Climatic Change (2023) 176:145
https://doi.org/10.1007/s10584-023-03617-x

What climate? The different meaning of climate indicators in violent conflict studies

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Received: 15 July 2022 / Accepted: 19 September 2023

Abstract

This paper explores the operationalization of climate-related indicators in violent conflict research. The climate-conflict narrative gained traction in recent decades and climate change is often referred to as a 'threat multiplier' by both policy makers and scholars. Yet, the relationships between climate-related phenomena and violent conflict are complex and context-specific. However, limited attention has been given to the climatic indicators applied in climate-conflict research. This paper addresses that gap by analyzing 32 studies published from 2004 to 2020 on the operationalization of climatic indicators and their relationship with violent conflict. It first categorizes climate indicators operationalization into five clusters: natural disasters, basic climate variability, advanced climate variability, freshwater availability, and the ENSO. The study evaluates the climate indicators for each cluster and shows that at an aggregate level these clusters examine 68 different climate representations. When paired with their respective conflict types, it finds a total of 113 climate-conflict combinations. Most operationalizations represent various forms of climate-related phenomena and variability rather than climate change. Some indicators are advancements over time, for example moving from changes in average rainfall to standardized precipitation indices. However, other indicators refer to various natural processes, making it challenging to determine whether climatic variability impacts conflict. The paper then demonstrates a discrepancy between the pathways through which climate may affect violent conflict and the representation of these pathways in the selected climate indicators. It discusses how the selection and operationalization of climate indicators requires careful consideration, and the phenomena researched should be well-specified in research findings.

Keywords Climate change · Conflict · Climate indicators · War · Security

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Published online: 17 October 2023

1 Introduction

Climate change has become an established theme in conflict research but the debate on its exact role and impact continues. Scholarly interest in the relation between environmental factors and conflict emerged early in the 1990s, when decades of scientific research had firmly established the causes and direct impacts of environmental degradation (Homer-Dixon 1994). During the 2000s, as security agencies started taking note of the emergent research, the relationship between climate change and conflict gained more attention and was identified as a potential security threat. Meanwhile multiple special issues have been dedicated to the mechanisms between climate and conflict (Nordås and Gleditsch 2007; Gleditsch 2012; Gemenne et al. 2014; Selby and Hoffmann 2014; Salehyan 2014; Gilmore 2017; von Uexkull and Buhaug 2021). Over the years, the idea that climate change serves as a threat multiplier for latent conflict turning active has become mainstream thought in policy circles (EU 2003; CNA 2007; European External Action Service 2016; The White House 2016; Detges 2017b).

Furthermore, the IPCC's 6th Assessment Report addressed climate change as a security concern as well. The report states that "Climate change may increase susceptibility to violent conflict, primarily intrastate conflicts, by strengthening climate-sensitive drivers of conflict (medium confidence)" (IPCC 2022, p. 181). However, "future violent conflict risk is highly mediated by socio-economic development trajectories (high confidence)" (IPCC 2022, p. 181). This reflects the current understanding that whether climate variability and change increase conflict risks depends on context-specific social, institutional, and political dynamics (Koubi 2019; Mach et al. 2020; von Uexkull and Buhaug 2021; Ide et al. 2021b).

However, there exist considerable differences in the causal frameworks and theoretical underpinnings, scope of analysis, research methods, and operationalization of indicators, which have contributed to diverging findings regarding the relation between climate and conflict. Mach et al. (2019) used expert elicitation to reflect on the available evidence. According to these experts, the influence of climate on violent conflicts within countries has been established, but the precise mechanisms through which this influence is exerted remain a key uncertainty.

Therefore, detailing the climate-related phenomena and the statistics used to represent them is vital to improve our understanding of the role of climate in the onset of violent conflict, continuation of conflict, and its potential preventive or pacifying effect on conflict. This need has also been expressed in earlier research. Seter (2016) calls for stronger theoretical frameworks answering questions to identify the relevant actors, to what (i.e., what climate variability and change) are these actors responding, what conflict type will be a likely result, and what are the most suitable temporal and spatial scale to assess these mechanisms. Abrahams and Carr (2017) advocate for a careful consideration of the temporal scale of climate and how this influences different types and scales of conflict given a specific geographical context. O'Loughlin et al. (2014b) hypothesized that climate anomalies are not likely to impact all forms of violence similarly. More recently, Mach et al. (2020) assessed directions for future research on the mechanisms between climate and conflict. One of their priorities is the call for "deepening insight in climate-conflict linkages and conditions under which they manifest."

To advance the understanding of variations in how climate is represented in large-N climate-conflict studies, we unpack the different climate representations, and the types of conflict they seek to explain, and cluster these utilized climate indicators according to key climate characteristics. We evaluate multiple representations of climate-related phenomena and their pairings with conflict types to find that most operationalizations represent various forms of climate variability rather than climate change. We additionally demonstrate a discrepancy between the pathways through which climate may affect violent conflict and the representation of these pathways in the selected climate indicators. Our study thus contributes to the climate-conflict literature, more specifically to the understanding of how climate is represented in violent conflict research.

The remainder of this paper is structured as follows: we explore the observed divergence in climate-conflict findings in section two. We describe the methods, inclusion criteria and data in the third section of this paper. In the fourth and fifth section, we present the research results followed by a discussion of how this work might inform future research and policy. The final section describes the key conclusions of this study.

2 Climate representations as sources of ambiguity

Thus far, studies examining the relationship between climate and violent conflict yield diverging results. A number of earlier studies find limited evidence for a generic direct link between climate and violent conflict or criticize its hypothesized causal mechanisms (Nordås and Gleditsch 2007; Gleditsch 2012; Scheffran et al. 2012; Theisen et al. 2013; Gemenne et al. 2014; Salehyan 2014; Selby 2014; Selby and Hoffmann 2014). Yet, Detges (2017b) states that "the absence of clear evidence does not imply evidence of the absence of a strong relation between climate adversity and political fragility." Other findings suggest that both phenomena are linked (Miguel et al. 2004; Hendrix and Glaser 2007; Hsiang et al. 2013; Schleussner et al. 2016; von Uexkull et al. 2016; Vesco et al. 2021).

Most econometric studies considering the relation between natural resources, such as freshwater, and violent conflict evaluate neo-Malthusian theories on abundance and scarcity (Homer-Dixon 1999; Gleditsch 2021). One pathway presumes that relative abundance of natural resources creates an incentive to engage in a conflict as it creates, among others, improved conditions for looting. According to Linke and Ruether (2021), abundance may also lead to violence aimed at denying adversaries access to resources. Alternatively, resource scarcity or economic hardship may affect conflict dynamics by decreasing individuals' opportunity costs of engaging in violence due to livelihood decline, thus increasing the propensity for conflict (Hendrix and Glaser 2007; Witsenburg and Adano 2009; Klomp and Bulte 2013).

Furthermore, research has shown that these climate-conflict interlinkages are highly context-dependent (Ide et al. 2021b, c). Through qualitative comparative analysis Ide (2015) found that no single variable was either necessary or sufficient. A combination of structural and triggering conditions were needed for these conflicts to spiral into violence. Juan and Hänze (2021) demonstrate deteriorating trust, leading to an increased risk on conflict, when ethnic groups experience an inequal impact of the same drought conditions. Moreover, the impact of climate variability is often experienced at the household level and influenced on local vulnerabilities and coping capacities (von Uexkull 2014). These, in turn, are shaped by the local political and institutional context. For example, Ide et al. (2021b) identified a democratic regime, large population, and either the exclusion of ethnic groups from political power or a flood with large impact as important scope conditions for the onset of flood-related political unrest.

Hence, groups affected by changes in resources availability may exhibit varying levels of coping capacity to sustain a period of economic hardship. This may interact with conflict drivers and alter the level of support for political violence (Detges 2017a) and the likelihood of armed conflict (Theisen et al. 2012; Detges 2017b). Conversely, as demonstrated by Nemeth and Lai (2022), the likelihood of negotiations may increase when both actors are hit by a natural disaster during a civil war. This highlights the time dependency (onset or incidence stage) of the likelihood of conflict and the way groups may respond.

Recent advancements in the climate-conflict discourse explore a variety of methodological approaches to further unpack the complexity of climate-conflict relations. These approaches include qualitative comparative analysis (Ide et al. 2020), regional case studies (van Weezel 2019), utilizing (social) media accounts (Koren et al. 2021), and survey-based analysis (von Uexkull et al. 2020). These studies deepen the understanding of the circumstances under which climate factors result in conflict. In addition to improving the current understanding of the complex connection between climate and conflict, and in order to increase its policy relevance, the field also moved towards short-term conflict prediction (Hegre et al. 2019) and long-term projections under climate change and socio-economic pathways (Hoch et al. 2021).

However, Adams et al. (2018) demonstrated that most studies on the connection between climate and conflict cover sub-Saharan Africa leading to a bias in the sampling practice. Sampling on the dependent variable, such as countries with historic or active conflict, may result in overrepresenting and overestimating the detected interlinkages. This, in turn, has resulted in gravitating attention almost exclusively towards climate-security risks instead of also investigating potential pacifying or peacebuilding drivers of climate factors in the climate-conflict domain. Yet, research suggest that short-term water scarcity can dampen intrastate conflict when experienced by both actors, and that climate variability resulting in temporary resource scarcity can increase cooperation (Devlin and Hendrix 2014; Gemenne et al. 2014).

