Article Title: Research methods for exploring the links between climate change and conflict

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Abstract

The potential links between climate change and conflict have received much attention in recent years, but there is little consensus on the issue in the relevant literature. So far, few methodological reflections exist in climate-conflict research. This is unfortunate given the tremendous innovations in methods the research field has experienced in recent years and the potential of diverse methods to shed light on different aspects of the subject matter, thereby increasing our understanding of potential climate–conflict links. In order to counteract this shortcoming, this paper provides a comprehensive review of the developments and innovations in methods in climate–conflict research. It first identifies and discusses the most common methods in the research field: large-N statistical analysis and qualitative case study. The paper goes on to evaluate four new methods that have emerged particularly since 2012: integration of statistical techniques and qualitative case studies; field experiment; risk analysis based on geographical information systems (GIS); and

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qualitative comparative analysis (QCA). The review provides an overview of these methods and their potentials and pitfalls when used to study climate–conflict links. It also discusses how future research can deal with a pluralism of methods in order to gain deeper insights into the relationship between climate change and conflict.

Introduction

The potential links between climate change and conflict have attracted much public and political attention in recent years. Since 2007, several high-ranking policymakers and institutions have linked climate change to societal unrest or even war, and the UN Security Council has held four debates on the issue.¹ Recently, US president Barack Obama, British Prince Charles and US presidential candidate Bernie Sanders, among others, claimed that climate change was among the factors triggering the onset of the devastating civil war in Syria.²

Scholars nowadays largely agree that climate change is unlikely to cause armed conflicts between states, at least in the next decades.³ But what about intra-state violent conflict (for the sake of simplicity, just termed ‘conflicts’ in the rest of the paper), by far the most prevalent form of violent conflict today?⁴ In theory, it is hypothesized that the predicted impacts of climate change could intensify competition for scarce resources (e.g., food, water, land), drive deprived individuals into the hands of violence entrepreneurs, fuel anti-state grievances, undermine the governance capacity of already weak states, and cause migration and associated conflicts in the receiving areas.^{5, 6}

Indeed, a meta-analysis of quantitative studies on temperature/precipitation changes and conflict concluded that ‘research has successfully established a causal relationship between climate and conflict.’^{7: 7} But when modifying contested elements of this meta-analysis, a collective of prominent climate–conflict researchers found ‘no evidence of a convergence of findings on climate variability and civil conflict.’^{8: 394} Also, no consensus has yet been achieved on the impact of freshwater scarcity, soil degradation, migration or more frequent/intense natural disasters on violent conflict.^{9, 10} Research largely agrees on the conflict-inducing effects of low economic growth^{11, 12} and rising food prices.^{13, 14} However, the pathways connecting climate change to food prices/economic growth to conflict are complex and still far from being well understood.^{15, 16} Similarly, several recent studies highlight the strong context dependency of potential climate–conflict links.¹⁷⁻¹⁹ A recent review in the pages of this journal thus summarized that climate–conflict research has so far revealed ‘few results that are robust across studies.’^{20: 269}

The aim of this paper is to reflect on the methods used in climate-conflict research. In line with the vast majority of studies, it will focus on the links between climate change and violent conflict within states or in areas of limited statehood (in other words: conflicts which involve at least one non-state actor as a main party). Broadly speaking, one can distinguish between two kinds of empirical studies on this issue: those that focus on the direct manifestations of climate change, such as higher

temperatures and changed precipitation patterns, and those that focus on the (predicted) socio-environmental impacts of climate change, including mitigation and adaptation efforts. This review will discuss both kinds of analyses. However, the latter category of studies will only be included if they relate their results explicitly to the research on climate change and conflict.

Critical voices have claimed that discussions linking climate change to conflict (a) provide legitimization resources for the existence of high military budgets or even for militarized interventions, (b) depoliticize conflicts by ignoring their political-economic drivers, and (c) facilitate Western-style adaptation rather than mitigation.²¹⁻²⁴ I find these criticisms insightful, but they are not further discussed in this review unless they explicitly analyze how such discourses (might) affect conflict dynamics within states, for instance in Israel²⁵ or Sudan.^{26, 27}

So far, few methodological reflections (that is, meta-debates about the methods used and their appropriateness) exist in the research on climate-conflict links. There have been several calls for multi-method research on climate change and conflict.^{7, 20, 28-31} However, besides being rather general, such calls often give implicit or explicit priority to quantitative, statistical methods. Case studies are frequently seen as mere supportive tools, while other methods are hardly considered. For instance, when Solow called for a more thorough integration of qualitative and quantitative methods in climate–conflict research, he stated: ‘The goal of both should be to develop statistical models that better reflect the real drivers of civil conflict.’^{28: 180} In other words, the ultimate research goal would be a well-elaborated statistical analysis.

