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Climate triggers: Rainfall anomalies, vulnerability and communal conflict in Sub-Saharan Africa

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ABSTRACT

The mounting evidence for climate change has put the security implications of increased climate variability high on the agenda of policymakers. However, several years of research have produced no consensus regarding whether climate variability increases the risk of armed conflict. Many have suggested that instead of outright civil war, climate variability is likely to heighten the risk of communal conflict. In particular, erratic rainfall, which reduces the availability of water and arable land, could create incentives for violent attacks against other communities to secure access to scarce resources. Yet, whether groups resort to violence in the face of environmentally induced hardship is likely to depend on the availability of alternative coping mechanisms, for example through market transfers or state accommodation. This suggests that the effect of rainfall anomalies on communal conflict will be stronger in the presence of economic and political marginalization. We evaluate these arguments statistically, utilizing a disaggregated dataset combining rainfall data with geo-referenced events data on the occurrence of communal conflict in Sub-Saharan Africa between 1990 and 2008. Our results suggest that large negative deviations in rainfall from the historical norm are associated with a higher risk of communal conflict. There is some evidence that the effect of rainfall shortages on the risk of communal conflict is amplified in regions inhabited by politically excluded ethno-political groups.

Introduction

As we see mounting evidence for global warming, the societal implications of climate change are ranking high on the agenda of policymakers. One of the suggested societal consequences of greater climate variability and more erratic rainfall patterns is an increased risk of armed conflict (c.f. Boko et al., 2007). In the words of US President Barack Obama, climate change “will fuel more conflict for decades” (The Economist, 2010). Africa is often held to be particularly vulnerable to political instability following climate change, as dependence on rain-fed agriculture and low institutional coping capacity make adaptation more difficult. For example, the conflicts in Darfur, Sudan, have been cited as evidence of this trend (Ban, 2007).

Academic research on the climate–conflict linkage has yet to produce conclusive evidence in support of such contentions. Instead, many large-N studies find little support that droughts or other sources of climate-induced environmental stress are associated with an increased risk of armed conflict in Africa, or anywhere else. After several years of systematic research, the relationship between climate and conflict thus remains speculative (Gleditsch, 2012). However, whereas most large-N studies focus on violent threats posed against state authority, case-based accounts of environmentally related conflicts tend to concern inter-group clashes over access to grazing land, water holes, livestock or cropland, that do not directly involve the agents of the state (e.g. Hagmann & Mulugeta, 2008; Meier, Bond, & Bond, 2007). Deviations from normal rainfall patterns undermine the livelihoods of large segments of African populations who base their income and food supply on rain-fed agriculture. We suggest, as have others, that economic desperation creates incentives for violent attacks against other communities in a direct effort to alter the allocation of scarce resources. Such violent responses to climate-induced hardships are more likely in a context of economic marginalization and political exclusion, since other coping strategies – for example offered through market-based mechanisms or state accommodation – are unavailable (Raleigh, 2010).

Based on the above observations, this article examines the association between rainfall anomalies and communal conflict in Sub-Saharan Africa. In spite of the importance of communal conflict for understanding the human security implications of climate

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change, cross-national studies that move beyond case-based accounts and anecdotal evidence are sparse. This paper addresses this gap by providing the first large-N analysis across a large number of countries over time of the impact of rainfall anomalies on the risk of communal conflict. To strengthen our inferential leverage we use a spatially disaggregated dataset combining rainfall data of high spatial resolution with geo-referenced events data on the occurrence of communal conflict in Sub-Saharan Africa, 1990–2008. To examine how economic and political marginalization influences the risk of communal conflict following rainfall anomalies, we use quantitative indicators of poverty and political exclusion of ethno-political groups at the local level.

Our results suggest that large negative deviations in rainfall from the historical norm are associated with a higher risk of organized violence between societal groups. There is some evidence that political exclusion plays a role in mediating this relationship: the effect of intra-annual rainfall shortages on the risk of communal conflict is amplified in regions inhabited by politically excluded ethno-political groups. Political and physical vulnerability might thus reinforce each other, and make violent coping strategies to climate induced hardships more likely. Contrary to our expectations, our results do not provide any evidence that poverty aggravates the risk of communal conflict following anomalies in precipitation patterns.

The paper proceeds by reviewing the existing literature on the environmental sources of armed conflict. It then outlines the theoretical framework for the association between rainfall anomalies, vulnerability and communal conflict. After presenting data and research design, we discuss our empirical findings. The final section concludes.

Previous research

Since the mid-1990s there has been a growing interest in understanding the societal implications of climate change. The issue of resource availability is central in this discussion. Rising temperatures will be associated with greater rainfall variability and increase the frequency of severe weather events such as droughts and floods (Boko et al., 2007). A likely consequence is increased scarcity of renewable resources such as water and strains on the productivity and availability of arable land.

The environmental security literature holds that environmental stress will alter the political stability of underdeveloped states and make political violence more likely (Baechler, 1999; Homer-Dixon, 1994, 1999). Scarcity of livelihood essentials such as water or arable land are purported to bring about violence along two interrelated pathways. First, groups could fight over a dwindling resource base, when supply-induced scarcity triggers competition over renewable resources (Homer-Dixon, 1999). Resource competition and deteriorating living conditions breed frustration and a sense of deprivation. As more powerful groups strive to shift the resource distribution in their own favor, societal turmoil and armed conflict may result (Homer-Dixon, 1999; Kahl, 2006). Second, resource scarcity and the associated loss of livelihood could also be a driver of migration as people flee from uninhabitable areas. Environmentally induced migration flows could increase competition over resources between migrants and inhabitants in the receiving communities, undermine the communities' ability to uphold basic services, and thereby increasing the potential for radicalization and mobilization for political violence (Homer-Dixon, 1999; Reuveny, 2007).

Recent, economically oriented literature suggests an additional factor that reinforces the potential for violence in this context. Unpredicted variations in rainfall patterns, associated with poor harvest or shortage of grazing land might undermine the foundations for economic activity in societies where a large share of the income is derived from agricultural activity. The population in Sub-Saharan Africa depends heavily on rain-fed agriculture for food-production and for income, with two-thirds of the labor force employed in the rural sector (Stern, 2006). Loss of livelihood, reduction in income and rising unemployment facilitate mobilization for violence as employment opportunities within the regular economic sector are reduced (Miguel, Satyanath, & Sergenti, 2004).

However, it is generally suggested that the link from environmental stress to violent conflict is not direct, but contingent on factors such as poverty and institutional weakness that limit the ability of societies to adapt to environmental hardship through accommodation and innovation (Homer-Dixon, 1999; Kahl, 2006). Yet, also government revenue in Sub-Saharan Africa depends heavily on the agricultural sector, and erratic rainfall reduces the tax base and places severe strains on public spending (Deaton, 1999; Deaton & Miller, 1995). This might further undermine the coping capacity of weak and under-financed state institutions to deal with armed challenges (Homer-Dixon, 1999; Kahl, 2006).

The environmental security literature offers a number of case-based accounts of armed conflict in Sub-Saharan Africa related to environmental issues (c.f. Baechler, 1999; Kahl, 2006). Yet, based on single case studies – purposely selected to explore the environmental scarcity-conflict linkage – and without an empirical base for comparison, it is impossible to tell whether these cases are just exceptions, or reflect a general relationship between environmental scarcity and armed conflict (Gleditsch, 1998). Systematic, comparative research assessing the empirical validity of the identified mechanisms has, to date, provided mixed evidence for a link between climate and conflict (Gleditsch, 2012). Theisen, Holtermann, and Buhaug (2011) present one of the most comprehensive large-N studies of the relationship between drought and civil war onset, relying on a spatially disaggregated research design and explicitly modeling the mediating impact of the ethno-political context in which environmental pressures occur. They do not find any evidence of a direct, short-term relationship between drought and civil war. Other studies do find evidence for a climate–civil war relationship (Burke, Miguel, Satyanath, Dykema, & Lobell, 2009; Hsiang, Meng, & Cane, 2011). However, the robustness of these findings has been questioned (Buhaug, 2010a; Gleditsch, 2012). Research that focuses on land and water resources and changes in the availability of these reiterates that political and economic variables, rather than environmental ones, are the strongest determinants of the risk of civil war (see for example Hendrix & Glaser, 2007; Raleigh & Urdal, 2007; Theisen, 2008).

