burke et al., 2009; Hsiang & Burke, 2018; Solow, 2013). Many syntheses have attempted and sometimes struggled to make sense of the current state of understanding, identifying areas of agreement and the reasons for disagreement (e.g. Gemenne et al., 2014; Hsiang, Burke & Miguel, 2013; Ide & Scheffran, 2014; Koubi, 2019; Mach et al., 2019; Salehyan, 2014).
Contestation about the state of knowledge, in turn, has limited the usability of this knowledge for decision-making and societal management of the risks.

Here, we explore these dynamics by connecting climate–conflict research with climate change research more broadly. Several decades of climate change assessment have resulted in extensive scholarship on how the societal relevance of research influences the scientific process itself (e.g. Mach & Field, 2017; Mitchell et al., 2006; Oppenheimer et al., 2019b). The sections that follow consider, first, the inevitable presence of societal and policy dynamics in climate–conflict knowledge production. Second, we discuss the implications of this real-time relevance and effective practices identified in the experiences of diverse climate-related disciplines. Our goal is to provoke insight on both the hurdles and the opportunities of research evaluating the relationship among climate, violent conflict, and security.

Science–policy dimensions of climate–conflict knowledge production

Positioning research on climate and conflict within the vast landscape of climate change research underscores unavoidable complications. Science–society dynamics are inherent in climate change research. They arise because the research is important in real time (e.g. Funtowicz & Ravetz, 1993; Head, 2008).

First, there are potentially large consequences in most domains of climate change research. Reasons for concern about climate change include the loss of unique ecosystems and cultures, damages from climate-related extremes, widespread impacts on food and water security, and possibly irreversible collapse of the ice sheets and substantial sea-level rise as a result (O’Neill et al., 2017). Related climate change impacts are increasingly being experienced. Examples include the recurrent flooding during high tides leading to traffic disruptions or intensified heat waves increasing morbidity and mortality.

Second, there are deep and difficult-to-quantify uncertainties. They result from the ways climate change impacts cascade and interact – for example, with flood disasters in urban areas simultaneously affecting transportation, communication, energy, and health systems and amplifying overall risks. They also stem from the long-term trajectories of socio-economic development shaping both vulnerability to climate impacts and the levels of heat-trapping emissions from associated energy and land systems.

Third, climate impacts and responses will be perceived and valued differently. Societal objectives affected range from economic and other measures of human well-being to sustainable development enabling future generations to meet their needs (Mach et al., 2016). For example, increasing societal attention to climate justice has included prioritization of equity in urban adaptation. It has also included emerging global frameworks for loss and damage, attuned to the disproportionate burden of climate change for frontline, marginalized communities (e.g. Article 8 of the Paris Agreement).

Scholarship on the relationship between climate and conflict shares these features. Violent conflict has profound and enduring detrimental consequences for people, economies, and environments. It compromises human well-being and the ability of people to pursue endeavors and goals at the core of human existence. Therefore, climate–conflict linkages are consequential even if small. At the same time, there are notable uncertainties about climate–conflict links. They include the relative importance of climate among drivers of conflict. They also involve the mechanisms underpinning climate–conflict interconnections, the conditions under which they manifest, and the difference between linkages to date and those that may become relevant with additional climate change (Buhaga, 2015; Gleditsch, 2012; Mach et al., 2019; Salehyan, 2014). Limited understanding of the specific links, whether through agriculture, economic shocks, disasters, or migration, in turn challenges practitioners and policymakers in making prudent investments and policies (Busby, 2018b). Associated discord encompasses the politics of framing violent conflict as a climate issue. There are simultaneous risks of downplaying or overemphasizing conflict risks from climate change (Gemenne et al., 2014). Since armed conflict is fundamentally a manifestation of political failure, politics, not merely policies, figure into climate–conflict solutions even more intensely than for other climate-related responses.

Science–society dynamics can impinge without invitation on the process of research and support of decision-making. Across the climate issue, prominent examples have included the ways in which the implicit threats of climate deniers (e.g. Mann, 2012) may lead climate change scientists to ‘err on the side of least drama’. That is, scientists favor characterizations of present-day understanding that are conservative and biased towards ensuring very low chances of being incorrect (Bryse et al., 2013). In other examples, standard scientific practices have become wildly controversial and politicized in intergovernmental science–policy contexts, for example related to applying a statistical economic value of human life or categorizing countries by income levels (Dubash, Fleurbaey & Kartha, 2014; Grubb, 1996).
These types of social complexities may contribute to the sometimes strident dialogues on scholarship related to climate and conflict. Societal relevance is prominent and therefore unavoidably present in knowledge production on the topic. In the climate and conflict context, the complexities have also been taken up through differing epistemological and theoretical approaches applied and adjusted through time (e.g. positivist, interpretivist, feminist, Marxist), as well as pragmatic and political questions about the voices, objects, and interests represented and engaged in the research – or not (Busby, 2018a; Gleditsch, 2021).

