Title:

Climate as a risk factor for armed conflict

Authors:

Katharine J. Mach[1], Caroline M. Kraan[2], W. Neil Adger[3], Halvard Buhaug[4,5], Marshall Burke[1,6], James D. Fearon[7], Christopher B. Field[2], Cullen S. Hendrix[8], Jean-Francois Maystadt[9,10], John O'Loughlin[11], Philip Roessler[12], Jürgen Scheffran[13], Kenneth A. Schultz[7], and Nina von Uexkull[4,14]

[1]Department of Earth System Science, Stanford University, Stanford, CA, USA. [2]Stanford Woods Institute for the Environment, Stanford University, Stanford, CA, USA. [3]Department of Geography, University of Exeter, Exeter, UK. [4]Peace Research Institute Oslo, Oslo, Norway. [5]Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway. [6]National Bureau of Economic Research, Cambridge, MA, USA. [7]Department of Political Science, Stanford University, Stanford, CA, USA. [8]Korbel School of International Studies, University of Denver, Denver, CO, USA. [9]Institute of Development Policy (IOB), University of Antwerp, Antwerp, Belgium. [10]Department of Economics, Lancaster University, Lancaster, UK. [11]Institute of Behavioral Science and Department of Geography, University of Colorado Boulder, Boulder, CO, USA. [12]Department of Government, College of William & Mary, Williamsburg, VA, USA. [13]Research Group Climate Change and Security (CLISEC), Institute of Geography, University of Hamburg, Hamburg, Germany. [14]Department of Peace and Conflict Research, Uppsala University, Uppsala, Sweden.

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Summary:
Research findings on the relationship between climate and conflict are diverse and contested. Based on the judgments of experts representing a broad range of disciplines and analytical approaches, we assess current understanding. The focus is on the importance of climate as a driver of organized armed conflict within countries, changes in conflict risk across climate futures, and implications for conflict risk reduction and climate change adaptation. Across experts, best estimates are that 3–20% of conflict risk over the last century has been influenced by climate, and none of their individual ranges excludes a role of climate in 10% of conflict risk to date. However, other drivers are judged substantially more influential for conflict overall, and the mechanisms of climate–conflict linkages are a key uncertainty. Intensifying climate change is estimated to increase future conflict risk as additional linkages become relevant, although uncertainties also expand.

Main Text:

Research over the past decade has established that climate variability and change may influence the risk of violent conflict, including organized armed conflict[1,2]. But use of different research designs, data sets, and methods has resulted in divergent findings and stark questions about legitimate approaches to scientific inference[1,3-9]. Past analyses, many from authors of this article, have both asserted and refuted a substantial role for climate in conflicts to date and have repeatedly triggered dissenting perspectives[1,3-6,9-22]. Even syntheses have failed to clarify areas of agreement and reasons for disagreement[2,4,5,8,9,12,13,23-26]. There are important uncertainties about when and how climate causes conflict to date and under future scenarios[8,23,27,28]. The lack of clarity on current knowledge limits informed management of the risks of conflict to states and human security and the risks of continuing greenhouse gas emissions.

Expert elicitation is a well-vetted method for documenting the judgments of experts about available evidence[29] (Methods). For societally relevant topics with divergent evidence, experimental comparisons of structured elicitation and group-panel assessment have long suggested that individual elicitation paired with collective assessment could better reveal the state of knowledge than either approach in isolation[30-32]. Here, we develop a first such synoptic assessment of the relationship between climate and conflict.

The assessment approach and expert group

The focus here is organized armed conflict within countries (Extended Data Fig. 1). Previous crosscutting analyses of climate and conflict have combined individual-level violence (e.g., suicide, domestic violence) through to war between countries[2,4,9]. However, drivers of suicide fundamentally differ from drivers of world wars. To enable a focused evaluation, the social scale of violence is constrained to organized armed conflict within countries (i.e., state-based armed conflict, non-state armed conflict, and one-sided violence against civilians)[33]. These forms of violent conflict may affect or be affected by conflict in neighboring areas or external intervention. In evaluating climate's effects, climate-related variability, hazards, trends, and change are all included (e.g., related to temperature, precipitation, modes of variability such as El Niño Southern Oscillation, and extreme events such as droughts and floods).