Rainfall anomalies, vulnerability and communal conflict

One possible reason for the mismatch between the strong claims in the environmental security literature and the weak empirical evidence offered by the large-N literature is the almost exclusive focus on armed rebellion against the state in the latter. Much of the arguments within the former literature suggest, however, that pressure on vital resources such as water or arable land is particularly likely to heighten inter-group tension, and spur violence between groups rather than attacks against the state.

Indeed, the narratives and case-study accounts of armed conflict related to scarcity of water and land often concern clashes between communal groups without explicit state involvement (see e.g. Hagmann & Mulugeta, 2008; UNEP, 2007). Such communal violence mobilizes actors along local cleavages based on ethnic or religious affiliations, kinship ties, or livelihood. Within Sub-Saharan Africa, for example, disputes over land frequently erupt between farmers and pastoralists. Their livelihood requirement differs: the former rely on land for crops, whereas the latter keep livestock and rely on the land for grazing. Conflicts between the two are therefore often voiced in zero-sum terms. Precipitation levels highly influence the availability of water and, in turn, the productivity and availability of both cropland and pastures. Droughts, which could destroy harvest and even lead deserts to expand into previously arable land might lower agricultural productivity. Also excess rain, which could lead to destructive flooding, soil erosion and landslides can have adverse economic effects (Tarhule, 2005). For example, in 2001 due to excess rainfall the Shabelle river inundated large tracts of farmland in the Middle Shabelle region of Somalia (BBC, 2001). The same month, two local sub-clans of the Abgal clan started fighting over access to a valuable piece of grazing land that would also link their villages to the Indian Ocean (IRIN, 2001). Rainfall anomalies thus shrink the resources available for subsistence and wealth accumulation for such groups. Increased inter-community competition over resources could trigger violent clashes between them (Homer-Dixon, 1999; Kimenye, 2006). Also groups with the same livelihood requirements become involved in rivalry over scarce resources. Competition over access to water and grazing land has been identified as the most important structural determinant for conflict between pastoralist groups in the Horn of Africa (Meier et al., 2007). For example, in Ethiopia, frequent clashes over water holes took place between the Issa and Afar pastoralist groups during the 1990s and tensions culminated during the drought of 2002, when large-scale violence occurred (UCDP, 2012).

We argue, as have others, that communal conflict is a more probable response in the face of environmentally induced hardships than large-scale rebellion against the state (Buhaug, Gleditsch, & Theisen, 2008; Hendrix & Salehyan, 2012; Theisen & Brandsegg, 2007). As Hendrix and Salehyan (2012) note, the occurrence of civil war following environmentally induced hardships is predicated on the belief that the government is the most appropriate target. Yet, if violence is used as a strategy to secure access to livelihood essentials such as land for farming and grazing or water holes, attacking agents of the state is only efficient if the state would mediate access to these resources short-term. This is a precondition that is not met in many peripheral regions of African states, characterized by minimal governance (Hendrix & Salehyan, 2012; Raleigh, 2010). In these regions, directing violence against other societal groups might be a more efficient short-term strategy to mediate access to resources critical to sustain the livelihood. Violent appropriation of resources from other communities is also more feasible, in terms of organizational capacity and resources, than launching a rebellion against the state. Thus, while a state's lack of responsiveness to environmental hardships over time can accumulate to large-scale grievances that inspire people to take up arms, the short-term response of affected communities is more likely to be organized violence against other communities.

Data availability has presented an obstacle for further exploring the environmental sources of communal conflict, and the studies that exist have been limited in temporal and geographical scope to a few years or a few countries (See e.g. Meier et al., 2007; Raleigh & Kniveton, 2012 and Theisen, 2012). A recent exception include Melander and Sundberg (2011) who, based on sub-national data from Sub-Saharan Africa between 1989 and 2004, conclude that there is limited evidence for a link between soil degradation and inter-group conflict, except when extreme levels of soil-degradation concur with high population density. Hendrix and Salehyan (2012) find that in Africa, country years with large positive or large negative deviations in rainfall see a higher risk of low-intensity political turmoil, such as riots. In spite of these few recent contributions, the suggested link between environmental pressures and communal conflict remains speculative. We propose the following hypothesis for statistical testing:

H1: Rainfall anomalies increase the likelihood of communal conflict.

Most theoretical accounts of the environmental sources of organized violence do not suggest a direct link, but emphasize the important role of political and economic structures in mediating this relationship. Vulnerability is determined, not only by the level of physical exposure, but also the level of resilience, i.e. the capacity of societies to anticipate, manage and recover from environmental hazards (Sabates-Wheeler et al., 2008). In spite of this, existing accounts of the environmental scarcity-conflict linkage have been criticized for being overly state-centric, and not properly accounting for how local configurations of wealth and political power shape the vulnerabilities of communities (Raleigh, 2010). Relatedly, the environmental security literature has also been criticized for underestimating the local capacity for negotiation, adaptation or innovation among local communities, and "seems to deny any role for agency in the non-violent resolution of local conflicts of interest" (Hussein, Sumberg, & Seddon, 1999: 414; see also Benjaminsen, 2008; Turner, 2004). Violence is a high-cost response to climate-induced hardships, and will hinge on the lack of alternative coping strategies. Hence, it is essential to take into account how economic vulnerability and political marginalization interact with physical exposure to shape the capacity for adaptation among local communities.

In Sub-Saharan Africa, economic vulnerability of local communities interacts with physical vulnerability, since the poor often inhabit marginalized and degraded land that is more exposed to natural disasters such as flooding. Poverty is likely to exercise a significant influence on the group's choice of using violence when faced with environmentally induced hardships. To begin with, poverty is one of the most robust predictors of collective violence. Feelings of deprivation – both in absolute and relative terms – breed frustration and aggression, which facilitate recruitment for violence against other communities (Fjelde & Østby, 2010; Gurr, 1993; Kahl, 1996). Poor people also have lower opportunity costs for participating in violence, since the income foregone when taking up arms and not engaging in regular economic activity is lower for the poorest (Collier et al., 2003). Importantly, poverty also strongly influences the abilities of local communities to withstand adverse changes in environmental conditions. First, poverty narrows the range of options available to communities when confronting the economic consequences of climatic anomalies. Limited accumulated assets, reliance on a single source of income, uncertain land tenure, and restricted access to economic markets all contribute to render poor people vulnerable to adverse changes in their livelihood base following erratic rainfall. Common coping strategies in the face of climatic anomalies involve inter-household transfers and loans, use of credit, rationing, sale of assets, commodity trading, dispersed grazing, and relief aid (Corbett, 1988). The majority of these strategies, however, tend to hinge on land tenure agreements, access to markets and economic power of the community (Corbett, 1988; Raleigh, 2010). Poverty hence narrows the range of options available to groups when confronting adverse effects of rainfall anomalies, suggesting that economic vulnerability is crucial for understanding the conflict potential of such events.

The poorest are not only the least resilient to climatic anomalies. Research also suggests that their level of economic vulnerability is exacerbated in periods of environmental hardships. Poor populations groups are forced to sell possessions that are needed to secure their income at distress prices, aggravating their economic marginalization (Sabates-Wheeler et al., 2008: 19). Feelings of deprivation can be absolute, when there is a discrepancy between what people get and what they need, but deprivation can also be relative, deriving from a discrepancy between what people get and what they feel they should have. In terms of the rainfall-conflict linkage, unequal access to infrastructure, service delivery, and other forms of state accommodation at the local level might strengthen feelings of marginalization and deprivation among population groups facing environmental hardships, thereby increasing the risk of violent mobilization (Fjelde & Østby, 2010).