This is unfortunate given the epistemological and ontological diversity as well as the plurality of methods that have emerged in the research field in recent years, but which can also be found in peace and conflict studies³² and interdisciplinary climate research.³³ Limited diversity of methods has been identified as a driver of incomplete or inconsistent empirical findings.³⁴ More comprehensive knowledge of issues and developments related to methods should help to improve future research on climate change and conflict.

This review will proceed as follows. In the second section, the two most common methods in climate–conflict research are identified and discussed: large-N statistical analysis and qualitative case study. More specifically, I will describe the general approach, more recent developments and the potentials and pitfalls of each method. The third section introduces four innovative methods which have emerged in the research field since 2012. It discusses their potential to study climate–conflict links: integration of statistical techniques and process tracing, field experiment, risk analysis based on geographical information systems (GIS), and qualitative comparative analysis (QCA). The fourth section discusses ways to productively deal with a pluralism of methods when investigating climate–conflict links, while the fifth section concludes the paper.

2 COMMON METHODS IN CLIMATE–CONFLICT RESEARCH

Figure 1 provides an overview of the methods used in the 76 papers published between 2007 and 2015 in the field's top research journals: *Climatic Change*, *Environmental Research Letters*, *Global Environmental Change*, *International Security*, *International Studies Quarterly*, *Journal of Conflict Resolution*, *Journal of Peace Research*, *Nature*, *Nature Climate Change*, *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, *Political Geography*, and *Science*. Of course, it is never easy to identify the leading journals in a given research area. But these are the journals which not only have a high impact factor, but are also most frequently quoted in policy reports, academic papers, and conference discussions on climate change and conflict.^{35, 36}

Figure 1: Methods used by papers on climate change and conflict published in the research field's top journals, 2007-2015

As one can easily see, large-N statistical analysis is the dominant method in research on climate change and conflict. Around 60% of the studies published in these upper-tier journals on climate–conflict links use this method, and it is the most common method in all years except 2013. Consequently, results based on large-N statistical analysis are also most frequently cited by literature reviews and policy reports.³⁶ Theoretical or review articles are the category with the second highest number of publications (around 18% of the studies), but do not constitute a genuine method and thus receive no further discussion here. The third most frequent method is qualitative case study (around 9% of the studies). Qualitative case studies are also very common in papers published outside of the top journals, especially in edited volumes.^{37, 38} Thus, large-N statistical analysis and qualitative case study are discussed as the most common methods in climate–conflict research later in this section.

All other methods identified (and discussed in further detail below) were used less frequently in papers on climate change and conflict published in the top journals: GIS-based risk analyses account for around 5% of all studies, integrated approaches combining statistical and qualitative field-based methods for nearly 4%, QCAs for nearly 3%, and empirical simulation models for slightly more than 1%. These approaches also tend to play marginal roles in others journals or edited volumes. However, climate–conflict research has experienced a notable diversification in methods since 2012. Prior to this point, only statistical analyses, qualitative case studies and theory/review articles were published in the research field’s high-ranking journals. But from 2012 onward, the journals increasingly published studies using other, new methods.

2.1 Large-N statistical analysis

Studies based on this method use statistical techniques, usually regression analysis, to detect correlations (or their absence) between certain manifestations or predicted consequences of climate change and some form of conflict. While a few studies analyze single countries,^{39, 40} most large-N statistical analyses in climate–conflict research draw on evidence from various countries (often in Africa). These will be at the focus of the subsequent discussion. Large-N statistical analysis is characterized by high external validity (generalizability) because its inferences are usually supported by a large number of cases with significant variation in the dependent and independent variables. In addition, it is likely that a possible link between climate change and conflict is not particularly strong compared to other drivers of violent conflict.^{41, 42} Such a research field favors quantitative cross-case methods, which can single out the average impacts of (the anticipated consequences of) climate change for a large number of cases.⁴³