The real-time societal relevance of knowledge can additionally play a deliberate role in processes of knowledge production, synthesis, and decision support. For the climate issue, climate change assessment has played a decades-long role (e.g. IPCC, 1990, 2014) in framing and informing decisions and policies (Mitchell et al., 2006). Over these decades, processes of science–policy interactions have emerged as the science has advanced. The interactions have included communication and dissemination of research through different products and venues. More substantively, ongoing co-production of knowledge has supported decisionmakers and stakeholders planning, implementing, and refining policies. The relevant climate responses involve reducing heat-trapping emissions, preparing for climate impacts, and now planning for carbon removal and even sunlight-reflection management (i.e. solar geoengineering).

As an important contrast, conflict management already involves established collaborations between researchers and practitioners. As climate–conflict scholarship has amassed, its conclusions are relevant for a large set of existing institutions and actors focused on conflict risk reduction, such as through mediation, peacekeeping, and aid. It is simultaneously relevant to more nascent contexts of climate change adaptation. For example, the US Department of Defense has raised the topic of climate and security in climate-specific directives, issue-based reports, and also recurring national security guidelines (e.g. national security, defense, and military strategies), underscoring the immediacy of potential connections. For climate and conflict research, the existence of direct potential connections to the policy field is both an asset and a potential source of controversy.

**Implications of real-time relevance for research and assessment**

The implications of science–society interactions have long been explored for climate change research and assessment (e.g. Mach & Field, 2017; Mitchell et al., 2006; Oppenheimer et al., 2019b). They are relevant to scholarship on climate and conflict as well. A first need is integrating diverse lines of evidence, including rigorous expert judgment, to understand the nature of the risks and inform societal decisionmaking. Further, there is the importance of encompassing the uncertainties that are difficult to quantify and the contested priorities surrounding societal responses. Finally, there are options for navigating and even encouraging interactions among researchers, decisionmakers, and societies.

**Integrating evidence**

The societal relevance of climate change risks often requires integration of diverse lines of evidence, in order for research and assessment to be meaningful for ongoing choices and actions. That is, climate-related scholarship can differ from basic research focused on tractable questions amenable to direct hypothesis testing. Yet the required integration is nontrivial; it requires distinct methods of analysis and synthesis (Mach & Field, 2017). This necessity of integration, long tackled in different domains of climate change research and assessment, is similarly relevant to scholarship on climate and conflict.

As a climate change example, assessment of the risks from sea level rise must integrate wide-ranging disciplines and topics (Oppenheimer et al., 2019a). They include the physics of the ice sheets and the engineering of the built environment in coastal settlements (e.g. drainage or transportation infrastructure). Social and policy sciences are also inherent to anticipating the likelihood of different adaptive responses occurring. Scientific advances have therefore focused on ways to make scenarios of sea-level rise relevant to coastal adaptation and decisionmaking. New approaches have integrated lines of evidence including model estimates, satellite-based observations, paleoclimate data, and expert judgment (Brysse et al., 2013; O’Reilly, Oreskes & Oppenheimer, 2012). Innovative methods of decision support have responded to the uncertainties, such as through scenario development based on both probabilistic and bounding analyses (Hall et al., 2019). Analysis of coastal adaptation has, in turn, involved economic modeling of response strategies across the many possible climatic and societal futures. It has evaluated dynamic pathways of adaptation that could be deployed and the diverse governance challenges inherent in responses (Oppenheimer et al., 2019a).

Similarly for climate and conflict, integration of different lines of evidence is necessary. Different disciplines,
as well as quantitative and qualitative modes of inquiry, are integral to understanding the risks and the options for response. The reasons are multifaceted. They include the importance of slow-trending factors (e.g. levels of socio-economic development or inequalities among groups). For such factors, causal inference is more difficult, including in their interaction with climate variability and change (Mach et al., 2019). The mechanisms linking climate with potential conflict outcomes will depend on context and change through time, as for other conflict drivers (Bowlsby et al., 2020). They also are bidirectional, with violent conflict exacerbating vulnerability to climate change (Adger et al., 2014).

Grappling with the strengths and limitations of different lines of evidence has become an increasing priority in the climate–conflict field, especially to provide useful assessments and inform decisionmaking (Busby, 2018b; Gemenne et al., 2014). There are enduring challenges in identifying appropriate proxies and finding data with the temporal coverage and spatial resolution to support analysis for all of the relevant indicators: climatic, social, economic, and political. Climate variability is often used as a proxy of climate change in analyzing the consequences of climate change for conflict risk. This leaves open questions about the potential for adaptation over time and the impacts of climate change fundamentally beyond historical experiences (Buhaug, 2015). Research is increasingly incorporating micro-level data from diverse sources, such as in the evaluation of interactions between internal migration and unrest (Ash & Obradovich, 2020).