Furthermore, a broader view of the role of climate and conflict can be conducive to finding solutions, which may be overlooked due to a narrow focus on climate as a driver or multiplier in conflict settings. Detailing insights gathered from development practitioners who addressed climate-conflict in Karamoja region, Uganda, Abrahams (2020) illustrates the constraints of translating this policy discourse into on-the-ground interventions. The relation between climate and conflict is complex and by limiting it to this single frame of reference may exclude valuable, local pathways towards conflict intervention, and peacebuilding.

The field of environmental peacebuilding has sought to address this gap by exploring the risk of conflict and the opportunities for cooperation over the environment along three dimensions: security, livelihoods and economy, and politics and social relations (Ide et al. 2021a). This field places greater emphasis on the role of political economy and how the corresponding variables may pacify what could turn into conflict in the face of increasing climate impact (de Soysa 2002; Homer-Dixon 1999; Barnett 2019). It shifts the attention of analysis towards identifying drivers and pathways for climate-resilient peace and the institutional requirements for it. These include, but are not limited to, the presence and efficacy of state institutions in dispute settlement, the type of political system and nature of decision-making, rural development policy, and social protection against climate shocks (Barnett 2019).

Various explanations have been offered to explain the divergence in climate-conflict findings in quantitative assessments. For example, insufficient understanding of the factors impacting the climate-conflict interactions (under-theorization) (Scheffran et al. 2012; Theisen et al. 2013; Selby 2014; Mach et al. 2020), which also relates to the way spatial correlation is controlled for (Couttenier and Soubeyran 2014; Vesco et al. 2021), the applied statistical methods and methodological diversity (O'Loughlin et al. 2014a; von Uexkull and

Buhaug 2021), the application and updates of different conflict datasets (Couttenier and Soubeyran 2014), and the lack of consistency and modeling of climate indicators. Additionally, specific explanations refer to the way the climate variable is included, and that the relationship between climate and conflict may vary depending on the type of conflict (Nordkvelle et al. 2017). A lack of distinction between climate variability, climate shocks and climate change, which are used interchangeably while representing different aspects of climate research, may also have contributed to these diverging results (Seter 2016; Abrahams and Carr 2017).

Furthermore, several review studies show a tendency to generalize or simplify the climate indicators, and as a result potentially lose important information. For example, Hendrix and Salehyan (2012) operationalize climate as a standardized annual rainfall deviation from a long-term (30 year) mean, as their independent climate indicator. However, Scheffran et al. (2012) and Selby (2014) simplify this in their review as "precipitation", and Pearson and Newman 2019 as "rainfall variability", although both precipitation and rainfall variability can also be operationalized through various other, more detailed, statistics. Similarly, while Theisen et al. (2012) categorize the monthly values for how the precipitation of the preceding six months deviates from the long-term distribution (SPI-6) into three classes, both Scheffran et al. (2012) and Selby (2014) simply refer to this in their respective reviews as variations in precipitation. Next to a heterogeneity in climate operationalizations this demonstrates a heterogeneity in interpretation of these variables as well.

We therefore argue that there is a need to unpack and analyze the definitions and operationalizations of climate variables in this complex climate-conflict discourse, which discrepancies we identify as potential sources of ambiguity and assess whether the theorized pathways align with the applied climate variables. A more precise characterization of these operationalizations can support meta-analyses of climate-conflict links. The purpose of our study is to contribute to such clarity.

3 Methods and sample

We focus on studies that concern the modern era (i.e., post-1946), are published in peer-reviewed journals, center on violent conflict and apply independent climate variables either in a global or African geographical setting. We take this geographical position as a major part of the econometric efforts to study climate-related conflicts focused on a global or African continent scale, while recognizing that these conflicts are neither restricted to Africa, nor are all African countries susceptible to them. We concentrate on multi-country analysis and exclude case studies or single-country assessments.

We select our sample using an iterative two-step design. We begin with four papers that systematically compared earlier studies for choices of independent climate and dependent conflict variables and results: Scheffran et al. (2012), Theisen et al. (2013), Hsiang and Burke (2013), and Selby (2014). For the period leading up to 2015, we concentrate on studies included in these reviews for our sample. These reviews focus on original quantitative data-based studies testing for a potential relationship between climate and conflict, violence or instability. In aggregate, the four review papers evaluate a total of 124 references, of which 62 references are published as peer-reviewed papers. Applying our selection criteria results in a sample size of 20 papers.

We then expand our sample to include more recent views on how climate is represented and carried out an online search for studies published in the period 2015 to 2020 in a selected set of four journals. The four journals were identified as prominent in the field, see SI Sect. 1.1. We searched on 24 combinations of climate and conflict-related search strings within the title, abstract or keywords, see Table 1. This identified 117 papers of which 12 papers meet our inclusion criteria, see the flow diagram in SI Sect. 1.1. This leads to a sample of 32 (20 + 12) studies to be analyzed. Although our sample is not complete given the range of journals publishing on this topic, we believe our sample captures a representative body of work on climate-conflict research and, specifically, dominant views on how climate is operationalized in these studies.

We analyze the dependent and independent variables, spatial and temporal scales, and map whether the hypothesized relation was confirmed. We refrain from replicating and reanalyzing the original data used in these studies.

Although we focus on the operationalization of the climate side of the equation, we also explore how these are used in combination with different types of conflict. The type of conflicts included can be categorized in four groups: civil war, with more than 25 battle-related deaths per year, major civil war, in case of more than 1000 battle-related deaths per year, non-state violence, with more than 25 battle-related deaths per year, and “violent events” that include a combination of types of violence, such as battles, violence against civilians, remote violence, and riots/protests.

The selected papers primarily utilized three conflict databases: the UCDP/PRIO Armed Conflict Dataset (UCDP/PRIO ACD; Gleditsch et al. 2002; Pettersson et al. 2021), the UCDP Georeferenced Event Dataset (UCDP GED; Sundberg and Melander 2013; Pettersson et al. 2021), and the Armed Conflict Location and Event Dataset (ACLED; Raleigh et al. 2010). The UCDP Non-State Conflict (UCDP NSC), the Social Conflict in Africa Dataset (SCAD) and the Political Instability Task Force (PITF) database are conflict datasets less often utilized in our sample. SI Sect. 1.2 describes the conflict definitions and data utilized in more detail.

4 Results

The 32 quantitative studies included in our analysis assessed a wide range of independent climate variables, dependent conflict variables, and many different time spans and units-of-analysis. SI Sect. 1.4 and Tables SI.2 to SI.7 present the overview of the findings, emphasizing the specific operationalization of the independent climate variable. In total, 62 different climate representations are explored. Section 4.1 outlines the identified clusters of climate variables, while Sect. 4.2 describes the key characteristics of the sample and whether the approaches used demonstrate a spatial and temporal evolution. Section 4.3 describes these findings per cluster of climate variables.

Table 1 Keywords used in the search

Search domain	Search string
Climate	‘*climate*’ OR ‘*temperature*’ OR ‘*rainfall*’ OR ‘*drought*’ OR ‘*flood*’ OR ‘*disasters*’ OR ‘*water scarcity*’ *OR* ‘*water shortage*’
Conflict	‘*war*’ OR ‘*conflict*’ OR ‘*violence*’

4.1 Climate indicator clusters

We classify the findings into clusters of similar independent climate variables and assess the explanatory power of the climate indicators included in each cluster. The studies contain a variety of climate-related variables, further referred to as climate variables. A study can include and assess multiple climate variables and therefore be included in multiple clusters. Based on our sample, we distinguish five clusters of climate variables: (climate-related) natural disasters, basic climate variability (BCV), advanced climate variability (ACV), freshwater availability, and El Niño/Southern Oscillation (ENSO). We categorize each climate operationalization into a single cluster; however, papers using multiple operationalizations may show up in more clusters. These clusters are named after their key inclusion criteria.

The cluster "(climate-related) Natural disasters" includes studies examining the connection between disasters and violent conflict. A disaster is included in the global EM-DAT International Disaster Database when it exceeds one of the following thresholds: 10 or more fatalities, 100 or more people affected, if a state of emergency is declared, or when an appeal for international assistance is made (EM-DAT, CRED / UCLouvain 2023). Whether an extreme variation in climate becomes a disaster depends upon the negative societal impact it causes, usually measured by fatalities, people impacted or economical damage. The disaster cluster includes both climate-related and other natural disasters such as earthquakes.

Whether a paper is categorized in the BCV or ACV cluster is subject to how variations in climate variables like rainfall or temperature are computed. The BCV cluster relates to climate variables not compared or scaled to a long-term average or distribution. The ACV cluster indicates that a (standardized) scaling to a long-term average of the corresponding climate indicator has been carried out. Hence, a month or year may be classified as "dry" in studies using a BCV operationalization when precipitation is less than the previous year. However, this same amount of precipitation may still exceed average long-term precipitation and could therefore be classified as "wet" had the ACV operationalization been applied.

The cluster "Freshwater availability" includes studies looking into the availability of water, either from surface or groundwater. Water availability is strictly speaking not a climate variable, but a climate-related variable: variations in water availability can be the result of climatic variations, but also of water use and regulation, for example upstream abstraction for irrigation.