The author team of this manuscript consists of 3 assessment facilitators and a climate and conflict expert group. The 11-person expert group is a sample of the most experienced and highly cited scholars on the topic, spanning relevant social science disciplines (e.g., political science, economics, geography, environmental science), epistemological approaches, and diverse previous conclusions about climate and conflict (Methods). Selection of the expert group targeted expertise necessary to resolve scientific disagreement about the contribution of climate to conflict risks globally and in conflict-prone regions, which requires consideration of comparative and crosscutting analyses and replicable empirical research. For climate and conflict overall, however, the scope of relevant expertise in scholarship, practice, and policy is vast. Semi-structured interviews with purposively sampled stakeholders were used to inform the project.

The expert group participated in 6-8 hour individual expert-elicitation interviews and a subsequent 2-day group deliberation (Methods). The interview and deliberation protocols were collectively developed by the author team and then administered by the assessment facilitators. 950 transcript pages from the interviews and deliberation were iteratively analyzed and distilled. Results presented here include subjective probabilistic judgments documented individually (Extended Data Figs 2–4) and the origins of these judgments in the scientific literature (Supplementary Information). The approach establishes a foundation for assessing—across the full academic field—the strengths and limitations of current understanding and the reasons for disagreement.

This assessment approach complements existing crosscutting reviews, meta-analyses, and perspectives on climate and conflict (e.g., [2,8,9,17,23,25-27]). The methods here go beyond previous syntheses by (1) systematically characterizing judgments about well-quantified risks and also more uncertain outcomes that may carry large consequences; (2) thoroughly exploring how these judgments are underpinned by present-day knowledge; and (3) rigorously combining individual and collective deliberations to minimize biases.

The climate–conflict relationship

The experts agree that, over the last century, climate variability, hazards, and trends have affected organized armed conflict within countries (Figs 1 and 2). They also agree that other conflict drivers are much more influential for conflict risk across experiences to date, compared to climate variability and change (Fig. 3).

Estimates of conflict risk related to climate to date overlap across experts (Fig. 1). Across the experts, best estimates are that 3–20% of conflict risk over the last century has been influenced by climate variability or change, and none of their individual estimated ranges excludes a role of climate in 10% of conflict risk to date. Throughout this assessment, risk is defined as the potential for consequences where something of value is at stake, which can be represented as probability multiplied by consequences[34]. Under this definition, an influence of climate on conflict risk can involve a changed likelihood of conflict occurring (e.g., the frequency of conflict outbreak or duration of conflict) or altered magnitudes of the resulting harmful consequences (e.g., number of deaths, destruction of assets, or legacies of violence). The definition allows for consideration of the initial outbreak and continuing incidence of violent conflict and its consequences[34].

In evaluating conflict drivers to date, each expert individually ranked causal factors that have most influenced the risk of conflict over the last century, drawing from a list of 16 factors collectively generated by the expert group (Fig. 3a, left column). Each expert also ranked factors based on how much uncertainty there is about their influence[35] (Fig. 3a, right column).

Across experts, four drivers are ranked as particularly influential for conflict risk to date: low socioeconomic development, low state capability, intergroup inequality (e.g., ethnic differences across groups), and recent history of violent conflict (Fig. 3a). The experts indicate more uncertainty about the influence of low socioeconomic development and recent conflict history, as compared to low state capability and intergroup inequality. There is high agreement that low socioeconomic development is one of the best predictors of intrastate conflict onset and continuing incidence[36]. Yet there is uncertainty about whether it is proxying for other mechanisms or is directly related to conflict risk, especially through fewer livelihood opportunities increasing the ease of mobilizing rebels (Supplementary Table 1). Similarly, recent conflict history is a strong predictor of subsequent conflict[36]. But there is uncertainty stemming from the many causal mechanisms possible, including more individuals with knowledge and weapons to fight, persistent factors contributing to instability, or continuation of grievances from previous violence.