Another factor that is salient in shaping a group's resilience to environmental hardship is its political standing. In African politics, individuals tend to rely on ethnic coalitions when organizing for collective action around political and economic demands. As a consequence, the distribution of political and economic resources tends to follow ethnic lines (Bates, 1983; Scarritt & Mozaffer, 1999). Exclusion of ethno-political groups from political power is in itself a strong empirical correlate of involvement in organized violence (Cederman, Min, & Wimmer, 2010; Fjelde & Østby, 2010; Gurr, 1993; Theisen et al., 2011). Ethno-political groups that are not represented in the political arena share grievances that motivate participation in violence. Ethno-political groups are also more likely to overcome collective action problems related to violent mobilization as individuals already define their preferences in collectivistic terms and a strong community facilitates both coordination and mobilization (Cederman et al., 2010; Kahl, 1998).

Importantly for the current argument, political exclusion also limits the range of responses available to local communities facing adverse environmental conditions. Raleigh (2010) suggests two different channels through which political exclusion shapes the potential for organized violence following environmental pressures. First, since political relevance dictates the distribution of state resources, peripheral areas inhabited by politically irrelevant groups are characterized by weak government presence, and are often effectively unincorporated (see also Boone, 2003; Herbst, 2000). These areas lack public services, physical infrastructure and efficient state administrative apparatuses that could serve as resource management and conflict resolution bodies, and could prevent scarcity-induced conflicts between local communities from turning violent. Raleigh (2010: 70) points out that in such areas, violence over access to resources is often chronic and a product of "self-governing". Inter-group violence is a way to mediate access to resources critical to sustain livelihood in a space of minimal governments (see also Hagmann & Mulugeta, 2008).

Second, and more directly, the status of the group conditions the response of the government in the face of severe weather events. Politically significant groups will see the adverse effects of rainfall anomalies mitigated by disaster relief, infrastructural investments and economic compensation policies. Groups in the physical and political periphery, which cannot threaten the political stability of the regime, are less likely to receive government assistance facing environmentally induced hardship (Raleigh, 2010). Physical vulnerability is thus reinforced by political marginalization, leaving excluded groups more susceptible to chronic poverty, migration and, in turn, violent coping strategies in the face of environmental hazards. One example is inter-group violence between two Arab tribes, the Reizegat and the Habaniya, in the marginalized Southern Darfur region of Sudan. Long-term rivalries over grazing land between the two groups escalated to a violent clash during a dry spell in 2006, which claimed 150 deaths (UCDP, 2012). Thus, the above discussion suggests that the lack of state accommodation in the wake of environmental hazards narrows the range of non-violent coping strategies available to politically excluded groups.

The presented arguments propose that both economic and political marginalization will leave communities more exposed to the adverse economic consequences of droughts and excess rainfall, as coping strategies otherwise offered through economic markets and through state accommodation will be limited. In this context, the competition over resource access – whether arable land, water or a market place – might intensify among local communities. In a context of lowered opportunity costs for using violence and a heightened sense of frustration and resentment against other groups, communal violence becomes more likely. Based on these arguments we propose the following hypotheses:

H2: The effect of rainfall anomalies on communal conflict is larger in regions with high poverty levels.

H3: The effect of rainfall anomalies on communal conflict is larger in regions inhabited by politically excluded ethno-political groups.

Data and research design

This article examines the relationship between rainfall anomalies and the occurrence of communal conflict in Sub-Saharan Africa, and empirically evaluates how this relationship is conditioned by local patterns of economic and political vulnerability. Through our empirical approach, we aim to remedy some of the shortcomings identified in much of the existing large-N literature on climate and conflict. First, we switch the focus from civil war to communal conflict, a form of organized violence held by many observers to be a more probable consequence of environmental change (Buhaug et al., 2008; Gleditsch, 2012). Second, we avoid the aggregated research designs of country level studies, and adopt a spatially disaggregated approach that allows us to consider the large variations in rainfall and violence that exists within countries. Third, we empirically evaluate the argument that political exclusion and economic marginalization amplify the effect of rainfall anomalies on communal conflict at the local level. We include interaction terms between these variables and our indicators of rainfall variability to explicitly examine these arguments in our statistical set-up.

The unit of analysis in our study is the annual observation of first-order administrative units. Time varying data on sub-national administrative divisions and their spatial extent are from the Global Administrative Unit Layers (GAUL) (EC-FAO, 2008). While the significance of these sub-national administrative units varies across countries depending, for example, on the level of political decentralization, they nevertheless tend to play a significant role in the political process; they are often a site of electoral contest; local government authority structures are often constructed based on these divisions; and they often see administrative bodies with important roles in the collection of tax-revenue and provision of public goods. Some existing disaggregated studies construct their units of analysis as equally sized grid squares that are constant across time and space (c.f. Buhaug, Gleditsch, Holtermann, Østby, & Tollefsen, 2011; Raleigh & Urdal, 2007; Theisen et al., 2011) However, a weakness of the grid-structure is the ignorance of politically relevant divisions and boundaries.

Dependent variable

For our dependent variable, we rely on data on non-state conflict from the UCDP Geo-referenced Event Dataset (UCDP GED) (Melander & Sundberg, 2011). A non-state conflict is defined by the Uppsala Conflict Data Program (UCDP) as "the use of armed force between two organized armed groups, neither of which is the government of a state, which results in at least 25 battle-related deaths in a year" (Sundberg, Eck, & Kreutz, 2012). We focus on groups that are organized along a shared communal identity, and exclude from our dependent variable non-state violence by rebel groups involved in civil war, or by other groups with permanent fighting organizations. This form of violence falls outside the explanatory scope of our theoretical framework and research suggest that other factors are more likely to explain such violence (see Fjelde & Nilsson, 2012). In the UCDP GED, all conflicts that meet the 25 annual battle-death threshold are geo-referenced, implying that all fighting that results in at least one fatality is given a latitude/longitude coordinate, and a date. By means of spatial overlay operations using GIS software, we assign communal conflict events to the polygons representing first order administrative units on an annual basis. Our dependent variable *Communal Conflict* takes the value of 1 if there is a communal conflict event in the locality that year and 0 otherwise. In total there are 286 administrative region years recorded with communal conflict in our dataset. The spatial distribution of communal conflict in Sub-Saharan Africa is shown on the map in Fig. 1. About half of the conflict observations are located in the ecologically fragile Sahel zone.

The UCDP GED dataset builds on an automated event data search, which retrieves news articles from international news agencies and local media sources. News articles are complemented with case-specific sources, such as reports from international and local NGOs, and books by case experts. Each report is individually read, as a basis for the event coding. The theoretical arguments would apply to conflict below the 25 battle-related deaths threshold. However, the collection of systematic data on less-severe violence over a large number of countries may face validity problems. The coverage of this kind of events in media and other public reports may vary widely as less-severe violence is less likely to attract media attention than events resulting in a larger number of fatalities. Yet, the exclusion of conflicts below the 25-battle death threshold is admittedly a limitation of our data. While for example the ACLED dataset (Raleigh, Linke, et al., 2010; Raleigh, Witmer, et al., 2010) could represent an alternative data source, it cannot rival UCDP GED's coverage across countries over time. Measures of conflict onset (Theisen et al., 2011) or conflict sites (Buhaug, 2010b) employed in previous disaggregated studies are coded only by civil war episode, and represent static and more simplified representations of the conflict process.