Early large-N statistical analyses of climate–conflict links overwhelmingly used national-level data and yearly aggregates while focusing on civil war as the dependent variable.^{44, 45} But in recent years, the research field experienced several innovations in this regard, most of which were stimulated by

the availability of more and better datasets. Firstly, a growing number of studies draw on subnational data and use artificial grid cells^{42, 46, 47}, administrative/socioeconomic areas^{48, 49} or ethnic groups¹⁸ as the unit of analysis. Secondly, there is a trend toward temporal disaggregated analyses, which use monthly rather than yearly data.^{50, 51} These are major improvements given that national/yearly averages can severely distort causal inferences, for instance when droughts or civil violence are confined to certain areas within a country and to certain time periods within a given year. Also, climate–conflict links can manifest themselves on different levels (e.g., local, regional, national), a fact that statistical analyses can now account for by choosing different degrees of spatial disaggregation.

However, statistical studies using subnational data have difficulty accounting for the fact that climate-related conflicts do not necessarily take place where the impacts of climate change are most severe. Violent groups might, for instance, decide that it is more promising to start a conflict in areas where state presence is weak or where natural resources are still abundant rather than in their home areas devastated by drought.⁵² Using actors or social groups rather than spatial areas as the unit of analysis could probably address this problem.⁵³ Similarly, even more than studies using yearly aggregates (often lagging by one or two years), statistical analyses of monthly data struggle to account for the long-term effects of climate change on conflict. For instance, climate change could trigger circular migration (temporary migration out of and back to home areas), which increases certain populations' exposure to revolutionary discourses over time.⁵⁴ It is also possible that climate change increases resource scarcity, which undermines social cohesion in the long term.⁵⁵

A third major improvement in statistical methods is the use of low-level conflicts rather than full-fledged civil wars as the dependent variable.^{56, 57} This is in line with significant evidence that environment-related conflict 'tends to be subnational, diffuse, and persistent,'^{58: 11} and enables researchers to uncover the impact of climate change on various types of conflict. But data on small-scale conflicts tend to be biased and miss a significant number of events in remote and insecure areas.⁹ Another disadvantage might be that the increasing amount of data available on various geographical, social and temporal scales and different types of conflict, while enabling more differentiated analysis, also complicate efforts draw comparisons across different studies.^{59, 60}

Fourthly, researchers increasingly consider the indirect effects of climate change on conflict via intermediary variables such as food price shocks⁶¹ rather than focusing on temperature and precipitation changes. Particularly innovative are two-step models, as they allow researchers to move away from correlations between two variables and to focus more specifically on the pathways connecting climate change to conflict. Recent studies evaluate, for instance, whether climate variability is linked to civil conflict via adverse impacts on food security¹⁶ or economic growth.¹⁵ Finally, a growing number of studies employ interaction effects or analyze different subsets of their samples separately in order to test the hypothesis that climate change is linked to conflict only under very specific circumstances.^{31, 47, 48}

Despite these considerable advantages, large-N statistical analysis still suffers from serious shortcomings when investigating climate–conflict links. Even with similar theoretical concepts and empirical data, the choice of different statistical models can yield widely diverging results.³⁶ Furthermore, although two-stage models represent significant progress, statistical studies ultimately detect correlations rather than causal links, since ‘we do not have an adequate explanation of the phenomenon under study until we can say why the model works.’^{62: 172}

Statistical analyses are also restricted by the kind of data they can use. For instance, little comparable quantitative data exists on (environmental) migration patterns, climate change adaptation or mitigation efforts, and local conflict/resource management institutions. All of these have been shown to impact conflict dynamics^{10, 63-65}, but are almost completely excluded by quantitative studies. Local perceptions of climatic and environmental changes can differ considerably from the data provided by Western scientific methods and are important for social actions in the respective localities, but can hardly be incorporated into large-N studies.^{66, 67} The same applies to the relevance of identities (Who is included in/excluded from the in-group? Who is an enemy/friend?)⁶⁸ and to place-specific dynamics of capitalist accumulation (Is an actor able to manipulate resource access for commercial purposes?).²⁷ Collecting such data for a larger number of cases might be possible (though with some limitations), but would be very labor-intensive and can (like all academic data gathering) suffer from coding errors and misinformation. Actors which are involved in intense conflicts or resource exploitation, for instance, face incentives to manipulate reporting patterns.⁶⁹

An issue related to data availability is construct validity; that is, does the indicator chosen actually measure the theoretical construct under study in the large number of cases analyzed? Several statistical studies of climate–conflict links use data on ethno-political marginalization to operationalize local grievances or mobilization opportunities,^{47, 70} but these are also frequently driven by class- or place-based factors rather than by ethnic divides.^{71, 72} In other words, there are serious concerns that statistical analyses of climate–conflict links ignore too much local complexity.