A vast range of disciplines is relevant to integrative understanding of climate–conflict linkages. The social and political sciences are essential for understanding potential climate–conflict links. At the same time, expertise in climate change science is also necessary. The ‘cone of uncertainty’ expands across multi-step connections. The interconnections stretch from the changing climate, to its diverse impacts for people and ecosystems modulated by human responses, to potential consequences for human security. Cross-cutting empirical analyses have been important in identifying the sensitivity of conflict to climate variability and change. Yet these findings have been difficult to integrate with quantitative and qualitative modes of inquiry shedding light on how and why such sensitivity arises (e.g. Gemenne et al., 2014; Hsiang, Burke & Miguel, 2013; Ide & Scheffran, 2014; Koubi, 2019; Mach et al., 2019; Salehyan, 2014). Such challenges for integration have unfolded in societal and policy contexts demanding simple, actionable recommendations and appealing to urgent needs for solutions – themes to which we will return.

**Grappling with uncertainties**

Another core implication of societal relevance is that difficult-to-quantify uncertainties matter for decision-making. For example, addressing climate change requires ambitious actions to reduce greenhouse gas emissions across global energy and land use systems. Much research has therefore evaluated pathways of emissions reductions in order to inform policy goals, technology development, and collaborative capacity building (Clarke et al., 2014). However, these pathways fundamentally depend on social, technical, economic, and institutional factors that become increasingly uncertain over relevant time frames, such as the entirety of the next century and beyond. For instance, the cost of different technologies or the state of global economies in 2100 is inherently uncertain, and key developments will remain unknowable despite their relevance to near-term choices. On the one hand, quantifying these drivers precisely is needed to explore system-level interactions. On the other, some of the most influential developments remain unknown or are unknowable (e.g. Davis et al., 2018). Scenario-based methods have been fundamental. But they also involve inherent trade-offs and risks when inappropriately applied in producing knowledge that can inform ongoing actions (Rogelj et al., 2019).

Similarly for climate and conflict, the uncertainties expand substantially into the future. Potential outcomes depend upon trajectories of climate change, human development, and global world order. Again, scenario-based methods are important. They range from highly detailed evaluations of interactions into the future, through to more suggestive bounding scenarios at a level of precision geared towards matching the depth of the uncertainties (Hegre et al., 2016; Witmer et al., 2017).

To be effective, scenario approaches need to consider the decision context and the uncertainties. Processes often must involve iterative exploration of goals, points of failure, and the potential for different interventions. Such approaches can be responsive to decisionmaker needs for straightforward, usable information. The opportunities for responsiveness to decisionmaking hold even under major uncertainties about future scenarios of climate change, geopolitics, political rights, socio-economics, and their implications for climate security links. For example, bounding scenarios can be used to emphasize the diversity of possible outcomes as a basis for exploring their implications for decisions. Robust
decisionmaking approaches can enable evaluation of where policy goals would fail to be met across different future scenarios (Mach & Field, 2017; Hall et al., 2019). Deliberate documentation of expert judgment is also needed, in order to communicate the full range of current understanding and the differences between best estimates and outlier perspectives (e.g. Adger et al., 2014; Mach et al., 2019).

In evaluating pathways of action, understanding the effectiveness of different interventions is also critical, from early warning to the sequenced steps thereafter (Busby, 2018b). In many cases, the decisionmaking context will involve environment and security interactions more holistically, where security outcomes of interest will be far short of armed conflict and climate will interact with resource availability under multiple stressors (Adger et al., 2021; De Juan & Hänze, 2021). Exchanges among researchers, practitioners, and stakeholders are central in identifying ways scenarios can inform decisions and policy choices relevant to different goals or trade-offs faced.

**Encompassing contested priorities**

For most climate change issues, there is unavoidable presence of contested priorities surrounding societal responses. Distinguishing ‘facts’ versus ‘values’ therefore can be important in processes of research and assessment. Doing so requires attention to the degree to which expertise is relevant to a given question (Mach & Field, 2017; Oppenheimer et al., 2019b). For example, there is a tendency for normative dimensions to remain implicit in climate, conflict, and security scholarship. They can include seemingly innocuous assumptions, such as thresholds for statistical significance, or more fundamental differences across disciplinary perspectives (e.g. Adger et al., 2013; Hendrix, 2017; Salehyan, 2014; Victor, 2015). For instance, evaluation of environmental services and resources requires quantification and reductionism prioritizing some worldviews over others (e.g. economic versus cultural perspectives) – even though such simplifications can nonetheless be beneficial in decisionmaking contexts (Pascual et al., 2017; Reid & Mooney, 2016; Settele et al., 2014). Effective approaches involve transparent scientific evaluations that unfold implications for different goals and values.