Independent variable: rainfall anomalies

Our main explanatory variables are different specifications of rainfall anomalies, i.e. deviations from normal rainfall patterns. Rainfall is a reliable indicator of climate variability (Solomon et al., 2007). The data to construct the rainfall measures are taken from the Global Precipitation Climatology Project, v. 2.2. (Adler et al., 2003). The resolution of the spatially explicit dataset is $2.5^\circ \times 2.5^\circ$. To generate the rainfall anomaly variable we follow the approach of Hendrix and Salehyan (2012) and calculate, for each $2.5^\circ \times 2.5^\circ$ area, the deviations from the long-term mean (1979–2010), and divide it by the panel's standard deviation. We intersect the data on rainfall deviations with the administrative units layer, and assign to each region the maximum value on the rainfall deviations measure recorded within the region that year. An alternative approach would be to take the mean value within the administrative unit, but this would potentially mask the influence of large deviations, particularly if there are both positive and negative deviations within a region. As noted in the theory section, both negative and positive deviations from normal rainfall patterns can decrease the availability of livelihood resources and have

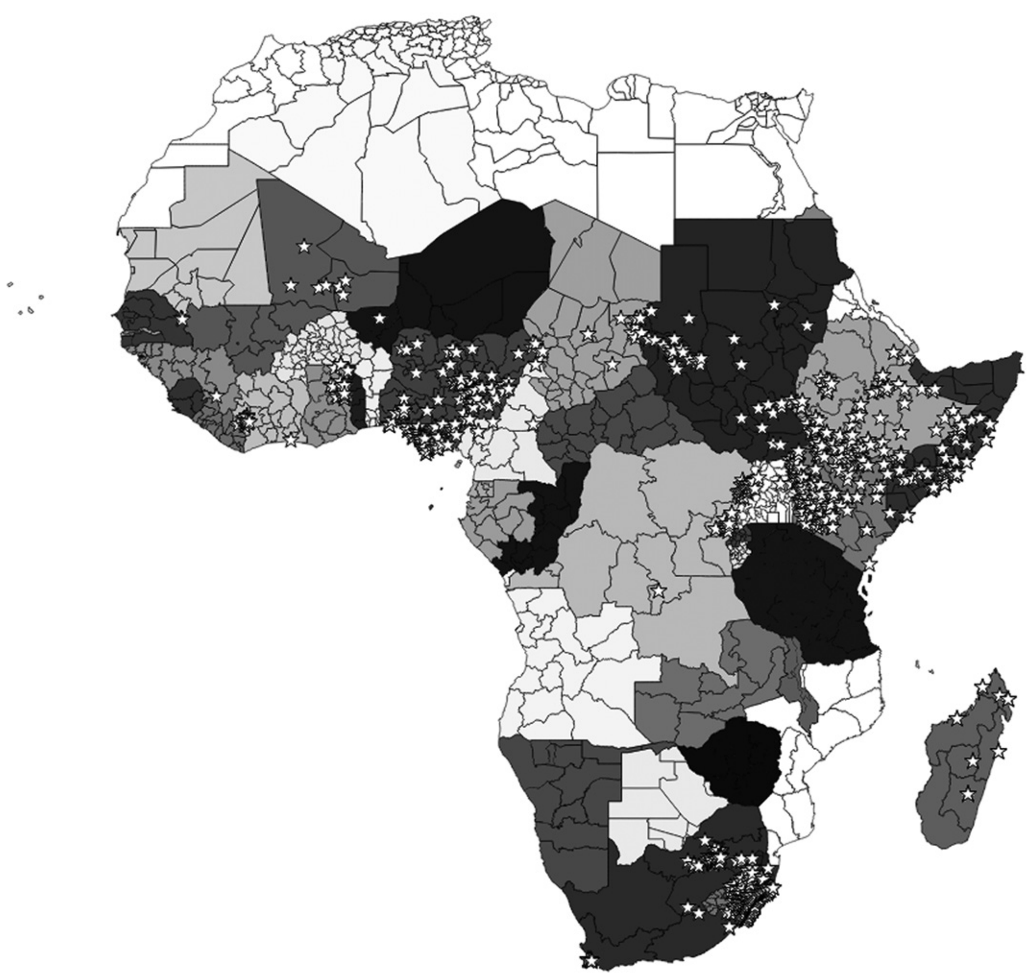

Fig. 1. Location of communal violence, Sub-Saharan Africa 1990–2008.

adverse economic consequences that lead to communal conflict. Yet, the impact of the two might differ. In the construction of our independent variable we therefore distinguish between negative and positive deviations. The variable *Inter-Annual Negative Rainfall Anomaly* takes the absolute value for all observations with negative standardized rainfall deviations, and sets all positive numbers to 0. The variable *Inter-Annual Positive Rainfall Anomaly* takes the absolute value for all observations with positive standardized rainfall deviations and sets all negative numbers to 0.

Measures of inter-annual rainfall deviations correlate well with severe rainfall anomalies, yet they may mask adverse effects of rain coming in the wrong seasons (cf. Theisen et al., 2011). We therefore also include another measure capturing intra-annual negative deviations from normal rainfall patterns. The original data is based on the Standardized Precipitation Index (SPI-6). This monthly index indicates deviations from long-term normal rainfall during the six preceding months for each month, separating between moderately dry conditions, severely dry conditions and extremely dry conditions (McKee, Doesken, & Kliest, 1993). We use the annualized SPI-6 index, available from the PRIO-GRID dataset (Tollefsen, Strand, & Buhaug, 2012). The annualized SPI-6 index is coded 0 if there are is no drought in the grid cell during the year; 1 if there are at least three consecutive months with moderate drought in the given grid cell during the year; 1.5 if there is a severe drought for at least two consecutive months; and 2.5 if both of the above criteria are met (extreme drought) (Tollefsen, 2012). For more information on what constitutes a drought see McKee et al. (1993). We construct the variable *Negative Intra-Annual Rainfall Anomaly* through spatial overlay operations between the PRIO-GRID and the administrative region layer, whereby each region is assigned the maximum value of the SPI-6 index recorded within the region that year.

Economic marginalization and political exclusion

To evaluate our second hypothesis holding that economic marginalization aggravates the risk of communal conflict following rainfall anomalies, we construct a measure of poverty based on the income distribution in our full sample. Data from the World Bank shows that 50.9% of the population in Sub-Saharan Africa lived below the poverty line of $1.25 a day in 2005 (World Bank, 2012). *Poverty* is a dichotomous variable, taking the value of 1 if local income levels fall below the 50th percentile of the income distribution for Sub-Saharan Africa within the time period covered in the analysis. We use income data from the G-Econ project (Nordhaus, 2006). The G-Econ dataset assembles data on local economic activity within countries, and provides estimates of the gross cell products within $1^\circ \times 1^\circ$ grid cells for 5-year intervals, beginning in 1990. We overlay administrative polygons with G-Econ cells, and aggregate income data to the level of the administrative units as the area-weighted sum of the cell areas that fall within or intersect with the administrative polygon. To construct our per capita income measure we divide the estimate of the administrative unit's gross product (given in 2005 USD at purchasing power parity exchange rates) by population size (see description below). We extrapolate the last observed values in-between observation years.

To evaluate our third hypothesis pertaining to political marginalization we use data on the political status of ethno-political groups from the Ethnic Power Relations (EPR) dataset. EPR identifies all politically relevant ethnic groups worldwide since 1945, and provides annual data on the group's access to executive power (Cederman et al., 2010). For our disaggregated analysis we couple these data with geographical information about the regional base and settlement patterns for each ethnic group included the EPR dataset using the GeoEPR dataset (Wucherpfennig et al., 2011). GeoEPR represents the settlement area of a group as a polygon (or a set of polygons). By overlaying group settlement polygons with administrative polygons we construct a dummy variable for *Political Exclusion.* The measure takes the value of 1 if a group settlement polygon of an excluded ethnic group intersects with the administrative polygon for a given year, and 0 otherwise.