2.2 Qualitative case study

Technically speaking, qualitative case study is not a research method but a research design, since it does not formulate specific requirements about how data should be collected and analysed.⁴³ Most qualitative case studies analyzing the links between climate change and conflict employ one or several of three techniques. Firstly, they engage in a form of process tracing to understand the causal links (or their absence) connecting a (predicted) manifestation of climate change to collective violence.^{73, 74} Secondly, they gather and analyze data in a less formalized and more ethnographic way and condense them to a narrative of climate-conflict links (usually strongly based on the views expressed by local inhabitants).^{75, 76} Finally, studies in the tradition of historical materialism and political ecology often resort to the technique of contextualization, that is, they show how relations between climate change, environmental stress and conflict are deeply embedded in, and thus

constituted by broader socio-political structures.^{77, 78} All these forms of qualitative case studies use data from academic, journalistic, government and NGO publications, interviews, participatory observation, and/or focus group discussions.

A major strength of qualitative case studies, especially when they are based on field research, is their ability to account for local complexity. They can consider location-specific factors that show considerable variation on the micro-level and for which no quantitative data is available, such as power relationships among groups or traditional institutions designed to cope with climate extremes and intergroup tensions.^{64, 76, 79} Process tracing and more ethnographic accounts can also consider temporally deferred or geographically distant impacts of climate change on conflict.^{54, 73} Drawing on the idea of contextualization, scholars can pinpoint such wider social, economic and political dynamics which are highly relevant for understanding climate-conflict links, but which are easily ignored by approaches focusing on the narrow relationships between two variables.⁸⁰ Examples of such macro-variables include international conversation discourses⁸¹, global carbon offsetting economies⁷⁸, or even geoengineering.^{82, 83}

Field-based qualitative studies can detect relevant (combinations of) variables and spatio-temporal patterns hardly considered by existing theories and use them to formulate new hypotheses to be tested by medium- and large-N approaches. This is especially important in climate–conflict research, where many observers still consider existing theoretical models to be too general.²⁹ Process tracing (explicitly aiming to analyze the pathways connecting two variables), but also more ethnographic analyses are also well suited to identify causality rather than just correlation.

Qualitative case studies in climate–conflict research have recently begun to draw more strongly on constructivist and poststructuralist theory, which assumes that reality cannot be objectively accessed, but that perceptions of reality are always filtered by pre-existing, intersubjectively established knowledge schemes. Studies inspired by this theoretical background often draw on discourse or narrative analysis (based on data gathered during field research) and ask how certain actions and events become possible or, to the contrary, remain unimaginable.^{26, 84-87} These methods are important in addressing the ‘positivist-rationalist bias’ characteristic to statistical analyses, but also to many qualitative studies of climate–conflict links.^{68: 70} Conflict research has shown the importance of identities and perceptions in the dynamics of violent conflict,⁸⁸ while interdisciplinary climate researchers emphasize that local knowledge and experiences strongly influence how people react to climate change.^{66, 89} Discourse and narrative analysis allows scholars to draw on these insights when studying climate change and conflict.

Whether they use process tracing, ethnographical approaches, contextualization or discourse analysis, qualitative case studies face a set of shared problems in the research field. From a pragmatic point of view, good qualitative case studies often require a certain amount of fieldwork, for which adequate organizational arrangements, language skills and financial resources are necessary. Researchers might also face a lack of personal security when travelling to conflict areas.

In addition, qualitative studies can hardly account for weak, unobservable links connecting climate change to conflict. For instance, higher temperatures are hypothesized to 'cause increases in aggression'^{90: 37} at the individual level, which could translate into a higher risk of collective violence. But a temperature–aggression nexus is very hard to detect by qualitative case studies. Of course, this issue is less acute when dealing with the conflict relevance of the indirect consequences of climate change, such as water scarcity, food price fluctuations or adaptation projects. Researchers also need to be aware that local informants might face incentives to misrepresent certain issues, for instance because they try to gather support from various constituencies or because they are afraid of their personal security. The literature already discusses several ways to deal with this issues, such as collaborating with local researchers or staying in the community for longer time periods.⁹¹

Especially discourse analysis, but at times also techniques of contextualization struggle to clarify the relationship between perceived and 'objective' environmental problems and injustices. Finally, it remains questionable whether inferences can be drawn from a qualitative study of a few locations and applied to a wider set of cases (external validity), especially given the low resolution of current climate models.⁹² There are several strategies available for choosing cases in order to increase the generalizability of the findings (see below). However, with the exception of some analyses focusing on most-likely cases,^{76, 93} most case studies in climate–conflict research do not elaborate on their case selection strategies or simply select on the dependent variable (presence of conflict).

