Come rain or shine: An analysis of conflict and climate variability in East Africa

Clionadh Raleigh and Dominic Kniveton

Journal of Peace Research 2012 49: 51

DOI: 10.1177/0022343311427754

journal of peace RESEARCH

Journal of Peace Research
49(1) 51–64

DOI: 10.1177/0022343311427754
jpr.sagepub.com
SAGE

Come rain or shine: An analysis of conflict and climate variability in East Africa

Clionadh Raleigh

Trinity College Dublin & Peace Research Institute Oslo (PRIO)

Dominic Kniveton

University of Sussex

Abstract

Previous research on environment and security has contested the existence, nature and significance of a climate driver of conflict. In this study, we have focused on small-scale conflict over East Africa where the link between resource availability and conflict is assumed to be more immediate and direct. Using the parameter of rainfall variability to explore the marginal influence of the climate on conflict, the article shows that in locations that experience rebel or communal conflict events, the frequency of these events increases in periods of extreme rainfall variation, irrespective of the sign of the rainfall change. Further, these results lend support to both a 'zero-sum' narrative, where conflicting groups use force and violence to compete for ever-scarcer resources, and an 'abundance' narrative, where resources spur rent-seeking/wealth-seeking and recruitment of people to participate in violence. Within the context of current uncertainty regarding the future direction of rainfall change over much of Africa, these results imply that small-scale conflict is likely to be exacerbated with increases in rainfall variability if the mean climate remains largely unchanged; preferentially higher rates of rebel conflict will be exhibited in anomalously dry conditions, while higher rates of communal conflict are expected in increasingly anomalous wet conditions.

Keywords

civil war, communal violence, East Africa, environment, rainfall

Introduction

Recent research has speculated that future climate-related shocks might spark violent conflict in a number of regions in the world (Swart, 1996; Sachs, 2005; Homer-Dixon, 2007; Stern, 2007). The fears that violent conflict will increase in the future are largely based on the reasoning that resource scarcity has historically been conceptualized as a driver for large-scale violence and because climate change is widely predicted to have a detrimental impact on resource availability. An oft-cited example of a recent climate-related violent conflict is the Darfur crisis (e.g. former UN Under-Secretary-General for Humanitarian Affairs Jan Egeland, cited in Nordås & Gleditsch, 2007; United Nations Secretary-General Ban Ki-moon cited in Salehyan, 2008).

This view of resource scarcity as a cause of the Darfur crisis, however, has been challenged by a number of authors (e.g. Butler, 2007; Kevane & Gray, 2008) who support a wider narrative in the conflict literature that refutes a climate change–civil war relationship. For example, a recent debate in the *PNAS* began with an assertion by Burke et al. (2009) that increases in

Corresponding author:
raleighc@tcd.ie

temperature were likely to cause unprecedented levels of violence in Africa in the near future. This was immediately countered by several academics, including Buhaug (2010) who noted that these results were based on analysis of recent large-scale conflict that selected only years and conflicts that fitted their environmental security narrative. Support for such counter-arguments also come from civil war model based studies which have shown in a number of situations that when standard political and economic variables are included in analyses of conflict, the importance of traditional 'environment' or 'climate change' variables are rarely significant (Nordås & Gleditsch, 2007; Raleigh & Urdal, 2007). Further, several additional studies have discounted degraded areas as being more likely to experience violence, international or national level water scarcity as underscoring conflict (Wolf, 1998, 2000), and natural disasters as likely to lead to leadership change as a function of government ability to respond (Nel & Righarts, 2008).

At the heart of the debate over the role of climate in conflict lies the desire to provide scenarios of future conflict patterns in a changing climate. In this context, the contestation over the linkage between conflict and the climate is set against a backdrop of significant uncertainty about climate change projections, as shown in the most recent report of the IPCC (2007). This scientific uncertainty is most pronounced for the parameter of rainfall, rather than temperature (Meehl et al., 2007). Given the relatively strong relationship between rainfall and economic resources in many of the world's agriculturally based countries, a large uncertainty exists in predicting any potential for climate change-related conflicts.