Control variables

We include a number of variables that might be correlated with both rainfall patterns in Sub-Saharan Africa and communal conflict. In all models, except those where we include the measure of *Poverty* as a conditioning variable, we control for *Income* per capita, using the data from the G-Econ project described above (Nordhaus, 2006). We also control for *Population* using data from the Gridded Population of the World database from Columbia University (CIESIN & CIAT, 2005). The raster data are reported for 5-year intervals, beginning in 1990, and we extrapolate the last observed value in-between the observation years. Both of these are standard controls in the literature on political violence (c.f. Buhaug et al., 2011; Raleigh & Hegre, 2009). Both income and population may also be correlated with precipitation levels and variability. For example, if income and rainfall is related, fewer people might settle in arid and semi-arid regions where rainfall is highly variable. Thus, although rainfall anomalies are causally external to these factors, frequency and magnitude may be correlated with other drivers of conflict.

Spatial and temporal dependence, the notion that units of analysis are not independent across space and time in a cross-section time-series dataset, is well-established in the social science literature in general (Beck, Gleditsch, & Beardsley, 2006; Beck, Katz, & Tucker, 1998), and also in the conflict literature (c.f. Buhaug et al., 2011; Gleditsch & Weidmann, 2012; Raleigh, Linke, et al., 2010; Raleigh, Witmer, et al., 2010). At the conceptual level, spatial and temporal correlation in conflict processes give rise to repeating cycles of political violence in conflict-affected locations — or what Collier et al. (2003) refer to as the 'conflict trap'. From a methodological point of view, these inter-dependencies warrant the inclusions of variables controlling for the occurrence of political violence at proximate places and in the near past when examining the impact of an independent variable on the risk of conflict. As a control for spatial dependence we include a spatially lagged dependent variable — *Spatial lag, Communal Conflict* — which takes the value of 1 for all units of analysis that fall within a radius of 150 km of the communal violence event. The temporal dependence might span beyond a year, and to address this we follow the advice of Beck et al. (1998) and include the variable *Time since Communal Conflict,* which counts the number of years since the past occurrence of communal violence, alongside three cubic splines. We also include five year-dummies in all models to control for unobserved temporal dependence between the units. The temporal and spatial dependence might not only be linked to communal conflict, but also other forms of organized violence and we include the variable *Spatial lag, Civil War Violence,* which marks locations within a 50 km radius of a civil war event, using data from UCDPGED (Melander & Sundberg 2011).

Results and analysis

In this section we present the results from multivariate regression analysis of the influence of rainfall anomalies on the risk of communal conflict. Given the dichotomous nature of our dependent variable, we use logit regression, and report robust standard errors adjusted for clustering on the administrative unit. In Table 1 we evaluate the first hypothesis that rainfall anomalies increase the

Table 1
Logit models, rainfall anomalies and communal conflict in Sub-Saharan Africa, 1990–2008.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Inter-annual neg. rainfall anomaly	0.215 (0.103)**				0.266 (0.133)**	
Inter-annual pos. rainfall anomaly		0.033 (0.088)	0.062 (0.218)			
Inter-annual pos. rainfall anomaly, sq			−0.013 (0.082)			
Intra-annual neg. rainfall anomaly, (SPI-6)				0.150 (0.062)**		0.183 (0.082)**
Income per capita$_{log\ t-1}$	−0.103 (0.052)**	−0.105 (0.052)**	−0.105 (0.053)**	−0.113 (0.051)**	−0.365 (0.153)**	−0.333 (0.151)**
Population$_{log}$	0.540 (0.102)***	0.552 (0.102)***	0.552 (0.102)***	0.528 (0.100)***	0.927 (1.148)	1.044 (1.150)
Spatial lag, communal conflict$_{t-1}$	0.945 (0.157)***	0.926 (0.158)***	0.925 (0.158)***	0.935 (0.159)***	0.195 (0.188)	0.159 (0.188)
Time since communal conflict	−0.576 (0.115)***	−0.582 (0.114)***	−0.581 (0.115)***	−0.573 (0.113)***	−0.443 (0.111)***	−0.458 (0.111)***
Spatial lag, civil war$_{t-1}$	0.450 (0.147)***	0.462 (0.149)***	0.461 (0.150)***	0.443 (0.146)***	0.310 (0.218)	0.320 (0.219)
1995–1999	0.781 (0.298)***	0.709 (0.299)**	0.708 (0.299)**	0.759 (0.289)***	−0.143 (0.257)	−0.140 (0.257)
2000–2004	0.703 (0.287)**	0.696 (0.286)**	0.697 (0.288)**	0.844 (0.278)***	−0.148 (0.230)	0.031 (0.239)
2005–2008	0.793 (0.275)***	0.746 (0.280)***	0.745 (0.279)***	0.944 (0.279)***	−0.616 (0.273)**	−0.450 (0.282)
Administrative-unit fixed effects					*Yes*	*Yes*
Constant	−9.625 (1.441)***	−9.638 (1.443)***	−9.637 (1.444)***	−9.448 (1.426)***		
Number of observations	9986	9986	9986	9860	1731	1731

**$p < 0.05$; ***$p < 0.01$ Three cubic splines are included in all regressions. Robust standard errors, clustered by administrative unit.

risk of communal conflict. We start by looking at negative rainfall anomalies. The results reported in Model 1 support the hypothesis: the coefficient for inter-annual negative rainfall anomalies is positive and significant at the 5% level. In line with the theoretical argument, dry years seem to be associated with an increased risk of communal conflict. Using the CLARIFY software (King, Wittenberg, & Tomz, 2003) we calculate substantive effects of negative rainfall anomalies when all other variables are held constant at their mean and the year is set to 2000. An increase from the 10th to the 90th percentile (i.e. from 0 to 1.44) on the observed values on the negative rainfall anomalies measure is associated with an increase in the annual predicted probability of communal conflict within an administrative region of 45% (from 1.1% to 1.6%). While the influence of negative rainfall anomalies might seem negligible, the effect is comparable to the influence of per capita income, one of the robust predictors of political violence. Moving from the 10th from 90th percentile on the income variable, in a year with no negative rainfall anomaly, reduces the estimated probability of communal conflict by 0.3% (based on parameter estimates reported in Model 1).

In Model 2, we examine the impact of positive deviations from normal rainfall patterns. The coefficient for inter-annual positive rainfall anomalies is not statistically significant, suggesting that there is no relationship between wet years and an increased risk of communal conflict. Large parts of Sub-Saharan Africa are dry areas, and moderate increases in precipitation might therefore be beneficial for agricultural output for livestock farms and lengthen growing seasons (Boko et al., 2007). There might hence be non-linear effects at work. In Model 3 we include a squared term of the positive rainfall anomaly variable. The coefficients for positive rainfall deviations remain non-significant, both separately and jointly. These findings contrast the results of recent publications with a limited geographical focus on East African countries finding that wetter years see a higher conflict risk (Raleigh & Kniveton, 2012; Theisen, 2012). The divergent results are possibly due to the prevalence of violent clashes between pastoralists in the context of cattle-raiding in East Africa, which is more profitable in times of abundance (Meier et al., 2007). In our data, any pacifying effect of a moderate increase in precipitation for regions with scarcity-driven contentions between communal groups might cancel out the conflict-driving effect of excess rainfall on some pastoralist conflicts.

In Model 4, we replace the measure for inter-annual rainfall anomalies with the indicator for intra-annual negative rainfall anomalies (SPI-6). Again, the results support the argument that rainfall shortages are associated with an increase in the risk of communal conflict. The coefficient is positive and significant at the 5% level. In substantive terms, moving from the 10th to the 90th percentile (from 0 to 2.5) on the SPI-6 measure increases the annual predicted probability of communal conflict with 50% (from 1.2% to 1.8%).

The results reported in Model 1 and 4 support the argument that negative deviations from normal rainfall patterns, within and across years, increase the risk of communal conflict. Next, we include administrative-unit fixed effects to make sure that these results cannot be attributed to any unobserved time-invariant heterogeneity among the administrative regions, for example differences in their colonial institutional legacies, historical property right regimes, or physical characteristics of the landscape. Model 5 and 6 report the results from a conditional fixed-effects logit model for the inter- and intra-annual negative rainfall anomaly measures respectively. Both the coefficient for inter-annual negative rainfall anomalies (Model 5) and the intra-annual SPI-6 measure (Model 6) remain positive and significant at the 5% level with the fixed-effects specifications. Both coefficients increase in size. Overall, this strengthens the interpretation that negative deviations from normal rainfall patterns act as a trigger for the occurrence of communal conflict within a region.