Increasingly in response to such themes, risk framings have been prioritized in climate change research and assessment (IPCC, 2014; Mach & Field, 2017; USGCRP, 2018). The risk focus is a response to the simultaneous potential for large consequences over long time frames, persistent uncertainties, and differing values and goals that are relevant. There are many definitions of risk. At the highest level, risk is the effect of uncertainty on objectives (ISO, 2018). In the climate context, risk has been defined as the potential for consequences where something of value is at stake and the outcome is uncertain, recognizing the diversity of values (IPCC, 2014). For climate and conflict, risk framings have enabled assessment of the role of climate as compared to other drivers of conflict, as well as the connection between current outcomes and potential changes into the future (Mach et al., 2019).

Even with deliberate scholarly approaches, value-based frames may be applied irrespective of distinctions made by scientists. Media reporting on climate change science, for example, often describes the science in alarmist or sensational terms (O’Neill et al., 2015). On the one hand, such reporting can favor high-end scenarios of what might happen with continued high emissions of heat-trapping gases. On the other, reporting may yoke in the other direction, such as during the purported ‘climate change hiatus’, or it may draw out a false balance between climate-science and climate-denier perspectives. Media reporting on climate, conflict, and security risks is subject to similar tendencies towards alarmist media frames. For climate and conflict, contested priorities can also include the relative focus on different dimensions of human security, on conflict risk reduction versus climate change, or on conflict versus peace (Gemenne et al., 2014; Ide & Scheffran, 2014). They can include politically convenient emphasis on the urgency of climate change as compared to sound governance – with climate change entering directly into politics. Awareness of such dynamics is essential in understanding the science–society landscape and encouraging productive interactions. Proactive interventions range from accessible communication and engagement by individual researchers, through to entire organizations dedicated to such boundary work.

**Encouraging science–society interactions**

There has been increased attention to the broader processes through which knowledge becomes actionable for decisionmaking. As climate change intensifies, climate research and assessment are increasingly being tailored to inform decisionmaking by different levels of government, the private sector, and communities. This decisionmaking has involved consideration of risks and risk-management options. And increasingly, it includes policy planning, implementation of different measures,
evaluation of resulting outcomes, and learning and adjustment through time (World Bank, 2013). Dedicated procedures and approaches to interactions among scientists, practitioners, and policymakers can together ensure that the science is credible, the process can be trusted by decisionmakers, and the knowledge is relevant to decision-making needs (Clark et al., 2016; Mitchell et al., 2006). Engagement between researchers and decisionmakers often needs to be tailored to the context and the participants, for example in developing scenarios that are usable and understandable how decisions and actions are changed (Mach et al., 2020). Iterative engagement is often important given the scientific uncertainties, the multifaceted decisionmaking priorities, and the need for adaptive pathways of action through time (e.g. Lempert et al., 2013; Ranger, Reeder & Lowe, 2013; Tschakert et al., 2014).

In scholarship on climate and conflict, there has been explicit development of policy-relevant assessment (e.g. Adger et al., 2014). There also have been calls for decision-focused evaluation of case studies and responses (e.g. Busby, 2018b) and exploration of risks under different socio-economic development pathways and societal decisionmaking options (e.g. Hegre et al., 2016; Witter et al., 2017). Researchers increasingly study, for example, the specific links among climate, conflict, and security (e.g. via agricultural impacts, economic shocks, or migration) – the points of intervention for societal investments managing the risks. Scholars are also expanding evaluation of conflict across social scales, broader security considerations, and the enablers of peace and stability (e.g. as commissioned by the G7 in the New Climate for Peace report; Rüttiger et al., 2015).

There are important, immediate opportunities to foster actionable, usable climate–conflict knowledge for the wide range of stakeholders already managing risks of violent conflict. The existing conflict management apparatus, however, will not take up lessons from current understanding of climate–conflict linkages without interactions among researchers and practitioners. Without increased exchange, there is potential for both academic irrelevance and policy incoherence (Busby, 2018b). Relevant decision-support methods are emerging from climate change science and policy. There are also the many methods already well developed, embedded, and deployed in the security, development, military, and intelligence communities.

**Conclusion**

The accumulating research on climate change and the risk of violent conflict has involved sometimes divergent findings and disagreement about them. Here, we have drawn from existing scholarship on climate change assessment and its science–policy dimensions to shed light on dynamics at play in climate–conflict research as well. These dynamics include the inevitability of science–society interactions in climate-related research and assessment. They can be addressed deliberately and productively through different methods of integrating evidence and encompassing deep uncertainties. Best practices attend to contested priorities and encourage collaborations and exchanges among researchers, practitioners, and policymakers. The relevance of science–policy interactions for climate–conflict research will only increase as global warming intensifies, emissions reductions efforts remain piecemeal, and diverse climate change impacts unfold, affecting people and societies worldwide.

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