One of the past problems in isolating the possible role of climate in violent conflict has been the focus on large-scale conflict. The occurrence and characteristics of large conflicts involve a complex interplay of numerous factors on several scales. In such scenarios, 'climate' and 'climate change' are often measured in long-term trends or annual variations. These measures are largely too static to display significant effects on annual conflict patterns. In this study, we focus on the relationship between subnational conflict and variations in past rainfall conditions to further understand the climate–conflict nexus. Furthermore, we explore the relationship between rainfall conditions and different types of conflict. The rationale for looking at different types of conflict rests in the premise that climate is never the only determinant of political violence. Climate's influence is mediated via other drivers of conflict such as resource availability, political unrest and economic pressures. Different types of conflicts have alternate sets of instability determinants and, hence, will have distinct relationships (if any) with climate variability and change. In particular this study uses disaggregated information on recent violence in East Africa to test whether, controlling for other conflict correlates, climate variability influences the propensity of a location to experience different levels and types of violence. East Africa is chosen for several reasons: this region has a history of various conflicts, so the assumption that core sociopolitical factors of instability exist is met. Conflict data for this region are comprehensive, and there is relatively strong agreement between different climate models over climate change in East Africa, despite widespread uncertainty over rainfall changes in the future in the low latitudes.

In the first section of the article, we outline the theoretical rationale for the different linkages between climate and conflict as mediated by rainfall variability. We present four scenarios through which climate may influence the propensity for political violence. These scenarios rest on the assumption that it is not necessarily the sign but the magnitude of the physical change that connects rainfall variability and conflict. We then assess evidence for these scenarios through a series of locational and time-specific measures of rainfall variation and political conflict event frequencies in East Africa for the period 1997–2009. We investigate the data through a regression analysis and supplement this with an epoch superposition analysis. Finally, we conclude with an argument relating to how extreme variability in climate is associated with increased frequencies of conflict.

Potential conflict types

Political conflict varies in participants, actors, victims, political strategy, goals, spatial signature and reliance upon physical geographies. Past studies of local-scale conflict and climate have come to different conclusions on the relationship between the two (Barnett, 2000; Nordås & Gleditsch, 2007; Raleigh & Urdal, 2007; Witsenburg & Adano, 2007; Theisen, 2008; Raleigh, 2010). In part, this results from a failure to separate conflicts into different groupings according to the structure, goals and participants of the conflict.

Violence perpetrated by different actors can be separated based on (1) the formality and characteristics of groups, (2) the actions and strategic goals of groups, (3) the contexts in which groups emerge, and (4) the relationships with other forms of violence. For the purposes of this article, we have distinguished between violent events involving formally established *rebels* as one side of a civil war, and *communal violence* involving informal, often ethnically based, small rural bands engaged in violent contest.

Rebel conflict

Rebels form an official military organization for the purposes of fighting the established military power of the state. Such groups are motivated by the acquisition of formal, internationally recognized power over a state's territory. Membership in rebel groups is defined for the period in which that group operates. Recognized rebel organizations may be associated with a group or region identity, but not all members of that group or region may belong or support violent actions. Rebels often seek to control territorial bases within a state and engage in battles with military forces or violence against civilians (see Raleigh & Hegre, 2009). Geographically, these groups seek control of the power centres of the state, including the capital, regional centres, garrison towns and infrastructure of the state (Herbst, 2000; Buhaug & Rød, 2006). During a civil war, activities involving rebel groups typically result in significant deaths and destruction. For the purposes of this article, any reference to civil wars or rebels is interchangeable.

Communal violence

Very few cross-group studies have been conducted on communal violence, yet the limited sample indicates that localized ethnic conflicts differ in form, intensity and frequency from other forms of internal violence. Communal conflict is broadly defined as a form of organized violence conducted between formalized militias, where the participants are civilians instead of professional or formal soldiers. Such conflict is limited to any politically motivated, low-intensity, local contest fought between group militias associated with ethnic, regional or religious identities. Membership in a self-identified group organization is based on local ethnic affiliation and the participants are typically young males. The collective use of violence is directed towards achieving local or regional control over territory or resources for a larger group (e.g. a religious militia). The majority of communal events involve clashes between militias, which serve as self-identified policing or security units for peripheral groups, who often have a history of connected acts. Conflict between communities is typically 'traditional' in that it has occurred for several generations and often at pre-defined times during the year. It is apparent from individual communal violence cases that communal violence actors often interact with the state through police or military clashes. But critically, the motivation for this violence differs significantly from more formally organized rebel groups, whose stated aim is to replace the regime in power. No such aim exists across communal violent groups.