We have performed a number of additional robustness checks on the results reported in Table 1, Model 1 and 4. (See Online Appendix for tables.) First, we have tried to include a lagged version of both the inter-annual and intra-annual rainfall anomaly measures. The main results remain unchanged. Second, we have tried to include a control for ethnic fractionalization, since ethnic divisions play a central role in the literature on inter-group conflict. Our measure for regional ethno-linguistic fractionalization is calculated based on geo-referenced data on the settlement patterns of the ethno-linguistic groups from the People Atlas of Africa (Felix & Meur, 2001). The inter-annual negative rainfall variable drops slightly in significance (10% level) when this control is included, whereas the intra-annual SPI-6 measure remains significant at the 5% level. Finally, due to the large number of observations with a zero on our dependent variable we have also ensured that all our results are robust to using a rare-events logit model (King & Zeng, 2001).

The control variables behave largely as expected. The estimated effect of income is negative and statistically significant (5% level), suggesting that the risk of communal conflict is higher in poor regions. Population is positive and significant across all models (1% level), except when administrative-units fixed effects are introduced. The spatial lag for communal conflict is positive and significant (1% level). The control variable for the time span since past communal conflict is negative and significant, suggesting that with the passing of time, the risk of renewed communal conflict goes down. Also the spatial lag for civil war events is positive and significant (5% level), corroborating the notion that there are indeed inter-dependencies between different types of violence. Finally, the five-year dummies are all positive and significant, suggesting that the early period (1990–1994) sees a lower risk of communal conflict. We note that the intra-annual rainfall measure (SPI-6) is sensitive to the exclusion of these temporal dummies. However, if we use alternative controls for time dependence that, in contrast to the cubic spline approximation, do not conflate the time since the start of the dataset and the time since past communal conflict, also the SPI-6 measure remains significant in the absence of five-year dummies.

We proceed to explore Hypotheses 2 and 3, which suggest that the impact of rainfall anomalies on the risk of communal conflict is conditioned by local configurations of income and political power. Based on the results in Table 1, we focus on negative deviations. In order to examine whether the marginal effect of negative rainfall anomalies on communal conflict is higher in the presence of poverty and political exclusion, we introduce interaction terms between rainfall deviations and these conditioning variables in the statistical model. The results are reported in Table 2.

With the introduction of interaction terms the model parameters require a different interpretation: constituent terms no longer denote marginal effects, but rather *conditional* marginal effects when the value of the other component term is equal to zero (Brambor, Clark, & Golder, 2006). We recode the modifying dummy variables (poverty and political exclusion) by subtracting 1 on all values. The coefficients for negative rainfall anomalies in Model 7 and 8 thus refer to conditional marginal effects of rainfall for poor regions and in Model 9, 10 and 11 for regions with politically excluded groups.

We begin by evaluating the hypothesis that the influence of rainfall anomalies on the risk of communal conflict is amplified in the presence of poverty. Looking at the conditional marginal effect of rainfall anomalies in the context of poverty, neither the inter-annual (Model 7) or intra-annual measure (Model 8) yield statistically significant effects. The interaction effects in both models are far from statistically significant, and actually have the opposite sign to what we expect. However, in non-linear models the significance of the interaction cannot be tested with a simple *t*-test on the interaction term and the interaction effect can be nonzero even if the coefficient of the interaction term is zero (Berry, DeMerrit, & Esarey, 2010). We follow the recommendations of Berry et al. (2010) to evaluate the presence of interaction effects by using the CLARIFY software to calculate estimated effects of moving from the 10th to the 90th percentile on the rainfall anomaly measure in poor and non-poor areas respectively. (See Online Appendix for tables). As suggested also by the coefficient estimates, the predicted conflict-inducing effect of rainfall is, if anything, smaller in the regions above the 50 percentile on the income distribution. Yet, the difference in risk between the poor and non-poor areas is not statistically significant for any of the two rainfall measures. In sum, we do not find support for our second hypothesis that the effect of rainfall anomalies is amplified in the presence of poverty. The lack of evidence for the proposed relationship might be due to a number of factors. The economic vulnerability we anticipate to have an effect on conflict risk is an attribute of individuals and societal groups, and might not show up in aggregate income data. Hence, although we employ a subnational measure of income, the resolution of the data might still be too high. A poverty measure based on the income level of the poorest 50 percentile within each region would perhaps render other results. In addition, the economic vulnerability we focus on in our argument might be more determined by livelihood requirements and reliance on agriculture than poverty per se. Finally, the African continent as such is often held to be particularly vulnerable to climate change due, amongst other things, to its widespread poverty. Perhaps the modifying effect of economic marginalization would be more visible when comparing African regions with a global sample.

Hypothesis 3 holds that the impact of negative rainfall deviations on communal conflict is greater in regions populated by politically marginalized ethno-political groups. The results for the inter-annual negative rainfall anomalies do not support this contention: neither the conditional marginal effect nor the interaction term is statistically significant. As above, we evaluate the interaction between rainfall anomalies and political exclusion by looking at substantive effects using CLARIFY. While the estimated

Table 2
Interaction models, negative rainfall anomalies and communal conflict in Sub-Saharan Africa 1990–2008.

	Model 7	Model 8	Model 9	Model 10	Model 11
Inter-annual neg. rainfall anomaly	0.102 (0.154)		0.210 (0.130)		
Poor, 50th pct	−0.011 (0.250)	0.028 (0.231)			
Inter-annual neg. rainfall anomaly*poor	−0.200 (0.209)				
Intra-annual neg. rainfall anomaly (SPI-6)		0.039 (0.088)		0.192 (0.077)**	0.282 (0.098)***
SPI-6*poor		−0.167 (0.128)			
Excluded			0.422 (0.221)*	0.287 (0.194)	1.458 (0.458)***
Inter-annual rainfall anomaly*excluded			0.013 (0.221)		
SPI-6*excluded				0.168 (0.134)	0.267 (0.159)*
Income per capita$_{\log\ t\text{-}1}$			−0.121 (0.053)**	−0.122 (0.052)**	−0.272 (0.150)*
Population$_{\log}$	0.510 (0.098)***	0.501 (0.097)***	0.519 (0.100)***	0.506 (0.098)***	1.197 (1.178)
Spatial lag, communal conflict$_{t\text{-}1}$	0.937 (0.158)***	0.924 (0.160)***	0.898 (0.158)***	0.883 (0.161)***	0.130 (0.190)
Time since communal conflict	−0.575 (0.110)***	−0.564 (0.106)***	−0.585 (0.115)***	−0.585 (0.113)***	−0.432 (0.113)***
Spatial lag, civil war$_{t\text{-}1}$	0.552 (0.146)***	0.549 (0.147)***	0.321 (0.143)**	0.303 (0.144)**	0.266 (0.220)
Five year dummies	Yes	Yes	Yes	Yes	Yes
Administrative-unit fixed effects					*Yes*
Constant	−9.896 (1.469)***	−9.798 (1.446)***	−8.957 (1.443)***	−8.862 (1.430)***	
Number of observations	9986	9860	9590	9518	1731

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$ Three cubic splines are included in all regressions. Robust standard errors, clustered by administrative unit. Note: the indicator for poor regions is coded −1 for non-poor regions and 0 for poor regions; the indicator for exclusion is coded −1 for non-excluded groups and 0 for excluded groups.

conflict-inducing effect of inter-annual rainfall anomalies is higher in areas inhabited by politically excluded groups, the difference is not statistically significant.