3 NEW METHODS IN CLIMATE-CONFLICT RESEARCH

In this section, I will discuss four methods that scholars have successfully used to analyze climate–conflict links in several studies since 2012, and which hold the potential to complement the most common methods in the research field.

3.1 Integration of statistical analyses and case study techniques

A growing number of studies on climate change and conflict combine case study techniques with statistical tools. Such integrated analyses have been conducted for parts of Kenya,⁹⁴⁻⁹⁶ Sudan,⁹⁷ Ethiopia,⁶⁴ Mali⁹⁸, and Bolivia, Mali, Nicaragua, Vietnam and Zambia.⁹⁹ Combining these two most widely used methods yields a number of advantages in climate–conflict research. Firstly, the number of cases (in the sense of distinct spatio-temporal units such as district years) is usually higher (otherwise, statistical techniques would not be feasible). This increases the generalizability of the results compared to qualitative case studies.

Secondly, integrated analyses avoid many of the pitfalls related to data quality and availability from which statistical studies suffer. For instance, Benjaminsen et al. and Ember et al. conducted field research to collect conflict data from local registers, thus reducing problems associated with biased conflict reporting patterns for marginal or insecure areas.^{94, 98} Similarly, Linke et al. collected and

analyzed data on individual beliefs about the necessity of using violence, about changes in drought patterns and about the quality of communal dialogue, among other variables.⁹⁵ They were therefore able to incorporate local perceptions of environmental changes and conflict realities as well as data on local institutions into their analysis.

Thirdly, qualitative techniques can complement statistical analysis by detecting causal pathways indicated by correlations, or else by explaining why these correlations are misleading. To give an example: The statistical parts of the studies by Witsenburg and Adano (for Marsabit/Kenya) and by De Juan (for Darfur/Sudan) both indicated a robust correlation between higher precipitation rates and a higher risk of violent conflict. However, intense qualitative knowledge of the regions led the two studies to strongly diverging interpretations of these correlations: Witsenburg and Adano concluded that wetter years offer more favorable conditions for violent cattle raids; the authors thus remained skeptical about climate–conflict links.⁹⁶ By contrast, De Juan reasoned that people from drought-affected regions in Darfur migrated to areas with sufficient rainfall and vegetation, thus intensifying competition and hostilities in wetter areas.⁹⁷

Despite their obvious advantages, studies combining statistical and case study techniques are still rare in climate–conflict research. One reason for this might be that they are demanding and labor intensive, as the same (team of) researchers must skillfully apply both methods and data collection on the ground is necessary. Because of this, all of the integrated studies conducted so far focus only on sub-regions of certain countries, thus limiting their generalizability and compatibility with global climate models. Collecting data from surveys could pose problems if respondents face incentives to report selectively. Finally, poststructuralist, feminist and critical scholars are still likely to insist that such multi-method studies cannot sufficiently address place-specific belief systems, gender relations and political ecologies, thus necessitating the use of methods more sensitive to local contexts and their embeddedness in wider political dynamics.^{27, 65, 100}

3.2 Field experiment

Originating mainly from the disciplines of economics and social psychology, field experiments have recently been used to assess the links between renewable resource scarcity and conflict (and thus indirectly between climate change and conflict). Such experiments conduct game theory simulations with inhabitants of the area of interest in order to assess which factors influence conflict or cooperation over renewable resources^{101, 102} or whether resource scarcity makes conflict-prone individual actions more likely.^{55, 103} For instance, Prediger et al. compared two regions in Namibia with similar political, economic and cultural characteristics, but with strong and stable differences in renewable resource scarcity as indicated by biomass production. They found that during their experiments, inhabitants from the resource-scarce region tended to engage much more often in spiteful behavior, thus increasing the likelihood that conflicts would occur.⁵⁵

Such studies typically employ statistical methods to analyze quantitative data collected through field research. But since their defining characteristic – data collection in the field via simulated games – is quite unique, I treat field experiment as a separate category rather than as a subset of the studies integrating statistical and case study techniques.