Communal violence is frequently conflated with 'pastoralist violence' or 'farmer–herder' violence. This is a simplification of the social categories present across East African and Sahel states. Pastoralists are present in over 21 African states and typically live in arid and semi-arid lands. Pastoralism is the livelihood of several nomadic or semi-settled ethno-regional groups. This is generally regarded as a livelihood type that is violent, with particular emphasis on resource competition. This highly organized and strategic violence is considered both a traditional and 'normal' occurrence between groups of pastoralists/herders/farmers. Cattle-raiding is the dominant form of organized violence involving a group invasion or attack by an outside group with the main objective of stealing cattle (Mulugeta & Hagmann, 2008). Raiding livestock of one's traditional enemies is a means to expand rangelands, restock herds and improve social status.

Previous researchers have noted that communal violence revolves around environmental and livelihood issues (livestock, grazing land, water access). Turner (2004: 865–870) finds that in most poor rural communities, conflicts can be interpreted as resource-related, but 'conflicts over resources' are produced from a set of broader processes of change that vary within specific historical contexts. Therefore, the focus on resources is superficial, as these struggles reflect broader social tensions (with ethnic dimensions) between and within social groups. Attacks invite retaliation and many of the ethnic disputes appear to be cyclical (Krätli & Swift, 1999). These conflicts, and the migrants they create, are often invisible to governments and conflict researchers.

These definitions differ from the standard classification as they are based on events and participants and not aggregate categories of conflict type. The rebel and communal definitions are applicable to contexts outside of East Africa. Each type may be rare, intermittent or chronic in different environments and exhibit spatial and temporal patterns that are unique to the group and contexts in which it operates.

Table I. Hypotheses

	Variation				Direction
Hypotheses	*Zero sum*	*No gain*	*Abundance*	*Equal access*	*Wet/dry*
Overall conflict	+	−	+	−	
Rebel	Increases	Stable/decreases	Increases	Stable/decreases	Dry
Communal	Increases	Decreases	Increases	Decreases	Wet

Climate–conflict relationships

The climate–conflict literature suffers from a lack of theoretical connections between its main driver (climate) and its possible consequence (conflict). As noted above, rainfall is a key climate variable in terms of its impact on society. This impact is particularly pronounced in Africa where the majority of the population relies on rain-fed agriculture and pastures as the basis for their livelihoods. Four possible relationships can link rainfall variability (hereinafter used to act as a proxy of both climate variability and change) to political conflict: the first is mentioned above with respect to 'scarcity': (1) Increased conflict is likely to follow periods of above average decreases in rainfall. This is the standard, direct, 'climatic' argument that contends groups will use force and violence to compete for ever-scarcer resources. This is a 'zero-sum' narrative. However, it is equally plausible that (2) decreases in conflict are likely to be correlated to decreased rainfall as there is little to fight for. This is a 'no-gain' argument, which contends that relative gains from conflict during a drier period are too low to justify the labour of conflict. Conversely, it is plausible that (3) increases in political violence will directly follow periods of higher than average rainfall. This hypothesis largely rests on the notion that abundance will spur rent-seeking/wealth-seeking and recruitment of people to participate in violence. Finally, this is counter to scenarios like (4) where there may be a decreased frequency in political violence following increases in rainfall as individuals and groups are self-sufficient and unlikely to motivate participants during these times.

In addition to variability as a driver of local violence, it is evident that conflict incidence patterns and types could be strongly associated with the sign of change. On the subnational level, some types of violence favour a particular environment. For example, rebel violence may be more prevalent during anomalously dry years, possibly due to the ease of movement or part-time recruitment of otherwise employed agricultural labour. Conflict logistics require less effort during dry seasons as there are fewer diseases, the harvest period allows for subsistence, and high value areas are accessible. Indeed, past accounts of interstate and civil wars referred to wet and dry seasons as determinants of strategy (see Kimble & O'Sullivan, 2002; Ziemke, 2008).

Other possibilities include that communal violence may be correlated with variation, but also favour wet periods when the result of raiding may be more successful (see Meier, Bond & Bond, 2007). Several studies have reiterated that pastoralist raiders 'like to attack during wet years because of the high grass, strong animals, dense bush to hide and availability of surface water, which makes it easier to trek with the animals' (Adano & Witsenburg, 2005: 723). During drought years, cattle raiding attacks decrease as additional burdens to pastoralist groups are avoided. These findings support Turner's (2004: 877) analysis that the high variability in the productive resources leads to strong variation in the competition over such resources and, relatedly, that conflicts resemble strategic contests to preserve or gain access over the long term. Cultural practices also dictate raid timing: persistent revenge attacks correspond to lunar cycles and attacks are designed to maximize surprise, celebrate significant events within warrior lives and limit the burden during drought years. Consequently, immediate climate variability can affect conflict both indirectly through the impact on resources and directly through mobility.