The results for the intra-annual rainfall anomaly measure (SPI-6) are generally more supportive of the hypotheses (Model 10). The effect of intra-annual rainfall anomalies in regions with politically marginalized ethno-political groups is positive and significant at the 5% level. Also the interaction term is positive as expected, albeit not significant. We evaluate the interaction effect by calculating substantive effects. In areas with politically excluded ethnic groups, moving from the 10th to the 90th percentile on the SPI-6 measure increases the risk of communal conflict with 0.9%. The corresponding increase in conflict risk in an area without politically excluded groups is 0.01%. The interaction effect thus seems non-trivial in a substantive sense, and the second difference is significant at the 10% level. When including administrative-unit fixed effects in Model 11, the results become stronger: the coefficients increase in size and the interaction effect becomes significant at the 10% level. In sum, there is some evidence that political exclusion increases the risk of communal conflict following intra-annual rainfall anomalies.

Conclusions

This study is the first large-N analysis across a large number of countries over time of the impact of climate variability on communal conflict in Sub-Saharan Africa. Utilizing a spatially disaggregated research design and drawing on new geo-referenced event data on armed conflicts, we statistically explore how rainfall anomalies are associated with communal conflict. The results suggest that communal conflict is more likely in dry years, which is consistently shown in two alternative measures of negative rainfall anomalies. We also find some suggestive evidence that political exclusion reinforces the conflict-inducing effect of rainfall shortages. Contrary to our expectations, there is no consistent pattern indicating that the conflict-inducing effect of negative rainfall anomalies is amplified in poor regions. Possibly our measure of poverty, which is based on the income distribution of the entire sample is too crude to capture economic vulnerability at the level of the individual or societal group. Nevertheless, these statistical findings suggest that case-based accounts from places such as Sudan and Ethiopia of armed conflict between politically marginalized societal groups over access to grazing land and water holes following droughts might indeed reflect a more general pattern.

The present study focuses on Sub-Saharan Africa, a region held to be particularly vulnerable to the adverse consequences of climate change due to its dependence on rain-fed agriculture; its weak state institutions; widespread poverty, and high prevalence of organized violence. As such, Sub-Saharan Africa represents "a most likely" case to find a correlation between rainfall anomalies and armed conflict (Theisen et al., 2011). Case-based accounts of climate-induced communal conflict do, however, not only refer to the African context. India, Philippines and Mexico are examples of other countries mentioned in the environmental security literature. While the data on communal conflict limits the geographical and temporal scope of this study, future research should probe the strength of this relationship in other regions of the world.

In a speech to the United Nations in 2009, US President Barack Obama warned that climate change is an "urgent, serious and growing threat" as more erratic rainfall and crop failure will "breed hunger and conflict" (Reuters, 2009). Academic research has so far provided limited empirical evidence in support of the linkage between climate variability and conflict. Our results suggest, however, that the attention by policymakers to the security implications of climate change might be warranted. While the magnitude of future climatic changes is difficult to predicted, an increase in climate variability could render vulnerable population groups even more exposed to organized violence threatening their physical and economic survival.

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Appendix A. Supplementary material

Supplementary material related to this article can be found at http://dx.doi.org/10.1016/j.polgeo.2012.08.004.

References

Adler, R. F., Huffman, G. J., Chang, A., Ferraro, R., Xie, P.-P., Janowiak, J., et al. (2003). The version-2 global precipitation climatology project (GPCP) monthly precipitation analysis (1979–present). *Journal of Hydrometeorology, 4*, 1147–1167.

Baechler, G. (1999). *Violence through environmental discrimination*. Dordrecht: Kluwer.

Ban, K.-M. (2007). A climate culprit in Darfur. *The Washington Post*, (16 June).

Bates, R. (1983). Modernization, ethnic competition and the rationality of politics in contemporary Africa. In D. Rotchild, & V. Olorunsola (Eds.), *State versus ethnic claims: African policy dilemmas* (pp. 152–171). Boulder: Westview Press.

BBC. (2001). *Floods inundate farmlands in southern Somalia* (15 May).

Beck, N., Gleditsch, K. S., & Beardsley, K. (2006). Space is more than geography: using spatial econometrics in the study of political economy. *International Studies Quarterly, 50*, 27–44.

Beck, N., Katz, J. N., & Tucker, R. (1998). Taking time seriously: time-series-cross-section analysis with a binary dependent variable. *American Journal of Political Science, 42*, 1260–1288.

Benjaminsen, T. A. (2008). Does supply-induced scarcity drive violent conflicts in the African Sahel? The case of the Tuareg rebellion in northern Mali. *Journal of Peace Research, 45*, 819–836.

Berry, W. D., DeMerrit, J., & Esarey, J. (2010). Testing for interaction in binary logit and probit models: is a product term essential? *American Journal of Political Science, 54*, 248–266.

Boko, M., Niang, I., Nyong, A., Vogel, C., Githenko, A., Medany, M., et al. (2007). Africa, climate change 2007: impacts, adaptation and vulnerability. In M. Parry, O. Canziani, J. Palutikof, P. Van der Linden, & C. Hanson (Eds.), *Assessment report of the intergovernmental panel on climate change* (pp. 433–467). Cambridge: Cambridge University Press.

Boone, C. (2003). *Political topographies of the African state: Territorial authority and institutional choice*. Cambridge: Cambridge University Press.

Brambor, T., Clark, W. R., & Golder, M. (2006). Understanding interaction models: improving empirical analyses. *Political Analysis, 14*, 63–82.

Buhaug, H. (2010a). Climate not to blame for African civil wars. *Proceedings of the National Academy of Sciences, 107*, 16477–16482.

Buhaug, H. (2010b). Dude, where's my conflict? *Conflict Management and Peace Science, 27*, 107–128.

Buhaug, H., Gleditsch N. P., & Theisen, O. M. (2008). Implications of climate change for armed conflict. Background paper commissioned by the World Bank for the workshop on social dimensions of climate change.

Buhaug, H., Gleditsch, K. S., Holtermann, H., Østby, G., & Tollefsen, A. F. (2011). It's the local economy, stupid! geographic wealth dispersion and conflict outbreak location. *Journal of Conflict Resolution, 55*, 814–840.

Burke, M. B., Miguel, E., Satyanath, S., Dykema, J. A., & Lobell, D. (2009). Warming increases the risk of civil war in Africa. *Proceedings of the National Academy of Sciences, 106*, 20670–20674.

Cederman, L. E., Min, B., & Wimmer, A. (2010). Why do ethnic groups rebel? New data and analysis. *World Politics, 62*, 87–119.

Center for International Earth Science Information Network (CIESIN) and Centro International de Agricultura Tropical (CIAT). (2005). *Gridded population of the world (GPW3) data collection*. Columbia University.

Collier, P., Elliot, L., Hegre, H., Hoeffler, A., Reynal-Querol, M., & Sambanis, N. (2003). *Breaking the conflict trap: Civil war and development policy*. Oxford: Oxford University Press.

Corbett, J. (1988). Famine and household coping strategies. *World Development, 16*, 1099–1112.

Deaton, A. (1999). Commodity prices and growth in Africa. *Journal of Economic Perspectives, 13*, 23–40.

Deaton, A., & Miller, R. (1995). International commodity prices and macroeconomic performance, and politics in Sub-Saharan Africa. *Princeton Studies in International Finance, 79*.

EC-FAO Food Security Programme. (2008-12-15). *The global administrative unit layers (GAUL) GAUL/Doc 01.*

Felix, M. L., & Meur, C. (2001). *Peoples of Africa: Enthnolinguistic map*. Brussels: Congo Basin Art History Research Center.

Fjelde, H., & Nilsson, D. (2012). Rebels against rebels. *Journal of Conflict Resolution, 56*, 604–628.

Fjelde, H., Østby, G. (2010). Economic inequality and non-state conflicts in Africa. Paper presented at the 2010 Annual Meeting of the American Political Science Association, Washington.

Gleditsch, N. P. (1998). Armed conflict and the environment: a critique of the literature. *Journal of Peace Research, 35*, 381–400.

Gleditsch, N. P. (2012). Whither the weather? Climate change and conflict. *Journal of Peace Research, 49*, 3–9.