Field experiments enable researchers to better understand the micro-dynamics of conflicts related to climate change. According to the micro-dynamics research paradigm, the ‘problem is not in understanding the causes of violence [...] but to understand how individuals [...] follow different trajectories leading to rebellion or not.’^{104: 161} Field experiments address this question by focusing on the drivers of individual decisions. As a method based on game theory, field experiments also enable climate–conflict scholars to connect their work more thoroughly with research on the management of common pool resources. This seems promising because a wide literature has evaluated how the characteristics of natural resources, resource users and resource governance institutions facilitate cooperation over natural resources, thus making conflicts less likely.^{105, 106} Since field experiments can be designed to simulate longer periods of resource scarcity, they are also well suited to assess the potential impact of climate change on conflict over the medium to long term (rather than with a time lag of one or two years, which is typically used by statistical analysis).^{55, 102}

Even more so than other approaches combining field research and statistical analysis, field experiments are rather demanding and usually only conducted for a particular region, which reduces generalizability. Moreover, because different studies employ different procedures, the comparability of the results is not guaranteed. Field experiments are also criticized for their low external validity; that is, people’s actions in experimental contexts may not necessarily resemble their real-life behavior.^{107, 108} Furthermore, field experiments tend to focus almost exclusively on individual decisions, while methodological individualism has been criticized in the study of (climate-related) violent conflicts.^{71, 87} Among other issues, the question remains open as to how individual preferences in favor of waging violence transform into collective action.

3.3 GIS-based risk analysis

In general, risk analysis based on geographic information systems (GIS) assesses the spatial distribution of factors that shape the likelihood of an undesirable outcome, such as civil conflict or fire disaster.^{109, 110} In order to do so, such studies identify, combine and visualize (usually quantitative) data on the supposed drivers of these outcomes. As early as 2006, Bocchi et al. combined spatial data on resource scarcity and human ingenuity and analyzed how they relate to the geographical distribution of conflicts in Kenya.¹¹¹ Drawing on significantly improved datasets, recent studies combine climate data with indicators for vulnerability and conflict likelihood to identify possible climate-conflict hotspots in Ethiopia, Kenya and Uganda.^{41, 112}

GIS-based risk analysis has several advantages, especially in research fields like climate change and conflict, which are characterized by a high degree of interdisciplinary and policy relevance. Such risk

analyses can combine and integrate a range of diverse data and thus account for conditional relationships. The produced 'hotspot maps can help to communicate issues in a manner that may be easier to interpret than text'^{113: 23}, particularly for audiences without a (relevant) academic background. GIS-based risk analysis also offers opportunities for fruitful interdisciplinary cooperation, as climate scientists can derive data on (future) hazards from climate models, while hydrologists, biologists and social scientists provide indicators for vulnerability and conflict risk.^{114, 115}

As discussed above, elaborate case selection strategies are rarely employed in (comparative) qualitative case studies on climate change and conflict. One reason for this might be that it is difficult to identify most-likely cases (characterized by a high climate-related conflict risk), least-likely cases (characterized by a low climate-conflict risk) or typical cases (characterized by hazard, vulnerability and conflict risk that are fairly characteristic of a larger region) before entering the field. GIS-based risk analysis has a high potential to improve case selection patterns by characterizing various regions through specified risk indices. Finally, GIS-based risk analysis can contribute to the improvement of quantitative datasets used in climate–conflict research because 'visualization can help uncover details that would not be visible in the tabular data.'^{116: 464} That is to say, (combinations of) relevant factors can be visualized in the form of maps, which are in turn shared with experts on the respective areas or with local inhabitants to discuss issues of data quality and interpretation.^{41, 117}

However, GIS-based risk analysis works with the same quantitative data as statistical models. It is therefore characterized by similar problems regarding sensitivity to local contexts, data availability, data quality and construct validity.¹¹³ And on their own, such risk analyses are rather descriptive because they primarily combine, integrate and visualize data. This can be an important contribution when it comes to checking data quality or selecting cases, but it tells us little about the links between climate change and conflict (or their absence) themselves.