Non-physical drivers on the local scale and above create contexts in which local environmental change can affect stability. Many studies of civil war and environmental factors reiterate that the 'political and economic characteristics' of countries are the strongest indicators of civil war risk and that environmental change might be best analyzed for its marginal influences (see Raleigh & Urdal, 2007 for a review).

To summarize, variation in rainfall – as a proxy for overall climate change – is related to overall increases or decreases in conflict risk. Comparing the motivations and reactions of rebel and communal groups to environmental variation tests whether conflict type is the most salient missing consideration of the environment–security

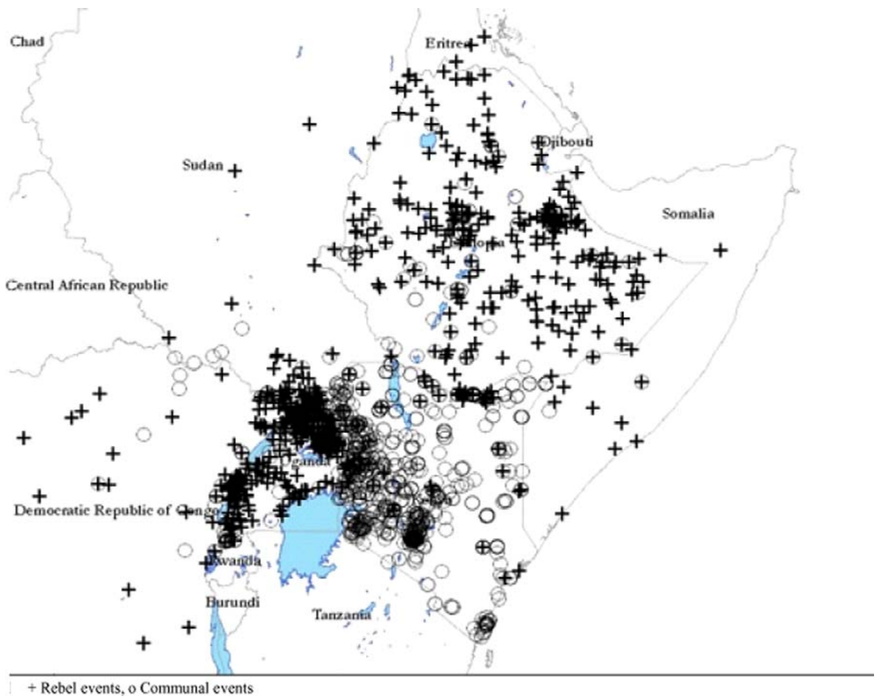

Figure 1. Map of study area

narrative. Table I summarizes the hypotheses. In addition to variation, absolute environmental characteristics, such as wet or dry seasons, may encourage or hinder rebel or communal violence. The final test is whether the relationship between environmental change and conflict is dependent upon the mediating conditions of demography, poverty and state capacity.

Data and methods

This study differs from others in three significant ways: conflict data for Uganda, Kenya and Ethiopia are disaggregated by type, date and location (e.g. town/village). Only those locations in which conflict did occur are used in the analysis. Using only those locations and times in which conflict occurred is a stricter test of the hypotheses that variations in environmental conditions significantly influence conflict patterns within countries. The arguments put forth by environmental security scholars indicate that increases of violence are a response to ecological change. A non-event cannot have variation, nor can a level of rainfall be associated with a likelihood of violence. As conflict is widespread throughout the sample area regardless of ecological variations, a test of increased or decreased frequency as a response to variation and climate conditions is most appropriate. Figure 1 displays the rebel and communal violence patterns across all three states; rebel violence is most extensive in both Ethiopia and Uganda, while communal violence is present across all three main states.

The use of disaggregated conflict data presents both theoretical and empirical opportunities and issues. Such fine-level data create possibilities for ecological inferences about local areas and individual actions. Empirically, conflict data are at a lower level of spatial and temporal disaggregation than most available independent variables. Compromises must be made to fit data together in a unit that is both theoretically and empirically defensible: it is exceedingly difficult to argue that a location, in and of itself, is an appropriate unit given the networks and movement of conflict over time. To rectify the impression that only location characteristics are considered in this analysis, these conflict data are combined with rainfall data for 1997–2009.