Gleditsch, K. S., & Weidmann, N. B. (2012). Richardson in the information age: geographic information systems and spatial data in international studies. *Annual Review of Political Science, 15*, 461–481.

Gurr, T. R. (1993). Why minorities rebel: a global analysis of communal mobilization and conflict since 1945. *International Political Science Review, 14*, 161–201.

Hagmann, T., & Mulugeta, A. (2008). Pastoral conflicts and state-building in the Ethiopian lowlands. *Afrika Spectrum, 43*, 19–37.

Hendrix, C. S., & Glaser, S. (2007). Trends and triggers: climate, climate change and civil conflict in Sub-Saharan Africa. *Political Geography, 26*, 695–715.

Hendrix, C. S., & Salehyan, I. (2012). Climate change, rainfall, and social conflict in Africa. *Journal of Peace Research, 49*, 35–50.

Herbst, J. (2000). *States and power in Africa. Comparative lessons in authority and control.* Princeton: Princeton University Press.

Homer-Dixon, T. F. (1994). Environmental scarcities and violent conflict: evidence from cases. *International Security, 19*, 5–40.

Homer-Dixon, T. F. (1999). *Environment, scarcity, and violence*. Ewing, NJ: Princeton University Press.

Hsiang, S. M., Meng, K. C., & Cane, M. A. (2011). Civil conflicts are associated with the global climate. *Nature, 476*, 438–441.

Hussein, K., Sumberg, J., & Seddon, D. (1999). Increasing violent conflict between herders and farmers in Africa: claims and evidence. *Development Policy Review, 17*, 397–418.

IRIN. (2001). *More Killed in Inter-Clan Fighting*. UN Integrated Regional Information Network (10 July).

Kahl, C. H. (1998). Population growth, environmental degradation, and state-sponsored violence: the case of Kenya, 1991–93. *International Security, 23*, 80–119.

Kahl, C. H. (2006). *States, scarcity, and civil strife in the developing world*. Princeton: Princeton University Press.

Kimenye, D. (2006). *Life on the edge of climate change: The plight of pastoralists in Northern Kenya*. Christian Aid.

King, G., Wittenberg, J., & Tomz, M. (2003). Clarify: software for interpreting and presenting statistical results. *Journal of Statistical Software, 8*, 1–30.

King, G., & Zeng, L. (2001). Logistic regression in rare events data. *Political Analysis, 9*, 137–163.

McKee, T. B., Doesken, N. L., & Kliest, J. (1993). The relationship of drought frequency and duration to time scales. In *Proceedings of the 8th conference of applied climatology* (pp. 179–184). Boston: American Meterological Society.

Meier, P., Bond, D., & Bond, J. (2007). Environmental influences on pastoral conflict in the Horn of Africa. *Political Geography, 26*(6), 716–735.

Melander, E., & Sundberg, R. (2011). Climate change, environmental stress and violent conflict-tests introducing the UCDP georeferenced event dataset. Paper presented at the 2011 Annual Meeting of the International Studies Association, Montreal.

Miguel, E., Satyanath, S., & Sergenti, E. (2004). Economic shocks and civil conflict: an instrumental variables approach. *The Journal of Political Economy, 112*, 725–753.

Nordhaus, W. D. (2006). Geography and macroeconomics: new data and new findings. *Proceedings of the National Academy of Sciences, 103*, 3510–3517.

Raleigh, C. (2010). Political marginalization, climate change, and conflict in African Sahel states. *International Studies Review, 12*, 69–86.

Raleigh, C., & Hegre, H. (2009). Population size, concentration and civil war. *Political Geography, 26*, 224–238.

Raleigh, C., & Kniveton, D. (2012). Come rain or shine: an analysis of conflict and climate variability in East Africa. *Journal of Peace Research, 49*, 51–64.

Raleigh, C., Linke, A., Hegre, H., & Karlsen, J. (2010). Introducing ACLED: an armed conflict location and event dataset. *Journal of Peace Research, 47*, 651–660.

Raleigh, C., & Urdal, H. (2007). Climate change, environmental degradation and armed conflict. *Political Geography, 26*, 674–694.

Raleigh, C., Witmer, F., & O'Loughlin, J. (2010). A review and assessment of spatial analysis and conflict: the geography of war. In R. Denemark (Ed.). *The international studies encyclopedia, Vol. X* (pp. 6534–6553). Oxford: Wiley-Blackwell.

Reuters News. (2009). *Obama's U.N. speech on climate change* (22 September).

Reuveny, R. (2007). Climate change-induced migration and violent conflict. *Political Geography, 26*, 656–673.

Sabates-Wheeler, R., Devereux, S., Mitchell, T., Tanner, T., Davies, M., & Leavy, J. (2008). *Rural disaster risk-poverty interface*. University of Sussex.

Scarritt, J., & Mozaffer, S. (1999). The specifications of ethnic cleavages and ethnopolitical groups for the analysis of democratic competition in contemporary Africa. *Nationalism and Ethnic Politics, 5*, 82–117.

Solomon, S., Qin, D., Manning, M., Marquis, M., Averyt, K. B., Tignor, M., et al. (2007). *Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change, 2007*. Cambridge, United Kingdom and New York: Cambridge University Press.

Stern, N. (2006). *Stern review on the economics of climate change*. National Archives HM Treasury (Accessed February 2012). http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm.

Sundberg, R., Eck, K., & Kreutz, J. (2012). Fighting without the state – introducing the UCDP non-state conflict dataset. *Journal of Peace Research, 49*, 351–362.

Tarhule, A. (2005). Damaging rainfall and flooding: the other Sahel hazards. *Climatic Change, 72*, 355–377.

The Economist. (2010). *Security and the environment: Climate wars* (Accessed 23.05.11). http://www.economist.com/node/16539538?story_id=16539538.

Theisen, O. M. (2008). Blood and soil? Resource scarcity and internal armed conflict revisited. *Journal of Peace Research, 45*, 801–818.

Theisen, O. M. (2012). Climate clashes? Weather variability, land pressure, and organized violence in Kenya, 1989–2004. *Journal of Peace Research, 49*, 81–96.

Theisen, O. M., & Brandsegg, K. B. (2007). The environment and non-state conflicts. Paper presented at the 2007 Annual Meeting of the International Studies Association, Chicago.

Theisen, O. M., Holtermann, H., & Buhaug, H. (2011). Climate wars? Assessing the claim that drought breeds conflict. *International Security, 36*, 79–106.

Tollefsen, A. F. (2012). *PRIO-GRID codebook*. Accessed August 2012. http://www.prio.no/upload/cscw/PRIO-GRID/PRIO-GRID_codebook_v1_01.pdf.

Tollefsen, A. F., Strand, H., & Buhaug, H. (2012). PRIO-GRID: a unified spatial data structure. *Journal of Peace Research, 49*, 363–374.

Turner, M. (2004). Political ecology and the moral dimensions of "resource conflicts": the case of farmer–herder conflicts in the Sahel. *Political Geography, 23*, 863–889.

United Nations Environment Program. (2007). *Sudan, post-conflict environmental assessment*. Nairobi: Kenya, Accessed 11.08.11. http://postconflict.unep.ch/publications/UNEP_Sudan.pdf.

Wucherpfennig, J., Weidmann, N. B., Girardin, L., Cederman, L. E., & Wimmer, A. (2011). Politically relevant ethnic groups across space and time. Introducing the GeoEPR dataset. *Conflict Management and Peace Science, 28*, 423–437.

Websites

Uppsala Conflict Data Program. (2012). *UCDP conflict Encyclopedia*. Uppsala University, Accessed August 2012. www.ucdp.uu.se/database.

World Bank. (2012). *Poverty and inequality database*. Accessed August 2012. http://databank.worldbank.org/ddp/home.do?Step=2&id=4&DisplayAggregation=N&SdmxSupported=N&CNO=1208&SET_BRANDING=YES.