The cluster "ENSO" includes papers that study the impact of the El Niño/Southern Oscillation phenomenon. This is a multi-annually recurring global phenomenon which affects weather patterns resulting in more extreme temperatures, precipitation, or droughts in many countries. ENSO can be considered a specific realization of climate variability, part of the "normal" reference climate. When the occurrence of the ENSO is applied as the climate variable the paper is included in the cluster "El Niño/Southern Oscillation".

4.2 Shifting spatial and temporal patterns

The sample shows the rise of statistically more sophisticated climate indicators. In total, 18 studies used an index as climate indicator while ten studies focused on the weather in the same year the conflict occurred or utilized a measure for the deviation to the previous year.

Section SI 1.3 provides a brief overview of these indices. From 2014 onwards, 75% of the papers utilized an indicator that fits in the ACV cluster, which means indicators are scaled to longer-term climate variability, while for the same period only one-sixth constructed a climate indicator classified in the BCV cluster.

The sample demonstrates a shift towards increased use of spatially distributed conflict data. Two studies combined conflict datasets, thus leading to 36 database utilizations. Of this, 19 studies select UCDP ACD, seven choose UCDP GED and six studies use ACLED as the primary conflict database, not accounting for sensitivity analysis with another conflict databases. The studies applying an ACV operationalization utilized UCDP GED or ACLED, demonstrating a shift towards spatially distributed conflict datasets, which include a more detailed location of conflict events than UCDP ACD. BCV operationalizations have only been applied when using the UCDP ACD.

Similarly, the results show a slight trend towards finer temporal resolutions. The preferred temporal unit-of-analysis is at "year"-level with 26 studies. Despite the increase in studies using "month" as the temporal resolution, with five out of six such studies published from 2014 onward, the majority of studies within that time frame—approximately 60%—still favor "year" as the temporal unit-of-analysis.

At the spatial scale a similar trend towards finer resolutions can be seen. The preferred spatial unit-of-analysis over the full sample period of 2004 to 2020 is the "country"-level with 19 studies. A spatially disaggregated approach is explored at subnational level (e.g., administrative regions) by six studies, while seven studies select a grid-approach with either a $0.5° \times 0.5°$ or a $1° \times 1°$ grid cell resolution. Half of the sample, 16 studies, apply the country-year level as the unit-of-analysis. The sample demonstrates a tendency to move away from the country level towards a spatially disaggregated approach as two-thirds of all studies utilizing either subnational level or a grid-approach are published from 2014 onwards. It does, however, display no clear evolving temporal pattern between these two disaggregation methods. Von Uexkull and Buhaug (2021) find this move towards spatially disaggregated quantitative studies as well. However, they note the concerns regarding the possible lack in spatial overlap between environmental drivers and conflict in such studies, emphasizing the call to align spatial and temporal scales to support actor-based research.

The majority of the studies, 26 in total, use a reduced-form model, where the effect of the climate indicator on violent conflict is evaluated directly. Just six studies deploy a two-stage procedure, where economic growth is the dominant intervening factor with four studies. Two alternative approaches take agricultural yield and food insecurity as specific channel. These six studies are part of the clusters "Natural disaster", BCV, and ACV with respectively one, three, and two studies. They do not demonstrate an evolving pattern over time.

The conflict type studied, and hence, the database utilized, influences the time span of the study considered. The median time span studied with the ACV and BCV classification is 22 years, a direct result of the available data in the UCDP GED and ACLED. Most of the climate-conflict research focused on two or three decades of data only. Figure 1 shows the period considered in each study of our sample, the type of conflict and how this relates to the five climate indicator clusters.

Despite the limited sample the analysis revealed developments over time from a focus on large scale violence to smaller violent events, logically analyzed at finer spatial and temporal resolutions. Similarly, the climate indicators have developed from more simple variations in temperature or rainfall to indicators including rainfall and evaporation variations in relation to long-term statistical distributions. Possibly the combination of increased understanding of climate-security linkages in combination with increased availability of

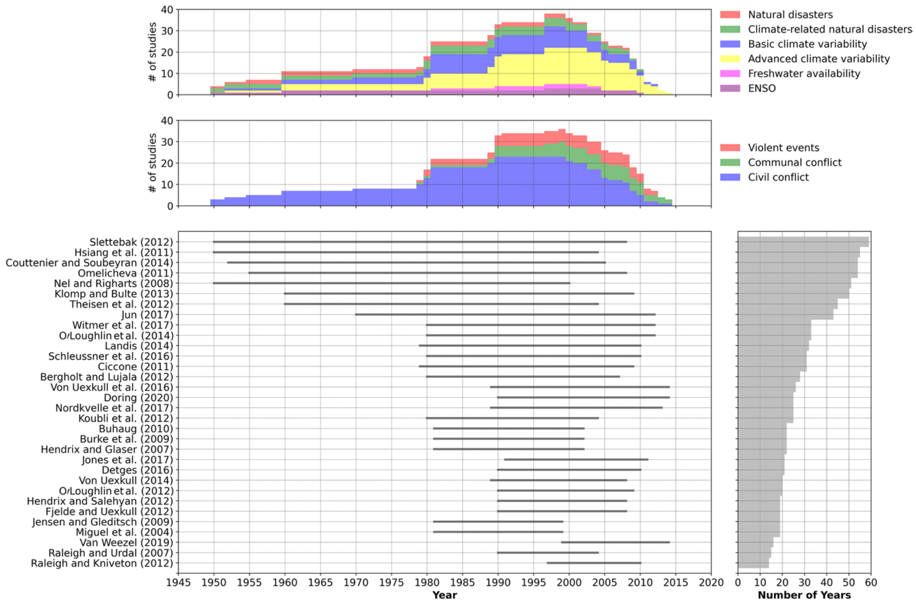

Fig. 1 Overview of the papers included in this study: the five climate indicator clusters and conflict types over time, the period of study and number of years analyzed

such data and indicators with global coverage and fine temporal and spatial resolution may have contributed to these developments.

The relation between climate and conflict is therefore examined with increasingly sophisticated approaches. Whereas in our sample only six studies carried out a two-stage procedure, recent work aims to better reflect the complexity of the interlinkages. For example, von Uexkull et al. (2020) investigate the impact of the (subjective perceived) level of resilience towards supporting the use of violence following agricultural yield shocks by climate variability. Vesco et al. (2021) explores a two-stage procedure moving from climate variability to the spatial concentration of agricultural production as a means towards an increased likelihood of conflict onset.

4.3 Climate representations

4.3.1 Natural disasters

Five studies examined the relation between disasters and conflict using 13 different disaster-conflict operationalizations, see Table SI.3. For most disaster types, the disaster data is aggregated at the country-level in the EM-DAT database. The primary focus of these studies is therefore at the country-year level and the onset of civil war. Both natural disasters and its subset of climate-related natural disasters have been studied reasoning that climate change may alter the frequency and intensity of these disasters. Inclusion of geological disasters, e.g. earthquakes, influences the results. Both Nel and Righarts (2008) and Omelicheva (2011) find some evidence that an increase in natural disasters will increase the risk of major civil war onset. Omelicheva (2011) explicitly states that the impact of natural disasters on the increased risk of conflict diminishes when pre-existing conditions specific to a country, especially the state's resilience to deal with crisis, are accounted for. Hence, this suggest that natural disasters can cause societal unrest and instability only in states that already show the characteristics of fragile societies.

The link of climate-related natural disasters, such as hydrological and meteorological disasters, with conflict shows a different perspective. Bergholt and Lujala (2012) and Nel and Righarts (2008) find no significant evidence to support the hypothesized link between climate-related natural disasters and the risk of civil war onset. To the contrary, Slettebak (2012) criticized the work by Nel and Righarts (2008) and shows that by including population size as variable and avoiding a confound effect, the risk on civil war onset decreases for countries impacted by climate-related natural disasters. Only when the climate-related natural disasters are categorized by damage in percentage of GDP, is some evidence for the link on increased conflict risk again found by Schleussner et al. (2016). One study focuses specifically on droughts. Slettebak (2012) finds a decrease in civil war onset around the world when the number of droughts within a country increase (a pacifying effect).

Hence, at a global, country-year level there is limited evidence that climate-related natural disasters increase the risk of civil war onset. This supports the findings of Ide et al. (2020). While Omelicheva (2011), Slettebak (2012), and Schleussner et al. (2016) already hinted towards the importance of pre-existing conditions when examining climate-disaster-conflict links, Ide et al. (2020) explores this context-dependency in the case of climate-related disasters and the risk of conflict onset. Their main finding is that countries vulnerable to a direct link between climate-related natural disasters and violent conflict have large populations, exclude certain ethnic groups politically and have a low-level of human development.

4.3.2 Basic climate variability

In total, ten studies examined a climate variable related to the BCV cluster. Two sub-clusters are identified: (i) the precipitation or temperature of this year (t) or previous year (t^{-1}) and (ii) the proportional or percent change from the previous year. These studies analyze 21 different BCV-conflict operationalizations, see Table SI.4. The primary focus of these studies is at the country-year level and the onset and incidence of civil war at the level of both 25 and 1000 fatalities.

The direct relation between rainfall in the current or previous year and conflict is investigated in six studies. When examining both the onset and incidence of (major) civil war no direct link is found in any of these studies. Klomp and Bulte (2013) find an indication of a weak link. The only study in our subset that examined the relation between direct rainfall, non-state conflicts, and violent events finds evidence for weak but significant links in countries with strong seasonality (Landis 2014).