Climate variability and/or change is low on the ranked list of most influential conflict drivers across experiences to date, and the experts rank it as most uncertain in its influence (Fig. 3a, Extended Data Tables 1 and 2, Supplementary Table 2). This judgment of uncertainty is perhaps unsurprising given the divergent research findings to date, which have motivated this expert assessment[1,3-7,9]. Within a risk framing, such uncertainty is important to assess when outcomes have low or difficult-to-quantify probabilities yet may carry large consequences relevant to ongoing decision-making[31,34,37].

The experts agree that additional climate change will amplify conflict risk, along with the associated uncertainties (Fig. 2). Climate variability and change are estimated to have substantially increased risk across 5% of conflicts to date (mean estimate across experts). By contrast, ~2°C global mean temperature increase above preindustrial levels is estimated to substantially increase conflict risk with 13% probability, rising to 26% probability under a ~4°C scenario. A “substantial” increase in conflict risk was defined in the elicitation as involving severe and widespread impacts, based on criteria for key risks developed and applied in assessment by the Intergovernmental Panel on Climate Change[34].

The judgments about increasing conflict risk in the ~2°C and ~4°C scenarios incorporate a hypothetical *current societies* constraint, i.e., assuming societies with current levels of socioeconomic development experience additional climate change. Even with this constraint, uncertainties increase notably. The range of individual expert estimates for a substantial increase in conflict risk due to climate grows from 0–15% of conflicts to date to 10–50% probability in the ~4°C scenario (Fig. 2).

Climate–conflict linkages

Across experts, there is low confidence in the mechanisms through which climate affects the risk of conflict (Fig. 3, Extended Data Tables 1 and 2). For each conflict driver across experiences to date, each expert estimated the frequency with which climate variability and change increased or decreased conflict risk through the driver or, by contrast, had negligible effect (Fig. 3, Extended Data Figs 5 and 6). For the four conflict drivers ranked as most influential overall, the experts estimate their climatic sensitivity to be relatively low (low socioeconomic development, low state capability, intergroup inequality, and recent conflict history in Fig. 3b). Non-climate factors and historical processes importantly shape these conflict drivers (Extended Data Table 1). However, where climate has affected conflict risk via these top-four conflict drivers, the experts estimate that climate has most often increased risk rather than decreased it (Fig. 3c).

By contrast, the causal factors judged most sensitive to climate are ranked as much less influential for the risk of conflict overall. In particular, economic shocks and natural resource dependency are judged to be likely climate–conflict linkages across experiences to date (Fig. 3b), yet their overall influence on conflict risk is much lower (Fig. 3a). Further, the experts estimate that climate has had more variable and uncertain effects in both increasing and decreasing conflict risk through these linkages (Fig. 3c).

Climate-related hazards, variability, and change can cause economic shocks through impacts on agricultural productivity or food prices or through the direct and indirect consequences of disasters such as floods, droughts, heat waves, or cyclones (Extended Data Table 2). Such shocks could heighten conflict risks through several potential mechanisms, including: reduced opportunity costs for violence, where adverse impacts on livelihoods make participation in violence relatively more attractive; uneven economic impacts precipitating the collapse of intergroup bargains; or deleterious effects on long-run socioeconomic development. The consequences of climate-related economic shocks are highly variable and depend on the affected areas and timing (e.g., growing-season drought in rain fed versus irrigated croplands), affected sectors and groups (e.g., exports impacting state capability and/or employment), and political will and response capacity (e.g., availability of cash transfers or alternative livelihoods).

Linkages via natural resource dependency also underscore uncertainty due to context-specific and multifaceted interactions (Extended Data Table 2). Climate-related resource scarcity can increase conflict risk, yet it can also stimulate cooperation to ensure fair distribution of resources, or decrease conflict risk if more time is spent on procuring food or conditions are unfavorable for sustaining an armed group[38,39]. Climate-related resource abundance can also have conditional and complex effects if there are higher opportunity costs for violence or, instead, improved conditions for mounting and sustaining conflict.