Conflict data

The geo-referenced Armed Conflict Location and Event dataset (ACLED) codes the specific date, location, actors and type of conflict activity across over 50 unstable states from 1997–2010 (Raleigh et al., 2010). For this study, data from Uganda, Ethiopia and Kenya for 1997–2010 are aggregated by the number of events by month-year

Table II. Conflict summary

	Total	*Kenya*	*Ethiopia*	*Uganda*
Total conflict count (1997–2009)	Events: 5,187 Units: 3,585 Locations: 1,067 Range: 1–26 Months: 151	Events: 1,661 Units: 1,092 Locations: 381 Range: 1–26	Events: 981 Units: 682 Locations: 283 Range: 1–15	Events: 2,545 Units: 1,811 Locations: 441 Range: 1–15
Rebel action	Events: 2,978 Units: 2,140 Locations: 631 Range: 1–15	Events: 53 Units: 44 Locations: 29 Range: 1–4	Events: 826 Units: 597 Locations: 256 Range: 1–14	Events: 2,099 Units: 1,499 Locations: 346 Range: 1–15
Communal violence	Events: 2,209 Units: 1,445 Locations: 575 Range: 1.26	Events: 1,608 Units: 1,048 Locations: 370 Range: 1–26	Events: 155 Units: 85 Locations: 51 Range: 1–15	Events: 446 Units: 312 Locations: 154 Range: 1–19

that occurred in specific locations, resulting in a rebel dataset of conflict event tallies by location date (aggregated to month) and a matching communal violence dataset of location date. Table II reviews the details of conflict frequency, location-month aggregate units, locations and types of violence. The exact number of incidents per month-year-location of conflict is collected for statistical analysis. Figure 2 displays the general relationship of conflict frequency and rainfall seasonality over space; there is clear variation in the total amount of violence experienced over the course of a year.

There are mean rates of chronic conflict in communal areas that can be largely ascribed to seasonal variation. There is a largely stable amount of conflict for most of the year, but the rate rises during the short rains and dips sharply during the January dry spell. Following this brief dry spell, conflict patterns increase before the long rainy season. The 'hungry season' at the end of the wet season is not associated with higher rates of communal conflict, but the summer months experience a more active rebel campaign over the dry season.

Rainfall data

Satellite-based rainfall data are used from the National Oceanic Atmospheric Agency (NOAA) Climate Prediction Centre (CPC) Merged Analysis of Precipitation ('CMAP') technique (hereafter referred to as CMAP data). These data are available along with monthly time scales for the whole of the globe.[1] The CMAP technique consists of merging observations from rain gauges with precipitation estimates from several satellite-based algorithms (Xie & Arkin, 1996). For the purposes of this research we use monthly data. The rainfall data are available on a 2.5 x 2.5 degree latitude/longitude grid and extend back to 1979. Rainfall averages for each month of the year were determined from 1997 to 2009. Positive or negative deviations were derived by month and were associated with the corresponding locations in which conflict occurred. Seasonal differences are not relevant as deviations from typical rainfall levels were used.

The resolution of the rainfall data is significantly poorer than that of the conflict data. The spatial discrepancy can be partially justified on the grounds that there is no reason to expect that parties will fight on the exact location of rainfall aberrations. However, it is recognized that smaller-scale rainfall data would have been preferential, if available.

For the regression analysis, rainfall data are manipulated to create two sets of measures. The first set includes dummies of no change, negative and positive rainfall. The second are a positive variation variable of values over zero and a negative variation variable to record all values where the deviations are below zero mm. For ease of interpretation, the positive and negative variation variables were transformed into standard deviations from zero. Similar rainfall variables for one and two months prior are also created. The correlation between positive rainfall anomalies for month 0 and month 1 is 29%, month 0 and month 2, 19% and month 1 to month 2, 26%. Slight differences are noted in the correlations between months with negative anomalies; month 0 is 36% correlated with negative values for month 1, whereas the correlation between month 0 and month 2 is 20% and month 1 to month 2 is 26%.

[1] Data from the CPC FTP server (ftp://ftp.cpc.ncep.noaa.gov/precip/cmap/).