Various studies have employed a climate variable representing the proportional change of rainfall to the previous year, albeit under different labels, such as "rainfall growth" (Miguel et al. 2004; Jensen and Gleditsch 2009), "rainfall trigger" (Hendrix and Glaser 2007), and "interannual growth" (Buhaug 2010). Miguel et al. (2004) and Hendrix and Glaser (2007) find that with negative rainfall growth the risk of civil war (onset and incidence) increases. This follows Seter (2016) theoretical mechanism of "economic hardship" were loss of livelihood increases the risk of conflict. However, the independent variable rainfall growth is not an undisputed measure for drought, since—and as Theisen et al.

(2012) argues—it may simply reflect a “regression to the mean”. Jensen and Gleditsch (2009) re-examine the study of Miguel et al. (2004) as in their view that study erroneously includes data of countries participating in civil wars beyond their own state borders. Restricting the analysis to conflicts within a country’s own territory reduces the effect found by Miguel et al. (2004) by 30%.

Next, Jensen and Gleditsch (2009) also show that accounting for the spatial correlation in rainfall growth can reduce the effect found on how strongly rainfall growth, as an indicator for economic growth, predicts civil war. Where Jensen and Gleditsch (2009) find lower effects when changing the study design, Buhaug (2010) finds no significant effects of inter-annual rainfall growth on the risk of increased onset and incidence of both civil and major civil war. Ciccone (2011), who also re-analyzes the Miguel et al. (2004) study by extending the time series with approximately 10 years of data, concludes that no direct link between rainfall growth and civil war can be found.

The relationship between temperature in the current or previous year and conflict is examined by six studies. These results are diverse and contradicting. Where Burke et al. (2009) finds a direct link between higher annual average temperatures and the risk of increased major civil war incidence, the findings of Couttenier and Soubeyran (2014) do not support this. Where Buhaug (2010) finds no link between temperature and civil war onset for the Sub-Saharan countries, Landis (2014) does find this direct link for countries around the world with strong seasonality. Next, Jun (2017) shows a direct relation between higher average temperature during maize grow seasons and civil war incidence. Landis (2014) is the only study in our sample that also focus on the direct link between temperature and non-state conflicts and violent events. It reveals a significant link for both types of conflicts only in countries with strong seasonality.

At the Sub-Saharan Africa and country-year level, there is strong evidence that rainfall (current or previous year) has no direct link with an increased risk of civil war. The results of both rainfall and temperature based BCV indicators are more diverse and mixed.

4.3.3 Advanced climate variability

In total, 18 studies apply a climate variable that considers deviations from the long-term climate at a given space–time scale. These studies explore 68 distinct ACV-conflict operationalizations, see Table SI.5. Two sub-clusters are identified: (i) precipitation or temperature deviations from a long-term mean with 13 specific links examined and (ii) precipitation or temperature standardized indexes with 55 specific links studied. Within these sub-clusters a wide range of operationalizations is applied. For example, in sub-cluster i, where Koubi et al. (2012) use the deviation of current precipitation levels from a 30-year moving average, Buhaug (2010) uses the proportional deviation of current levels from the mean annual level over the 1960—2004 period, Klomp and Bulte (2013) apply a measure for the precipitation variability of a 10-year moving window, while Van Weezel (2019) employs a 15-year moving average.

The three studies (Buhaug 2010; Koubi et al. 2012; Klomp and Bulte 2013) that include a precipitation or temperature deviation from the long-term mean measure find no direct link between their climate operationalizations and civil war onset. Only Klomp and Bulte (2013) find a significant direct link between temperature variability and civil war onset. Van Weezel (2019) demonstrates a correlation between reduced precipitation and increased reported communal conflict yet mentions to not overstate this relation as its predictive performance is relatively mediocre.

The primary indices applied in these studies are the Standardized Precipitation Index (SPI) and Temperature Index (TI). Couttenier and Soubeyran (2014) apply the Palmer Drought Severity Index (PDSI). von Uexkull et al. (2016) use the SPEI which includes potential evapotranspiration. Jones et al. (2017) find a direct link between the SPI-1 and violent events whereas Raleigh and Kniveton (2012) find direct links between both positive and negative deviations from the SPI-1 (i.e., situations with wetter and dryer conditions than long-term average) and rebel events and non-state conflicts in East Africa. However, Landis (2014) did not find a similar correlation at the global level while Nordkvelle et al. (2017) did not find evidence for a link with positive nor negative binary SPI-1 deviations and non-state conflicts.

Multiple studies examine the link between an annualized SPI-6 and civil war. No significant direct link is found with the onset and incidence of civil war (Theisen et al. 2012; von Uexkull 2014; Detges 2016). However, when this index is combined with specific regional information on rainfed cropland (von Uexkull 2014), or low-density paved roads (Detges 2016), it provides a significant contribution towards civil war incidence. Using the same index, von Uexkull (2014) established a correlation of both the sum of drought years and consecutive drought years with civil war incidence arguing that successive years of drought erode the coping capacity of societies with primary focus on (rainfed) agriculture as a source for food and income.

Violent events and SPI-6 demonstrated no significant direct link (O'Loughlin et al. 2012; O'Loughlin et al. 2014b; Witmer et al. 2017), except for a binary version focused on positive deviations (i.e., wetter than long-term average) that shows significance. Nordkvelle et al. (2017) conclude the opposite for non-state conflict: a link during negative binary SPI-6 deviations and no direct link during wetter conditions (positive binary SPI-6 deviations). Fjelde and von Uexkull (2012) and Detges (2016) also examine the correlation between annualized SPI-6 and non-state conflict. They report opposite findings: a significant link and no relation respectively. Yet, when Detges (2016) includes "areas with poor access to alternative water resources" in the model, a significant link is found for a positive relation between drought and the risk of non-state conflict.

Fjelde and von Uexkull (2012) and Nordkvelle et al. (2017) both conclude the absence of a strong direct link between wetter periods (i.e., positive annualized and binary SPI-12 deviations respectively) and non-state conflict. However, for dryer conditions, they arrive at contradictory conclusions. Hendrix and Salehyan (2012) find that deviations from the annual long-term average increases the risk of civil war onset and violent events.

The two studies that apply a different index, the PDSI (Couttenier and Soubeyran 2014) and SPEI (von Uexkull et al. 2016) did not find a correlation with (major) civil war. Only for ethnic groups with a large agricultural dependence and politically marginalized did von Uexkull et al. (2016) find a direct link with civil war incidence. Focusing on temperature analysis in the ACV cluster, the studies conducted by O'Loughlin et al. (2012), O'Loughlin et al. (2014b), and Witmer et al. (2017) suggest a link between the TI-6 temperature index and violent events. Jones et al. (2017) find a relationship between TI-1 and violent events. However, the findings are more varied when differentiating between positive and negative deviations of the temperature index. Landis (2014) and O'Loughlin et al (2012) find no association between positive deviations of the temperature index and violent events, for respectively TI-1 and TI-6. Yet, Landis (2014) does find that association with negative deviations of TI-1, which O'Loughlin et al (2012) did not find for TI-6. Landis (2014) did establish a link for non-state conflicts and positive deviations of TI-1, yet none of negative deviations.

Landis (2014) is the only study in our sample which examines the link between a positive or negative deviation of TI-1 with non-state conflicts and (major) civil war; no evidence is found except for non-state conflicts and positive deviations of TI-1.

The findings within the ACV cluster and its applications on precipitation and temperature show that the multitude of standardized climate indexes used and combined with different types of conflicts, ranging from major civil war to violent events like rioting and protesting, offers space for a range of (inconsistent) conclusions.

4.3.4 Freshwater availability

Three studies use freshwater availability as independent variable: two focus on overall water availability, one focuses solely on groundwater. In total, these three studies analyze five specific freshwater availability-conflict operationalizations.

Two studies take freshwater supply as independent variable, see Table SI.6. They approach it, however, from opposite perspectives. Where Hendrix and Glaser (2007) hypothesize that an increase in freshwater supply per capita would increase the risk of civil war, Raleigh and Urdal (2007) theorize that a decrease in easily available freshwater would increase the risk of civil war. Although their hypotheses were in opposite directions on the link between freshwater availability and the increase of risk on civil war, both studies find a significant direct causation. Focusing on Hendrix and Glaser (2007), a 5-year interval for freshwater data per capita is used and combined with conflict data at the year-level; this is a very different dynamic than utilized in other studies. With only two studies included using dedicated freshwater availability-conflict operationalizations, discussion on the data applied, and opposite findings, there is inconclusive evidence that there is a link between freshwater availability and the increase of risk on civil war.

However, when the mechanism of water shortage cascading towards an increased risk of conflict is expected, a freshwater availability measure might be useful. However, Devlin and Hendrix (2014) argue that the FAO's Aquastat database, which provides a freshwater availability measure utilized per capita as applied by Hendrix and Glaser (2007), mischaracterizes the actual availability of water due to several reasons, e.g., the maximum theoretical yearly amount of water, non-stationarity in the per capita data, collinearity with population data. If a "freshwater availability" variable is to be used, they argue, it should consider these aspects and account for variability over time.