Into the future, climate change could increase the risk of conflict through channels beyond climate-variability effects to date (Extended Data Table 2). Because such linkages exceed historical experiences, uncertainties increase especially under large magnitudes of climate change, e.g., ~4°C global mean warming (Fig. 2). Extrapolation from historical relationships is fraught with uncertainty because complex climate–conflict linkages partly depend on future socioeconomic development pathways, macroeconomic patterns (e.g., global recession), shifts in state capability, ideological fluctuations, and the state of global order and cooperation (e.g., via the UN Security Council).

Future climate–conflict linkages could involve exacerbation of climate–conflict connections present in experiences to date, climate change impacts fundamentally beyond previous experiences, or circumstances where existing response capacities reach limits. Across these categories, relevant climate change risks include substantial economic impacts, climatic extremes and associated disasters, impacts on agricultural production, or differential climate change impacts increasing intergroup inequalities (Extended Data Table 2). Such impacts could also reveal "missing" institutions, where governance mechanisms do not yet exist to address emergent climate change risks (e.g., the potential for substantial increases in migration).

The potential for risk reduction

The experts agree that conflict risk related to climate can be reduced with substantial investments in conflict risk reduction (Extended Data Fig. 7 and Table 3). For conflicts to date, the experts estimate a 67% probability that climate-related conflict risk could be reduced through investments addressing known drivers (mean estimates across experts). For a ~4°C scenario, however, the estimated potential for reducing climate-related conflict risk drops to 57% probability, given more severe climate change impacts.

The potential for synergies exists between conflict risk reduction and climate change adaptation (Extended Data Table 3). Similar factors determine vulnerability to both climate change and armed conflict. Specific measures addressing these factors can ameliorate climate–conflict linkages and advance sustainable development and human security, interlinked with the quality of governance, the persistence of structural inequities, and capacity across levels of government. Relevant adaptation options (e.g., crop insurance, training services, cash transfers, postharvest storage, improved land tenure) can support food and livelihood security and economic diversification beyond agricultural livelihoods. Further, consideration of climate could be incorporated into standard conflict risk reduction via conflict mediation, peacekeeping operations, and post-conflict aid and reconstruction. Climate–conflict linkages could be reduced by addressing environmental challenges in building cooperation and peace or by preventing relapse into conflict in societies with especially high vulnerability and exposure to climatic hazards[40].

However, there is a need to increase understanding of both the effectiveness and the potential adverse side-effects of different actions (Supplementary Table 3). Trade-offs include the ways climate responses can create new problems or unintended consequences, potentially affecting conflict risk[2]. For example, actions that are adaptive from one perspective, such as food export bans following climate-related crop failures, can increase instability elsewhere. Adaptation policies favoring some groups over others or displacing climatic hazards to more vulnerable groups could also affect conflict risk. Limitations in reducing conflict in general will also apply to climate–conflict linkages, such as challenges in predicting the onset and severity of conflict or in addressing the root causes of exclusion and unequal access to services and markets. Effective management of the risks will benefit from improved evidence and also approaches appropriate for deeper, difficult-to-quantify uncertainties.

Analytical challenges

Challenges in analysis strongly contribute to key uncertainties identified in this assessment, especially (1) the relative importance of climate as a driver of conflict, (2) the mechanisms through which climate affects conflict, (3) the conditions under which they materialize, and (4) the implications of future climate change for conflict risk (Supplementary Table 4).