3.4 Qualitative comparative analysis

Qualitative comparative analysis (QCA) is based on set theory and often considered an intermediary between qualitative and quantitative methods. It requires researchers to decide for each variable whether a case belongs to the set of cases where this variable is present (calibrated as 1) or not (calibrated as 0). More elaborate versions of QCA allow for in-between values or multiple (rather than binary) sets. After all cases are calibrated with regard to all variables, a logical minimization procedure based on Boolean algebra detects whether a (combination of) conditions (~independent variables) is necessary or sufficient for the outcome of interest (~dependent variable) to occur.¹¹⁸ Only in 2015 were the first two analyses using QCA in this research field published. Based on a sample of 31 resource-scarce countries and quantitative indicators, Bretthauer studied the circumstances under which water and land scarcity facilitate violent conflict.¹¹⁹ He drew on evidence from 20 qualitative case studies to investigate why conflicts over renewable resources escalate into

violence.¹¹⁷ A recent study used QCA to investigate the conflict-relevance of dam projects in Asia, which are considered as climate change mitigation efforts.¹²⁰

In theoretical terms, QCA is based on the assumption of conjunctural causation. In other words, it is possible and even likely that conditions have no independent effect on the outcome; their impact only occurs in conjunction with other conditions.¹¹⁸ Consequentially, QCA is well suited to uncover causal links between a condition and an outcome that are strongly dependent on the presence or absence of several (combinations of) context factors. This makes the method very suitable for the research field, as potential climate–conflict links are hypothesized to manifest themselves only under very specific circumstances.¹²¹ Furthermore, QCA is able to distinguish among several causal pathways and among necessary, sufficient and irrelevant conditions for a certain outcome, which increases its potential to disentangle complex links in climate–conflict research. Another major strength of QCA is that quantitative data (e.g., on temperature changes or casualties) and qualitative data (e.g., on local perceptions or power relationships) can be combined in the same analysis by the calibration procedure.

However, so far, only the study of Kirchherr, Charles and Walton has utilized the latter advantage.¹²⁰ Thus, QCA's potential to bridge quantitative and qualitative approaches in the research field still lies idle. Furthermore, in comparison to other methods, QCA can only take a limited number of causal conditions into account. Marx and Dusa found that QCAs processing binary data need at least twenty cases for an analysis with five conditions; otherwise, random patterns might appear as robust results.¹²² This problem is aggravated by the fact that QCA is best suited to handle a medium or moderately large number of cases.¹²³ This could potentially reduce the generalizability of QCA results compared to statistical analysis. Under certain circumstances, QCA practitioners recommend drawing on empirically unobserved cases and theoretical knowledge in order to yield more parsimonious results during the minimization procedure. This practice has been criticized in general¹²⁴, but it seems especially problematic in a research field like climate change and conflict, where there is so far little consensual theoretical knowledge. Finally, like other methods in the research field, QCA can suffer from measurement errors, biases in the data used, and (if using a larger number of cases) a lack of sensitivity to the local context.¹²⁵

4 TOWARD A PLURALISM OF METHODS IN CLIMATE-CONFLICT RESEARCH

The developments discussed above seem to indicate that the research field is becoming more pluralistic in terms of methods. Given the significant potentials and pitfalls of the various methods, research on climate change and conflict would profit from welcoming and cultivating this trend. If such a pluralism can accommodate strongly positivist as well as critical and poststructuralist methods, it would enable the research field to compensate for the shortcomings of the individual methods. It would also allow scholars to account for the full spectrum of theoretically relevant

variables, ranging from global mitigation strategies to regional precipitation changes to local identity constructions. Such a pluralism can be pursued via two, mutually not-exclusive pathways: integration and dialogue.

The first pathway refers to the combination and integration of various methods in one or several related research projects. For instance, one could conduct a GIS-based risk analysis (drawing on the results of past studies) in order to map the locations that are most likely to suffer from climate-related conflicts in the past years. This map, complemented by data on actual conflicts, would be a suitable tool to select cases for further in-depth qualitative studies. Promising case selection strategies include the study of deviant cases (strongly deviating from established theoretical knowledge), most-likely cases (where climate–conflict links are most likely to be found), diverse cases (showing strong variation with regard to climate change impacts, conflict and relevant context variables), most-similar cases (similar with regard to all variables except for the conflict outcome and one or a few context factors of interest), most-different cases (different with regard to all variables except for one or a few relevant context factors and the conflict outcome), or a mixture of these.¹²⁶