Döring (2020) takes an alternative approach to freshwater availability and examines the impact of scarce groundwater resources on communal conflict. Next to groundwater, the study included rainfall, drought using the SPEI, and surface water presence indicators to account for substitute freshwater resources influencing a link between climate and conflict. Döring (2020) finds that a lack of access to groundwater increases the risk of communal conflict.

The issue of accounting for water use and for water storage in groundwater and surface water is also part of the discussion regarding the role of drought in the start of the civil war in Syria. Gleick (2017) criticizes the narrow definition of drought (i.e., precipitation) used by Selby et al. (2017), by stating the need to include among others groundwater levels and soil moisture. This can be further expanded towards including the actual water demand, water infrastructure, and management when assessing whether reduced water availability leads to reduced yields or failed harvest that subsequently may result in increased (internal) displacement or conflict.

4.3.5 El Niño/Southern Oscillation

Three studies include the El Niño/Southern Oscillation (ENSO) as an independent variable. These studies analyze six different ENSO-conflict operationalizations, see Table SI.7. Hsiang et al. (2011) find that the likelihood of civil war onset in the tropics doubles during El Niño years comparative to La Niña years. This study uses the UCDP ACD to establish an annual conflict risk for ENSO teleconnected regions. Klomp and Bulte (2013) and Landis (2014) both consider El Niño years in their analysis. Landis (2014) investigates the link between El Niño years and (major) civil war, non-state conflict, and violent events. Klomp and Bulte (2013) replicate Hsiang et al. (2011) to assess the ENSO claim and carry out a second analysis by including a rolling regression in their model. The results of both Klomp and Bulte (2013) and Landis (2014) provide limited evidence to support the existence of a direct link between ENSO and civil war as neither study demonstrates an increased risk of civil war onset due to El Niño years.

4.3.6 Cluster findings

In total, the selected studies examined 147 relationships between climate and conflict variables with 113 specific combinations. Figure 2 shows the distribution and the consistency in findings of the climate representations per cluster and conflict type. The analysis does not discriminate for the direction of the significant findings; for example, the two studies on freshwater availability arrive at significant, but opposing ends. The figure demonstrates a focus on civil conflict and the primary use of the BCV and ACV clusters. When a BCV variable was used, few relationships are found with a significant link. Additionally, limited evidence for a direct, significant relationship with conflict onset was found within the BCV and ACV clusters; whether using rainfall or temperature. Also, the relationship of rainfall and temperature indices with conflict incidence resulted in diverse findings.

5 Discussion

Our sample of 32 papers shows a plethora of climate representations. Even within the identified clusters, little consensus was found; supporting research challenging the idea of a direct climate-conflict link and affirming the perspective of a threat multiplier, catalyst or risk factor that compounds other social, economic, or political risk factors. Each cluster comprises a range of various climate representations; 62 different climate representations were used leading to 113 distinct climate-conflict combinations assessed. Therefore, it is no surprise that there is variation in the findings. In addition, there are numerous variations in research design, making it difficult to pinpoint specific causes of diverging findings or to find consensus within subsets of hypotheses.

Additionally, we demonstrate that most empirical studies assessing the relation between climate and conflict study climate variability or other phenomena instead of climate change. Climate can be defined as the mean and variability of selected weather variables like temperature or rainfall for a certain area and period, most commonly 30 years. Climate variability indicates a deviation of climatic statistics for a given area and period when compared to long-term statistics for the same period, beyond those of individual weather events, while climate change refers to persisting statistically significant changes to the

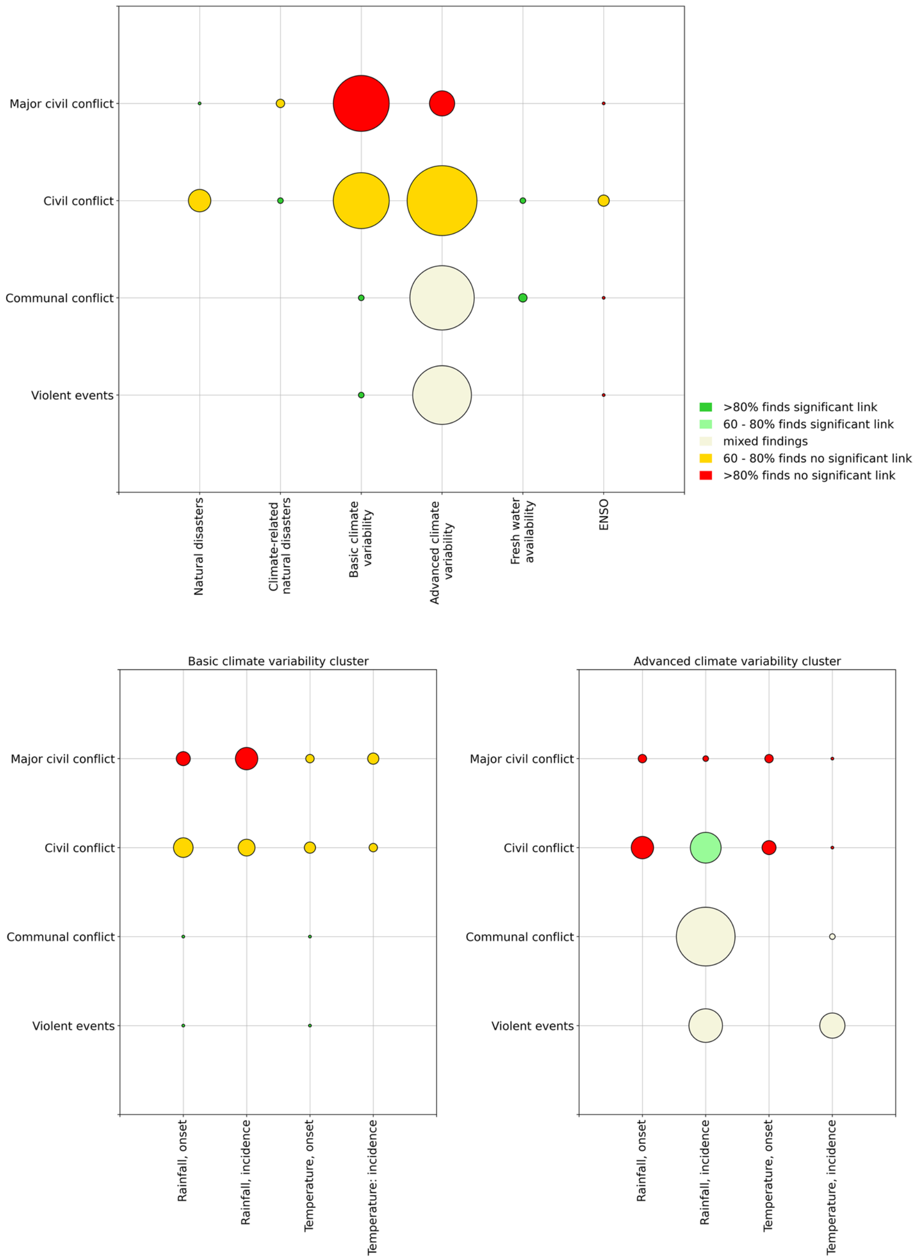

Fig. 2 Distribution of all climate-conflict operationalizations per climate clusters and conflict type. The bubble size shows the number of studies in a cluster and is exponential scaled. Top: all climate clusters, bottom: detailing the BCV and ACV cluster

natural mean state and its variations (WMO 2022). Most climate-conflict studies applying quantitative analysis in our sample consider variations in climate parameters and conflicts during a period of 20–50 years, without comparing these to values of the same parameter during a different period, and thus, study climate variability and not climate change.

The climate variables used in the large-N climate-conflict field span a wide range of climate-related phenomena. These are operationalized through various statistics. These statistics include the average annual values, changes in annual averages compared to previous years, or standardization that determine the deviation of values compared to statistical distributions of these values over longer time periods. The standardization of deviational differences in rainfall or temperature allows for comparisons between spatial units. It recognizes that temporal variations in rainfall and temperature, at daily, monthly, annual, or even decadal scale, are part of a normal climate. Phenomena include climate parameters such as temperature or precipitation, the resulting water availability, or the negative societal consequences of extreme climate variations that can become a natural disaster. Both the choice of climate phenomena and the statistics through which they are represented can have important implications for the results and may form part of the explanation of the diverging findings in climate-conflict research. Gaining a deeper understanding of these climate operationalizations is therefore crucial to contextualize the findings within a conflict related context.

We reveal an additional discrepancy between the pathways through which climate may result in violent conflict and the representation of these pathways in the selected variables. Reduced precipitation or increases in evaporation—the two parameters that formed the basis of most indicators in our sample—will only have a societal impact when they disrupt key functions during or after a shock event. Such changes will, therefore, only affect agriculture, livestock, food security, and thereby the actors involved in a conflict, if water resources are under stress, and water demands can no longer be met. If infrastructure is available to store water, it can take months or years before a reduction in precipitation is experienced as a change in water availability. Without an increase in water shortage cascading to a change in livelihoods and human well-being, and thus actors involved, there is no reason to assume an increasing risk of conflict via this mechanism.