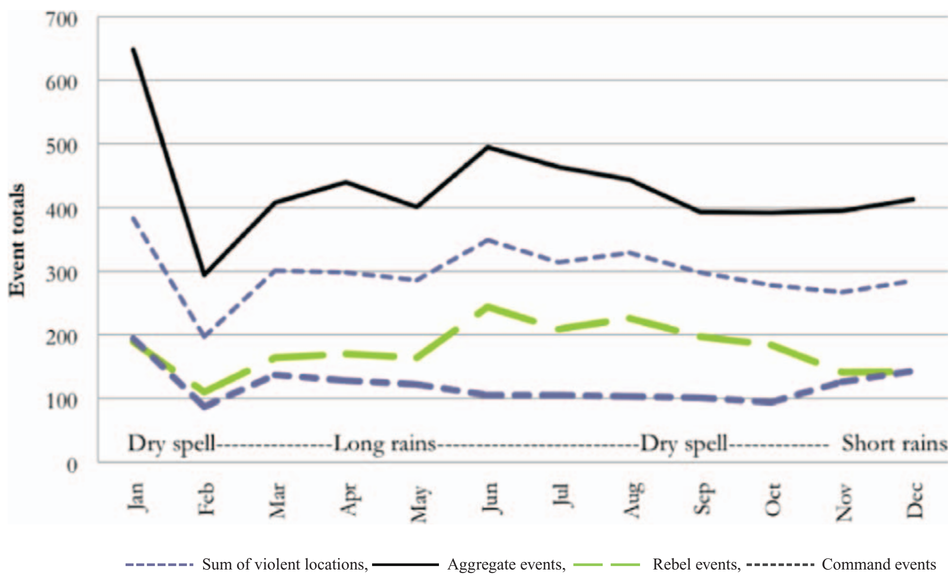

Figure 2. Monthly conflict

Controls

Several controls for violence frequencies are included in the analyses. Unfortunately, many controls are not disaggregated to the level at which conflict occurs, nor are they time varying. These controls include measures of population in conflict locations for the year 2000 (from CIESIN, 2005a), relative poverty in conflict location as proxied by the percentage of children under five who are underweight (CIESIN, 2005b,c) and finally the distance (in degrees) of the location to the nearest urban centre (population larger than 50,000) (UNEP, 2006). Each of these controls is used to assess the marginal effects of rainfall variation on violence within local contexts. Raleigh & Hegre (2009) found that local population and distance measures were critical in explaining the geography of conflict in Central Africa, while several studies have confirmed the importance of population on the national level. In addition, Hegre, Østby & Raleigh (2009) reviewed how local poverty indices explain the patterns of conflict during the Liberian civil war. As low and variable GDP is one of the strongest indicators of civil war risk on the national level, it is equally likely that poverty creates grievance and opportunity-seeking on the local level. However, the poverty indicator is set at 2.5 degrees (250 km^2) in 1995 terms and therefore can only act as a basic proxy for relative poverty in the region. To account for relative poverty, the control variable is the deviation level of each location from the national mean of underweight children.

The impact of spatial and temporal autocorrelation of conflict levels is assessed by incorporating the previous conflict events by month and months one year previous by locations. Conflicts are also clustered by a locator variable, in subregions and in ethnic group homelands. Areas with violence proximate to each other are likely to be contained in the same rainfall unit, so controlling for neighbouring lags is unnecessary. Further, when compiling datasets for large numbers of events, the controls and surrounding locations cancel the need for additional lagged variables as it is assumed such dependence is incorporated into the event occurrence rates.

Two basic methods were used to examine the relationship between rainfall variability and conflict. The first is negative binomial count regression of conflict frequency in location-date units. Regression models were created separately for different conflict types, using dummies to control for countries. Frequencies of conflict are examined in relation to positive or negative deviations from the mean expected rainfall in locations and month of conflict (and one and two months prior) for the entire sample.

The second method of analysis is composite analysis (or 'epoch superposition') methodology in which the conflict data are sorted in terms of the number of incidences of violence across the region per month, and rainfall collated from each location where violence occurred during the month for an aggregated monthly total (Todd & Kniveton, 2001). The monthly totals of conflict are then sorted from high to low, and from this sorted list, two samples are taken of the 20% lowest and highest numbers of conflicts per month and the rainfall anomalies compared. This simple methodology thus focuses on comparing rainfall conditions for extreme conflict situations and hence not all conflicts as in the regression analysis. Also, such an approach does not make any assumptions about the distribution of the conflict data. The months of December 2007 and January 2008 for Nairobi, Kenya were excluded from this analysis due to the election-related conflict. Mann Whitney tests and t-tests were then used to assess the significance of differences between rainfalls for high conflict months and low conflict months. Critical t-test and Mann Whitney test thresholds at 90% significance levels were calculated using a Monte Carlo simulation method using 1,000 iterations of randomly selected samples of rainfall to account for temporal autocorrelation in the rainfall data.