In understanding why conflict occurs, tight causal inference is elusive for many fundamental questions of interest, including what most distinguishes countries with conflict onset versus not, and how particular cases can be understood in the context of broader patterns (Supplementary Table 4). Model design and interpretation of reported results are limited accordingly (e.g., see the sections on model design, the garden of forking paths, and the file drawer in Supplementary Table 4). Causal inference is more feasible for temperature variability as compared to slow-trending variables such as levels of socioeconomic development, state capability, or intergroup inequality. This limits understanding of climate's relative importance for conflict, the mechanisms and mediators of climate's effect on conflict, and its interactions with other conflict drivers (e.g., the degree to which climate modulates the timing of conflict versus increasing the overall number of conflicts that occur). Compared to studies of the outbreak of war, the climate and conflict literature has been less focused on theory and mechanisms of effects, such as through process tracing and examination of case studies to generate hypotheses for subsequent systematic testing.

Relationships between conflict drivers and outcomes tend to be temporally bounded and place dependent[41] (Supplementary Table 4). As is also the case for general conflict studies, much empirical evaluation to date has examined climate–conflict linkages since 1945, a period in which organized armed conflict has predominantly occurred in unique conditions resulting from the breakdown of colonial empires and the rise of weak independent states. Analysis has focused on contexts where climate variability has led to conflict, rather than resilient, cooperative, and peaceful outcomes evident in ethnographic works.

Analyzing the effects of climate variability through such approaches leads to multiple uncertainties about implications for the future. Future climate–conflict linkages will involve climate variability, mean climate change, and diverse resulting climate change impacts, even though empirical investigation has focused largely on climate variability (e.g., temperature or precipitation variability). Open questions pertain to the ways climate affects distinct phases in conflict, ranging from its onset and escalation through to termination. The future will entail societal adjustments to new climate baselines, potential limits to such adaptation, and thresholds in climate change impacts for which historical precedents do not exist. The implications for conflict will be importantly modulated by state systems and the policies of major powers, which will also be impacted in uncertain ways by climate change.

Conclusion

The aim of this analysis has been a comprehensive and balanced assessment of the relationship between climate and conflict risks, reconciling contradictory findings in comparative and empirical research. Based on the methods applied here, there is agreement that climate variability and change shape the risk of organized armed conflict within countries. In conflicts to date, however, the role of climate is judged to be small compared to other conflict drivers, and the mechanisms of climate's effect on conflict are uncertain. As risks grow under additional climate change, many more potential climate–conflict linkages become relevant and extend beyond historical experiences.

What is the usefulness of resolving the scientific disagreement and identifying areas of agreement? For those focused on climate, synoptic understanding of the climate–conflict relationship is important even if climate's role is relatively minor among the drivers of conflict. Given that conflict has pervasive detrimental human, economic, and environmental consequences, climate–conflict linkages, even if minor, would significantly influence the social costs of carbon and decisions to limit future climate change. For those focused on conflict, the assessment has pointed to the different ways climate may interact with the major drivers of conflict risk. Effectively managing such interactions will require mainstream and holistic, rather than myopic, consideration of climate's role across diverse settings and attention to uncertainties that will persist. And finally, appreciation of the future role of climate change and its security impacts can help prioritize societal responses, which could include enhanced global aid and cooperation.

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End Notes:

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Main Text Figure Captions:

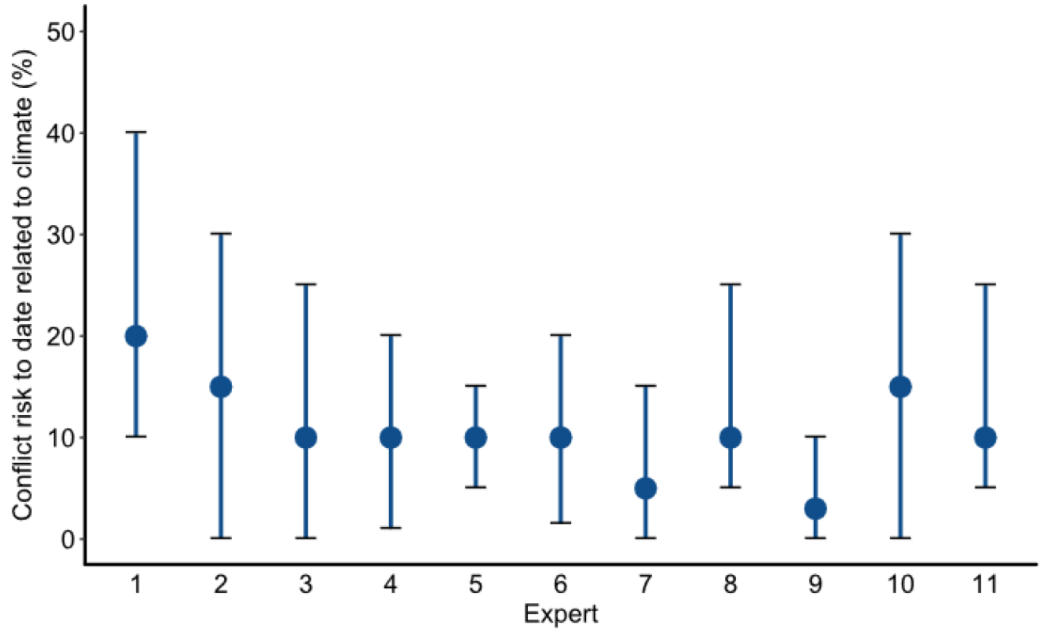

Figure 1. The estimated relationship between climate and conflict risk to date. Each expert provided subjective probabilistic judgments of the percent of total conflict risk related to climate across experiences over the last century. The estimated 1st, 50th, and 99th percentiles are shown for each expert.

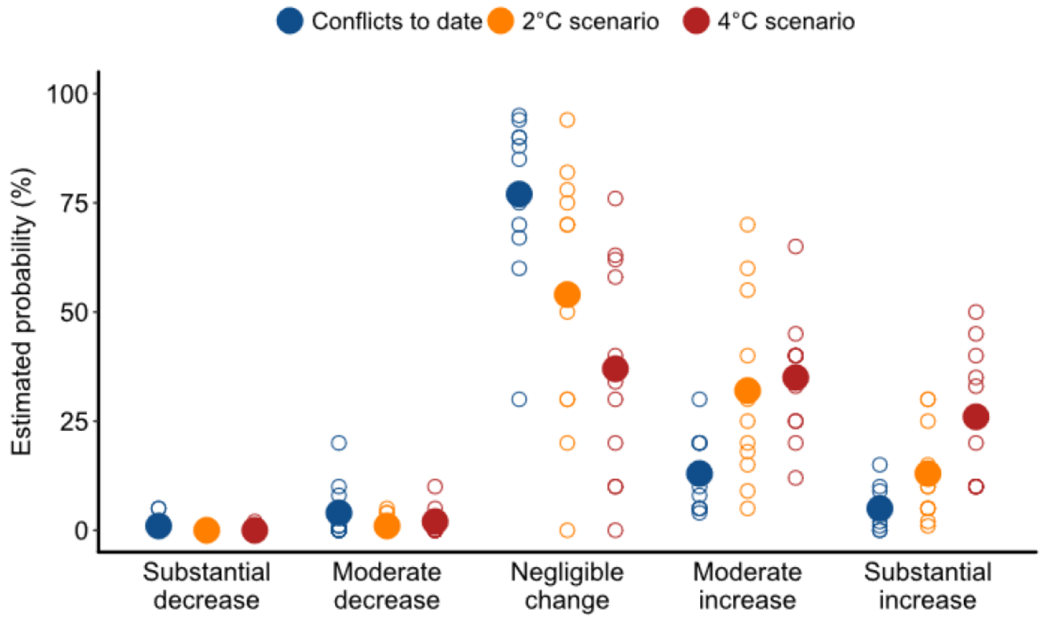

Figure 2. Estimated changes in the relationship between climate and conflict risk under increasing climate change. For three scenarios, each expert estimated the likelihood that climate leads to negligible, moderate, or substantial changes in conflict risk. For violent conflicts to date (blue), probability estimates indicate how frequently climate variability and change have led to the specified changes in conflict risk. For a ~2°C (orange) and a ~4°C (red) scenario, probability estimates indicate potential changes in conflict risk compared to today's climate. For these hypothetical ~2°C and ~4°C scenarios, each expert considered associated effects of climate change for current societies, assuming, for example, current levels of socioeconomic development, population, and government capacity. Open circle: individual estimate; filled circle: mean across experts.