Case studies and regional analysis revealed the complexity of such causal mechanisms and how climate, and the chosen climate operationalization, acts on the different components. See for example Ide et al. (2020) on small-scale (water-related) conflict during drought in the MENA region, Abrahams (2020) on climate-conflict interventions in Karamoja region, Uganda, and van Weezel (2019) on precipitation decline and communal conflict in Ethiopia and Kenya. The assessment whether a more comprehensive understanding of local conditions and conflict or peacebuilding pathways could lead to alternative operationalization methods than those presented in this study could provide valuable insights. For example, to inform the development of climate indicators for large-N studies. We argue that if it is, for example water shortage and failed harvest, that people respond to, future studies should consider the combined impact of climate variability, water use, and water regulation infrastructure. At least, these studies should control for the water use and water regulation factors in similar ways as other intervening factors are controlled for. Alternatively, studies could make use of model-based variables who integrate these various components. Global water balance models that integrate climate, water use, and infrastructure, such as the PCR-GLOBWB framework (Sutanudjaja et al. 2018), could be a useful source to create these model-derived variables. Hoch et al. (2021) demonstrated this by applying a model-derived independent variable for the upper soil water storage. Although a conflict may affect local (data on) water use and infrastructure, the use of a model-based approach for generating the indicator and resulting time series ensures no interference from the actors involved in the conflict.

How can the diverging findings inform policy actions towards conflict-sensitive climate adaptation and climate-sensitive peacebuilding? Critics have argued that environmental overdetermination obscures the role of more pressing (root) factors and scope conditions like poverty or state failure that explain the onset or duration of conflicts (Buhaug 2010; Gemenne et al. 2014; Ide et al. 2021b). A potential role of climate as conflict-cause may be mis-used by those involved in civil conflict to depoliticize the situation and conveniently divert attention away from conflict factors that to a large degree fall under their control or responsibility (Dalby and Moussavi 2017).

These insights from climate-conflict research should be used to design adaptive policies that can prevent or reduce climate-related security risks. This is not an easy task based upon divergent findings. Moreover, the climate may be changing in ways not previously experienced, and humans may respond in new ways as well. However, the impacts of climate change on root factors may, according to Gleditsch (2021), be the strongest case for a climate-conflict link. To decrease the "threat multiplier" effect, the most effective approach may be to address root factors of conflict in a climate-sensitive way (see also Gemenne et al. 2014; Abrahams and Carr 2017; Mach et al. 2019; Koubi 2019).

Next, some of the findings in our sample might suggest that the perspective of demonstrating a positive relation between climate and an increased likelihood of conflict was dominant over a neutral stand or explicitly exploring whether any conflict-dampening side effects could be found. This warrants further analysis in light of the role climate variability may have towards peacebuilding and therefore is something to be explored in future studies.

The outcomes of climate-conflict studies are probably more bound by time and place than previously assumed, thereby decreasing the value of historical analysis for prediction of future conflicts (Gemenne et al. 2014; Selby 2014; Selby and Hoffmann 2014). Selby (2014) consequently argues that large-N empirical studies have little value to inform us of future risks. Yet, several studies used their quantitative assessment to explore the impact of climate change and whether the probability of future conflict will change due to global warming (Hendrix and Glaser 2007; Burke et al. 2009; Landis 2014; Hegre et al. 2016; Jun 2017; Witmer et al. 2017). The IPCC's Shared Socio-economic Pathways (SSP) are used by Hegre et al. (2016), Witmer et al. (2017) and Hoch et al. (2021) to account for societal projections of the future. Witmer et al. (2017) showed that if political rights and governance improve, future levels of violence are likely to remain stable or decline, despite future temperature rise and population growth. Hence, Witmer et al. (2017) argue that good governance can dampen the societal impacts of climate change.

When it comes to dealing with these kinds of uncertainties it becomes crucial to be aware of the range of possible futures. This understanding enables the identification and prioritization of policy actions that will be effective irrespective of future developments, to prepare for alternative actions, and keep options open in order to respond to what the future brings (Haasnoot et al. 2011). Conflict-sensitivity should thus become part of adaptive climate policy development and the vast amount of research in this field will help to do this in a more targeted way. We reason that the results can help reduce this uncertainty related to environmental factors to some extent, especially when the climate indicators are further improved, but that they should be seen as exactly that: uncertainty reduction as part of the puzzle, not a definite answer.

6 Conclusions

We analyzed a sample of 32 papers to increase understanding on how climate as an independent variable is operationalized in quantitative assessments within the climate-conflict domain. To this end, we classified the different operationalizations into five clusters: (climate-related) natural disasters, basic and advanced climate variability, freshwater availability, and ENSO. A multitude of specific direct relations between climate and conflict is studied within each cluster. Most notably, 13 different links focus on disasters and conflict, 21 relations studied a BCV-conflict interaction, and 68 specific links between ACV and conflict were examined in the sample. In total, we found 113 different combinations to study the mechanisms between a climate variable and the conflict variable. There are numerous variations in research design, making it difficult to pinpoint specific causes of diverging findings or to find consensus within subsets of hypotheses.

The empirical evidence at the global, country-year level regarding the impact of climate-related natural disasters on the risk of civil war onset is limited. However, the presence of pre-existing conditions plays a crucial role when examining these climate disaster-conflict relations. We demonstrated a similar lack of evidence for the relation between civil war onset and El Niño years.

The effect of temperature on the risk of conflict appears to be divers across conflict types and operationalizations in the BCV and ACV clusters. Although various studies establish a relationship between temperature anomalies and conflict, this link often disappears upon further differentiation between positive and negative deviations. Moreover, some pathways by which temperature affects conflict risk, such as livelihood conditions, agricultural yield, and food security, can be considered a proxy for water availability affected by temperature.

Furthermore, many studies in the BCV, ACV, and freshwater availability clusters assume an impact of climate on conflict via water shortage and reduced agricultural production. However, water shortage is impacted not only by climate variability, but also by increases in water use and water regulation. Hence, these variables do not reflect the actual impact of climate-related water stresses that could trigger socio-economic downturn leading, in some cases, to political unrest and potentially conflict. The studies do not include additional variables to control for other factors leading to water stress.

We suggest two ways to further quantitative climate-conflict research and advance the applicability of findings for policy purposes to reduce the risk of conflict or enhance peacebuilding efforts. First, continue the exploration of climate-related indicators that reflect the causal mechanisms through which climate variability disrupts communities and their livelihood conditions. Recent developments like the SPEI-6 for growing season or model-derived upper soil water storage are a good example. It could be explored whether further control for water use and regulation is possible, either as separate factor or by selecting a (model-derived) indicator of water shortage.

Second, take the manifold interactions between climate and the risk of violent conflict to envision a range of plausible future scenarios. Subsequently, devise adaptive policies that are sensitive to both climate and conflict dynamics. This will help to better prepare for future climate change and supports the identification of effective interventions under adaptive policy planning aimed at reducing climate-related security risks and leverage potential conflict-dampening or peacebuilding opportunities.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10584-023-03617-x.

Acknowledgements We would like to acknowledge Kars de Bruijne (Clingendael) for providing valuable input during the conceptualization of the study. This publication received the support of the Water, Peace, and Security (WPS) partnership, funded by the Netherlands Ministry of Foreign Affairs. We express our gratitude for the insightful feedback by the anonymous reviewers on earlier versions of the paper.

Author contribution The study was conceptualized by R.D., K.M., and L.S. All authors contributed to the methodology and formal analysis. The first draft of the manuscript was written by R.D. and E.K., and all authors commented on preceding versions of the manuscript. All authors read and approved the final manuscript.

Funding This research was supported by the strategic research program of the Deltares (R.D. and K.M.).

Data availability During this study, no datasets were generated. All results are shared in the Supplementary Information.

Declarations

Conflict of interest The authors declare no competing interests.

References

Abrahams D (2020) Conflict in abundance and peacebuilding in scarcity: challenges and opportunities in addressing climate change and conflict. World Dev 132:104998. https://doi.org/10.1016/j.worlddev.2020.104998

Abrahams D, Carr E (2017) Understanding the connections between climate change and conflict: contributions from geography and political ecology. Curr Clim Change Rep 3(4):233–242. https://doi.org/10.1007/s40641-017-0080-z

Adams C, Ide T, Barnett J, Detges A (2018) Sampling bias in climate-conflict research. Nat Clim Change 8(3):200–203. https://doi.org/10.1038/s41558-018-0068-2

Barnett J (2019) Global environmental change I: climate resilient peace? Prog Hum Geogr 43(5):927–936. https://doi.org/10.1177/030913251879807

Bergholt D, Lujala P (2012) Climate-related natural disasters, economic growth, and armed civil conflict. J Peace Res 49(1):147–162. https://doi.org/10.1177/0022343311426167

Buhaug H (2010) Climate not to blame for African civil wars. Proc Natl Acad Sci USA 107:16477–16482. https://doi.org/10.1073/pnas.1005739107

Buhaug H (2015) (2015) Climate–conflict research: some reflections on the way forward. Wires Clim Change 6:269–275. https://doi.org/10.1002/wcc.336

Burke M-B, Miguel E, Satyanath S, Dykema J-A, Lobell D-B (2009) Warming increases the risk of civil war in Africa. Proc Natl Acad Sci USA 106:20670–20674. https://doi.org/10.1073/pnas.0907998106

Ciccone A (2011) Economic shocks and civil conflict: a comment. Am Econ J Appl Econ 3(4):215–227. https://doi.org/10.1257/app.3.4.215

CNA (2007) National security and the threat of climate change. Alexandria, VA. Retrieved from https://www.cna.org/reports/2007/national-security-and-the-threat-of-climate-change. Accessed 5 May 2022