The case studies should be based on field research and, ideally, draw on multiple techniques, such as process tracing, contextualization, ethnography, discourse analysis, or field experiments. Ideally, several case studies should be conducted using a coherent case selection strategy and a similar research design. The cases could then be compared by means of QCA, drawing on quantitative and qualitative data. This would open up several avenues for further research. Complex causal pathways indicated by the QCA and the case studies could, for example, provide interaction terms or two-step models to be used in statistical analysis, but inspire new qualitative case studies as well. The results could also feed into a GIS-based analysis, which is discussed with local stakeholders and research partners in order to (a) share insights gained with local partners and (b) receive additional information and feedback, for instance by using participatory mapping approaches.^{117, 127}

But the idea of an integration of diverse methods is not free of problems. For one, the more methods are employed in a given project, the bigger the team of researcher has to be as a single scholar is unlikely to have advanced knowledge of, say, QCA, discourse analysis, and GIS applications. The same is true for the audience of the research results, which needs to be familiarized with various methods. Research teams (but also individual researchers) could also face high transaction costs when they have to “translate” between the logics and results of various methods. This is especially challenging as different methods are frequently based on different epistemological, ontological and axiological assumptions. To give an example: Statistical analyses aim to predict patterns of an objectively measureable reality in a value-free way by analyzing a large-number of randomly chosen cases, while discourse analyses usually promote engaged research, choose one or few cases on purpose, highlight the existence of several socially constructed worlds, and thus insists that prediction is neither possible nor desirable.^{128, 129}

Proponents of this “incompatibility thesis”^{129: 270} would thus opt for dialogue, the second pathway to a pluralism of methods in climate-conflict research. Pursuing this pathway would imply that climate-conflict researchers are much more engaged in exchanging about the assumptions, implications, strengths and weaknesses of their respective methods (and the associated epistemologies, ontologies, and axiologies), rather than just issuing vague calls for multi-method research or discussing ways to improve large-N studies.²⁸ But while doing so, they would avoid some of the incompatibilities and transaction costs associated with an integration of various methods in a single research design. However, such a dialogue pathway faces its own risks, as dialogue might be hampered by the fact that most researchers are only familiar with one tradition of methods, while several scholars underscore the high potential of combining seemingly contradictory methods.¹²⁹

Conclusion

Motivated by the claims (a) that the research field recently experienced tremendous developments in methods, (b) that limited diversity and reflection of methods can hamper research progress, and (c) that many discussions about methods in the field focus primarily on ways to improve statistical analyses, the goal of this paper was to review and evaluate developments in methods in climate–conflict research. In order to do so, I first identified and discussed the two most common methods in the research field. Then, I focused on four new methods that have gained prominence since 2012. Finally, the paper discussed how future research can deal with a pluralism of methods, as there is no ‘silver bullet method,’ no single method superior to all others in research on climate change and conflict.

One task for future research is thus to refine existing methods and to explore new (combinations of) methods for investigating climate–conflict links. For instance, while several studies have used formal models as a heuristic device,^{130, 131} it would be interesting to explore the utility of empirical models in climate–conflict research. So far, only one study has used this approach.¹³² Especially agent-based models could draw on the results of field experiments. Like formal models, more elaborate scenario techniques can be used to investigate the conflict relevance of climate change consequences for which few historical precedents exist.¹³³ Consider, for example, disputes over shipping, fishing and oil/gas development in a melting Arctic¹³⁴ or large-scale adaptation and geoengineering projects.^{63, 83} Approaches such as participatory observation and participatory mapping¹³⁵ would enable research to shed more light on the highly context-sensitive meanings and micro-dynamics of human reactions to environmental changes (including conflict and cooperation).

As the use of multiple methods (accommodating various epistemological and ontological approaches) enriches our understanding of the subject, climate–conflict researchers are encouraged to draw on (and probably combine) the many methods that have become available in the research field in recent years, or that remain to be explored in the future. Although they are valuable

instruments, large-N statistical analyses will have to lose some of their dominance in favor of a more balanced method mix. In any case, making use of the complementarities and synergies among various 'research methods requires an understanding of the relative comparative advantages, trade-offs, and limitations of each method and an ability to translate between different methods.'^{136: 19} Hopefully this paper has contributed to generating such an understanding in the research on climate change and conflict.

Related WIREs Articles

DOI	Article title
wcc.336	Climate–conflict research: some reflections on the way forward
wcc.66	Climate change, adaptation and peace
wcc.346	Knowledge problems in climate change and security research

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