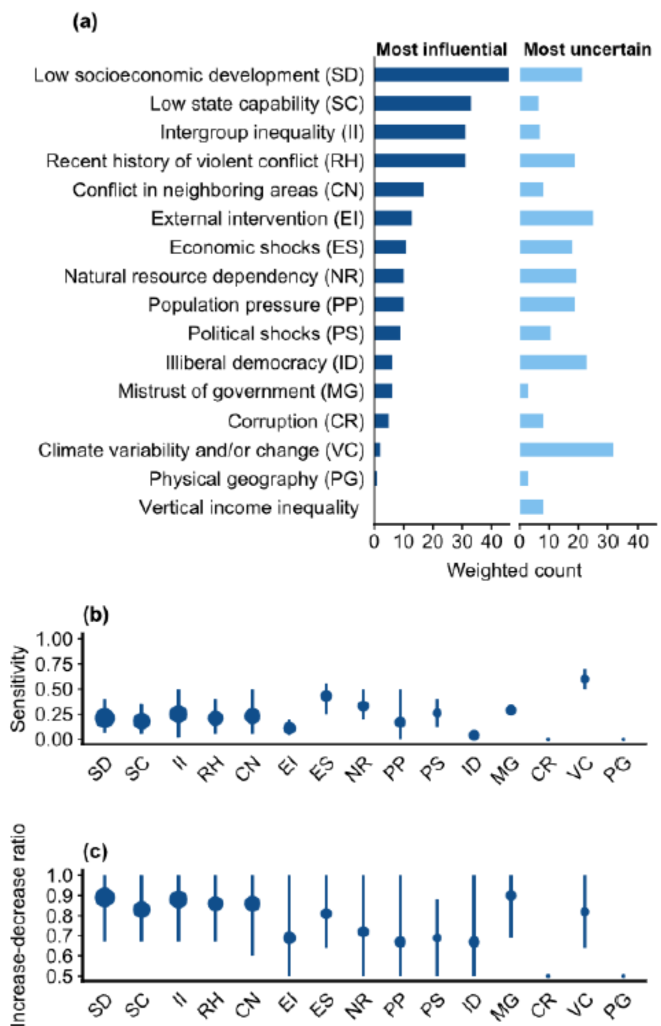

Figure 3. Factors driving conflict risk and their relationship to climate in experiences to date. (**a**) Rankings of causal factors most influencing conflict risk. Each expert individually ranked six causal factors most influencing violent conflict to date, and then ranked six causal factors for which there is the most uncertainty about their influence. Aggregated weighted rankings of the causal factors are indicated: a factor ranked first in the listing of an expert is assigned a value of 6, through to a value of 1 for a factor ranked sixth. (**b** and **c**) The relationship between factors driving conflict risk (from **a**) and climate in experiences to date. Two measures are shown: (**b**) climate sensitivity and (**c**) increase–decrease ratio. For conflicts to date in which each causal factor is relevant, climate sensitivity is the estimated fraction of these conflicts for which climate has affected conflict risk, increasing or decreasing it. Of this, the increase–decrease ratio is the fraction allocated to increased conflict risk. For climate sensitivity, a higher value indicates that climate variability and change have more frequently modulated conflict risk through the factor. For the increase–decrease ratio, a value of 1 indicates climate sensitivity estimated only to increase conflict risk, whereas a value of 0.5 indicates climate sensitivity equally increasing and decreasing conflict risk. Filled circle: mean across experts, with circle size indicating the number of experts who ranked the factor in their top-six list; range for each factor: minimum and maximum values across the 11 experts.