Couttenier M, Soubeyran R (2014) Drought and civil war in sub-Saharan Africa. Econ J 124(575):201–244. https://doi.org/10.1111/ecoj.12042

Dai A, National Center for Atmospheric Research Staff (Eds). 'The Climate Data Guide: Palmer Drought Severity Index (PDSI).' Retrieved from https://climatedataguide.ucar.edu/climate-data/palmer-drought-severity-index-pdsi Accessed 5 May 2022

Dalby S, Moussavi Z (2017) Environmental security, geopolitics and the case of Lake Urmia's disappearance. Glob Change Peace Secur 29(1):39–55. https://doi.org/10.1080/14781158.2016.1228623

De Juan A, Hänze N (2021) Climate and cohesion: the effects of droughts on intra-ethnic and inter-ethnic trust. J Peace Res 58(1):151–167. https://doi.org/10.1177/0022343320974096

de Soysa I (2002) Ecoviolence: shrinking pie, or honey pot? Glob Environ Polit 2(4):1–34

Detges A (2016) Local conditions of drought-related violence in sub-Saharan Africa: the role of road and water infrastructures. J Peace Res 53(5):696–710. https://doi.org/10.1177/0022343316651922

Detges A (2017a) Droughts, state-citizen relations and support for political violence in Sub-Saharan Africa: a micro-level analysis. Polit Geogr 61:88–98. https://doi.org/10.1016/j.polgeo.2017.07.005

Detges A (2017b) Climate and conflict: reviewing the statistical evidence - a summary for policy-makers. Climate Diplomacy. Adelphi, Berlin

Devlin C, Hendrix C-S (2014) Trends and triggers redux: climate change, rainfall, and interstate conflict. Polit Geogr 43:27–39. https://doi.org/10.1016/j.polgeo.2014.07.001

Eck K (2012) In data we trust? A comparison of UCDP GED and ACLED conflict events datasets. J Peace Res 47(1):124–141. https://doi.org/10.1177/0010836711434463

EM-DAT, CRED / UCLouvain (2023) Brussels, Belgium, www.emdat.be

EU (2003) European security strategy: a secure Europe in a better world. Brussels. Retrieved from https://eclan.eu/files/attachments/.1615/doc_10184_290_en.pdf Accessed 5 May 2022
European External Action Service (2016) Shared vision, common action: a stronger Europe. A global strategy for the European Union's Foreign and Security Policy. Publications Office. https://data.europa.eu/doi/10.2871/9875
Fjelde H, von Uexkull N (2012) Climate triggers: rainfall anomalies, vulnerability and communal conflict in sub-Saharan Africa. Polit Geogr 31:444–453. https://doi.org/10.1016/j.polgeo.2012.08.004
Gemenne F, Barnett J, Adger W-N, Dabelko G-D (2014) Climate and security: evidence, emerging risks, and a new agenda. Clim Change 123:1–9. https://doi.org/10.1007/s10584-014-1074-7
Gilmore E (2017) Disciplinary perspectives on climate change and conflict. Curr Clim Change Rep 3:193–199. https://doi.org/10.1007/s40641-017-0081-y
Gleditsch N-P (2012) Whither the weather? Climate change and conflict. J Peace Res 49:3–9. https://doi.org/10.1177/0022343311431288
Gleditsch N-P (2021) This time is different! Or is it? NeoMalthusians and environmental optimists in the age of climate change. J Peace Res 58(1):177–185. https://doi.org/10.1177/0022343320969785
Gleditsch N-P, Wallensteen P, Eriksson M, Sollenberg M, Strand H (2002) Armed conflict 1946–2001: a new dataset. J Peace Res 39(5):615–637. https://doi.org/10.1177/0022343302039005007
Gleick P-H (2017) Climate, water, and conflict: commentary on Selby et al. (2017). Polit Geogr 60:248–250. https://doi.org/10.1016/j.polgeo.2017.06.009
Haasnoot M, Middelkoop H, van Beek E, van Deursen W-P-A (2011) A method to develop sustainable water management strategies for an uncertain future. Sustain Dev 19(6):369–381. https://doi.org/10.1002/sd.438
Hegre H, Buhaug H, Calvin K-V, Nordkvelle J, Waldhoff S-T, Gilmore E (2016) Forecasting civil conflict along the shared socioeconomic pathways. Environ Res Lett 11:054002. https://doi.org/10.1088/1748-9326/11/5/054002
Hendrix C-S, Glaser S-M (2007) Trends and triggers: climate, climate change and civil conflict in Sub-Saharan Africa. Polit Geogr 26(6):695–715. https://doi.org/10.1177/0022343311426165
Hendrix C-S, Salehyan I (2012) Climate change, rainfall, and social conflict in Africa. J Peace Res 49:35–50. https://doi.org/10.1177/0022343311426165
Hoch J-M, de Bruin S-P, Buhaug H, von Uexkull N, van Beek R, Wanders N (2021) Projecting armed conflict risk in Africa towards 2050 along the SSP-RCP scenarios: a machine learning approach. Environ Res Lett 16(12). https://doi.org/10.1088/1748-9326/ac3db2
Homer-Dixon T-F (1994) Environmental scarcities and violent conflict: evidence from cases. Int Secur 19, 5–40. https://www.jstor.org/stable/2539147
Homer-Dixon T-F (1999) Environment, scarcity, and violence. Princeton University Press, Princeton, NJ
Hsiang S-M, Burke M (2013) Climate, conflict, and social stability: what does the evidence say? Clim Change 123:39–55. https://doi.org/10.1007/s10584-013-0868-3
Hsiang S-M, Meng K-C, Cane M-A (2011) Civil conflicts are associated with the global climate. Nature 476:438–441. https://doi.org/10.1038/nature10311
Hsiang S-M, Burke M, Miguel E (2013) Quantifying the influence of climate on human conflict. Sci 341:1235367. https://doi.org/10.1126/science.1235367
Ide T (2015) Why do conflicts over scarce renewableresources turn violent? A qualitative comparative analysis. Glob Environ Change 33:61–70. https://doi.org/10.1016/j.gloenvcha.2015.04.008
Ide T, Bruch C, Carius A, Conca K, Dabelko G-D, Matthew R, Weinthal E (2021a) The past and future(s) of environmental peacebuilding. Int Aff 97(1):1–16. https://doi.org/10.1093/ia/iiaa177
Ide T, Kristensen A, Bartusevičius H (2021b) First comes the river, then comes the conflict? A qualitative comparative analysis of flood-related political unrest. J Peace Res 58(1):83–97. https://doi.org/10.1177/0022343320966783
Ide T, Lopez M-R, Fröhlich C, Scheffran J (2021c) Pathways to water conflict during drought in the MENA region. J Peace Res 58(3):568–582. https://doi.org/10.1177/0022343320910777
Ide T, Brzoska M, Donges J-F, Schleussner C-F (2020) Multi-method evidence for when and how climate-related disasters contribute to armed conflict risk. Glob Environ Change 62 (May). https://doi.org/10.1016/j.gloenvcha.2020.102063
IPCC (2022) Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. In: Pörtner HO, Roberts DC, Tignor M, Poloczanska ES, Mintenbeck K, Alegría A, Craig M, Langsdorf S, Löschke S, Möller V, Okem A, Rama B (eds.) Cambridge University Press, Cambridge, UK and New York. https://doi.org/10.1017/9781009325844
Jensen P-S, Gleditsch K-S (2009) Rain, growth, and civil war: the importance of location. Def Peace Econ 20(5):359–372. https://doi.org/10.1080/10242690902868277

Jones B-T, Mattiacci E, Braumoeller B-F (2017) Food scarcity and state vulnerability: unpacking the link between climate variability and violent unrest. J Peace Res 54(3):335–350. https://doi.org/10.1177/0022343316684662
Jun T (2017) Temperature, maize yield, and civil conflicts in sub-Saharan Africa. Clim Change 142(1):183–197. https://doi.org/10.1007/s10584-017-1941-0
Keyantash J, National Center for Atmospheric Research Staff (Eds). 'The climate data guide: standardized precipitation index (SPI).' Retrieved from https://climatedataguide.ucar.edu/climate-data/standardized-precipitation-index-spi Accessed 5 May 2022
Klomp J, Bulte E (2013) Climate change, weather shocks, and violent conflict: a critical look at the evidence. Agric Econ 44(S1):63–78. https://doi.org/10.1111/agec.12051
Koren O, Bagozzi B-E, Benson T-S (2021) Food and water insecurity as causes of social unrest: evidence from geolocated Twitter data. J Peace Res 58(1):67–82. https://doi.org/10.1177/0022343320975091
Koubi V (2019) Climate change and conflict. Annu Rev Polit Sci 22:343–360. https://doi.org/10.1146/annurev-polisci-050317-070830
Koubi V, Bernauer T, Kalbhenn A, Spilker G (2012) Climate variability, economic growth, and civil conflict. J Peace Res 49(1):113–127. https://doi.org/10.1177/0022343311427173
Landis, (2014) Temperature seasonality and violent conflict: the inconsistencies of a warming planet. J Peace Res 51(5):603–618. https://doi.org/10.1177/0022343314538275
Linke A-M, Ruether B (2021) Weather, wheat, and war: security implications of climate variability for conflict in Syria. J Peace Res 58(1):114–131. https://doi.org/10.1177/0022343320973070
Mach K-J, Kraan C-M, Adger W-N, Buhaug H, Burke M-B, Fearon J-D, Field C-B, Hendrix C-S, Maystadt J, O'Loughlin J, Roessler P, Scheffran J, Schultz K-A, Von Uexkull N (2019) Climate as a risk factor for armed conflict. Nature 571(7764):193–197. https://doi.org/10.1038/s41586-019-1300-6
Mach K-J, Adger W-N, Buhaug H, Burke M-B, Fearon J-D, Field C-B, Hendrix C-S, Kraan C-M, Maystadt J, O'Loughlin J, Roessler P, Scheffran J, Schultz K-A, von Uexkull N (2020) Directions for research on climate and conflict. Earth's Future 8:e2020EF001532. https://doi.org/10.1029/2020EF001532
Miguel E, Satyanath S, Sergenti E (2004) Economic shocks and civil conflict: an instrumental variables approach. J Polit Econ 112:725–753. https://doi.org/10.1086/421174
Nel P, Righarts M (2008) Natural disasters and the risk of violent civil conflict. Int Stud Q 52:159–185. https://doi.org/10.1111/j.1468-2478.2007.00495.x
Nemeth S, Lai B (2022) When do natural disasters lead to negotiations in a civil war? J Peace Res 59(1):28–42. https://doi.org/10.1177/00223433211061952
Nordås R, Gleditsch N-P (2007) Climate Change and Conflict. Polit Geogr 26:627–638. https://doi.org/10.1016/j.polgeo.2007.06.003
Nordkvelle J, Rustad S-A, Salmivalli M (2017) Identifying the effect of climate variability on communal conflict through randomization. Clim Change 141:627–639. https://doi.org/10.1007/s10584-017-1914-3
O'Loughlin J, Witmer F-D-W, Linke A-M, Laing A, Gettelman A, Dudhia J (2012) Climate variability and conflict risk in East Africa, 1990–2009. Proc Natl Acad Sci USA 109(45):18344–18349. https://doi.org/10.1073/pnas.1205130109
O'Loughlin J, Linke A-M, Witmer F-D-W (2014a) Modeling and data choices sway conclusions about climate-conflict links. Proc Natl Acad Sci USA 111(6):2054–2055. https://doi.org/10.1073/pnas.1323417111
O'Loughlin J, Linke A-M, Witmer F-D-W (2014b) Effects of temperature and precipitation variability on the risk of violence in sub-Saharan Africa, 1980–2012. Proc Natl Acad Sci USA 111(47):16712–16717. https://doi.org/10.1073/pnas.1411899111
Omelicheva M-Y (2011) Natural disasters: triggers of political instability? Int Interact 37(4):441–465. https://doi.org/10.1080/03050629.2011.622653
Pearson D, Newman P (2019) Climate security and a vulnerability model for conflict prevention: a systematic literature review focusing on African agriculture. Sustain Earth 2:2. https://doi.org/10.1186/s42055-019-0009-6
Pettersson T, Davies S, Deniz A, Engström G, Hawach N, Högbladh S, Öberg M-S-M (2021) Organized violence 1989–2020, with a special emphasis on Syria. J Peace Res 58(4):809–825. https://doi.org/10.1177/00223433211026126
Raleigh C, Kniveton D (2012) Come rain or shine: an analysis of conflict and climate variability. J Peace Res 49(1):51–64. https://doi.org/10.1177/0022343311427754
Raleigh C, Urdal H (2007) Climate change, environmental degradation and armed conflict. Polit Geogr 26:674–694. https://doi.org/10.1016/j.polgeo.2007.06.005
Raleigh C, Linke A-M, Hegre H, Karleson J (2010) Introducing ACLED: an armed conflict location and event dataset. J Peace Res 47(5):651–660. https://doi.org/10.1177/0022343310378914

Salehyan I (2014) Climate change and conflict: making sense of disparate findings. Polit Geogr 43:1–5. https://doi.org/10.1016/j.polgeo.2014.10.004

Scheffran J, Broszka M, Kominek J, Link P-M, Schilling J (2012) Disentangling the climate-conflict nexus: empirical and theoretical assessment of vulnerabilities and pathways. Rev Eur Stud 4:1. https://doi.org/10.5539/res.v4n5p1

Schleussner C-F, Donges J-F, Donner R-V, Schellnhuber H-J (2016) Armed-conflict risks enhanced by climate-related disasters in ethnically fractionalized countries. Proc Natl Acad Sci USA 113:9216–9221. https://doi.org/10.1073/pnas.1601611113

Selby J (2014) Positivist climate conflict research: a critique. Geopolit 19:829–856. https://doi.org/10.1080/14650045.2014.964865

Selby J, Hoffmann C (2014) Rethinking climate change, conflict and security. Geopolit 19:747–756. https://doi.org/10.1080/14650045.2014.964866

Selby J, Dahi O-S, Fröhlich C, Hulme M (2017) Climate change and the Syrian civil war revisited. Polit Geogr 60:232–244. https://doi.org/10.1016/j.polgeo.2017.05.007

Seter H (2016) Connecting climate variability and conflict: implications for empirical testing. Polit Geogr 53:1–9. https://doi.org/10.1016/j.polgeo.2016.01.002

Sharifi A, Simangan D, Lee C-Y, Reyes S-R, Katramiz T, Josol J-C, dos Muchangos L, Virji H, Kaneko S, Tandog T-K, Tandog L, Islam M (2021) Climate-induced stressors to peace: a review of recent literature. In Environ Res Lett 16(7). https://doi.org/10.1088/1748-9326/abfc08

Slettebak R-T (2012) Don't blame the weather! Climate-related natural disasters and civil conflict. J Peace Res 49(1):163–176. https://doi.org/10.1177/0022343311425693

Sundberg R, Melander E (2013) Introducing the UCDP georeferenced event dataset. J Peace Res 50(4):523–532. https://doi.org/10.1177/0022343313484347

Sutanudjaja E-H, van Beek R, Wanders N, Wada Y, Bosmans J-H-C, Drost N, van der Ent R-J, de Graaf I-E-M, Hoch J-M, de Jong K, Karssenberg D, López López P, Peßenteiner S, Schmitz O, Straatsma M-W, Vannametee E, Wisser D, Bierkens M-F-P (2018) PCR-GLOBWB 2: A 5 arcmin global hydrological and water resources model. Geosci Model Dev 11:2429–2453. https://doi.org/10.5194/gmd-11-2429-2018

The White House (2016) FACT SHEET: President Obama takes a historic step to address the national security implications of climate change. Retrieved from https://obamawhitehouse.archives.gov/the-press-office/2016/09/21/fact-sheet-president-obama-takes-historic-step-address-national-security Accessed 5 May 2022

Theisen O-M, Holtermann H, Buhaug H (2012) Climate wars? Assessing the claim that drought breeds conflict. Int Secur 36(3):79–106. https://doi.org/10.1162/ISEC_a_00065

Theisen O-M, Gleditsch N-P, Buhaug H (2013) Is climate change a driver of armed conflict? Clim Change 117:613–625. https://doi.org/10.1007/s10584-012-0649-4

Van Weezel S (2019) On climate and conflict: precipitation decline and communal conflict in Ethiopia and Kenya. J Peace Res 56(4):514–528. https://doi.org/10.1177/0022343319826409

Vesco P, Kovacic M, Mistry M, Croicu M (2021) Climate variability, crop and conflict: exploring the impacts of spatial concentration in agricultural production. J Peace Res 58(1):98–113. https://doi.org/10.1177/0022343320971020

Vicente-Serrano S-M, National Center for Atmospheric Research Staff (Eds). 'The climate data guide: standardized precipitation evapotranspiration index (SPEI).' Retrieved from https://climatedataguide.ucar.edu/climate-data/standardized-precipitation-evapotranspiration-index-spei Accessed 5 May 2022

Von Uexkull N (2014) Sustained drought, vulnerability and civil conflict in Sub-Saharan Africa. Polit Geogr 43:16–26. https://doi.org/10.1016/j.polgeo.2014.10.003

Von Uexkull N, Buhaug H (2021) Security implications of climate change: a decade of scientific progress. In J Peace Res 58(1):3–17. https://doi.org/10.1177/0022343320984210

Von Uexkull N, Croicu M, Fjelde H, Buhaug H (2016) Civil conflict sensitivity to growing-season drought. Proc Natl Acad Sci USA 113:12391–12396. https://doi.org/10.1073/pnas.1607542113

von Uexkull N, d'Errico M, Jackson J (2020) Drought, resilience, and support for violence: Householdsurvey evidence from DR Congo. J Confl Resolut 64(10):1994–2021. https://doi.org/10.1177/0022002720923400

Witmer F-D-W, Linke A-M, O'Loughlin J, Gettelman A, Laing A (2017) Subnational violent conflict forecasts for sub-Saharan Africa, 2015–65, using climate-sensitive models. J Peace Res 54(2):175–192. https://doi.org/10.1177/0022343316682064

Witsenburg K-M, Adano W-R (2009) Of rain and raids: violent livestock raiding in Northern Kenya. Civ Wars 11(4):514–538. https://doi.org/10.1080/13698240903403915

WMO (2022) What is climate? World Metereological Organization Retrieved from https://public.wmo.int/en/about-us/frequently-asked-questions/climate Accessed 24 October 2022