Results

The regression results are reported in two stages to distinguish between dummy variable and variation results. Each type of model is further distinguished by whether it means to explain rebel and communal conflict events. Dummy variable models (not shown) for positive or negative monthly deviations from average climate averages compared to no changes in climate report higher rates of conflict in both wetter and drier periods. While wetter and drier results are of equivalent strength in the 'rebel' sample, for the 'communal' sample, wetter periods are more conflict prone compared to drier and no-change periods. In addition, for communal violence, while both positive and negative deviations are significantly related to conflict, one-month prior positive rainfall deviations are correlated with higher rates of communal conflict. This conclusion is largely in line with Meier, Bond & Bond (2007) who note that communal raiders frequently rely on vegetation for strategic advantage.

Table III presents the positive and negative variation models for rebel violence. The model largely supports the conclusions of the blunter dummy variables, but with important exceptions. Climatic triggers at the extremes of positive and negative scales are both related to violence, and the number of predicted incidences is strongly orientated towards smaller vacillations in positive deviations. The proportion of violence explained remains relatively low, which reflects the lack of significant political and social dynamics in the model and the marginal role of climate in conflict variability.

The communal models in Table IV return slightly less positive rainfall variation coefficients than the negative variation counterparts. This indicates that negative shifts may have a stronger effect on the location and frequency of violence. Yet, the predicted values in Figure 3 display that the vast majority of conflict events occur in periods with minimal to no deviations, which again supports the notion that climate variability is of marginal significance.

The control variables are largely insignificant for the rebel study. For the communal conflict's dummy and variation models, poverty, the conflict at the location in previous months, and distance to urban areas are highly significant. The control coefficient for mean poverty rate (measured as percentage of underweight children) indicates that areas that experience communal violence are among the poorest in the state. In addition, these areas are remote and suffer from chronic violence in that it repeats over time and space. This is significant as locations in which rebel and communal violence occur do not overlap significantly (approximately 10% of locations in the model have experienced both types of conflict). Hence, although the weather and environment have some relationship to both types of violence, the contexts in which that effect is present differ significantly for a rebel versus a communal fighter. Poor rural locations have a higher instance of communal violence, which is exacerbated by higher climatic variation. The intersection would imply that environmental scarcity and abundance is dependent upon pre-conditions including livelihoods and wealth.

In the rebel sample, it is more plausible that the environment functions largely as a tactical consideration, as the locations in which rebel violence occurs are far more widespread with fewer repeated events and no correlation to poverty, attacks on primarily urban centres or population places.

Whether we take the data and separate into wet (positive) or dry (negative) models, or designate positive and negative variation models, the strongest signals suggest that the zero sum and abundance arguments can be moderately accepted. There are stronger positive variation drivers in the rebel sample and slightly stronger negative deviations and conflict in the communal cases. The zero-sum behaviour appears to be conditionally true in cases of extremes – in poorer, communal areas these arguments may largely conform to typical raiding behaviour. The no-gain argument can be rejected as both types of violence are found at a stable rate regardless of small rainfall deviations, and both types of violence increase at extreme climatic deviations. The fourth equal-access argument also does not hold as there is increased conflict following increased rainfall deviations.

The number of conflict events occurring at a location strongly influences the regression results, which largely find that deviations are not necessary for explaining a standard rate of conflict: most conflicts occur in areas which have not experienced strong variation. Finally, there are clear and sharp differences between the

Table III. Rebel event variation models

	Rebel			
	Month (pos.)	*Month (neg.)*	*All (pos.)*	*All (neg.)*
Positive rainfall variation	.176***		.105***	
	(.013)		(.014)	
Positive rainfall variation (month prior)			.074***	
			(.009)	
Positive rainfall variation (2 months prior)			.115***	
			(.010)	
Negative rainfall variation		−.130***		−.088***
		(.011)		(.134)
Negative rainfall variation (month prior)				−.078***
				(.017)
Negative rainfall variation (2 months prior)				−.115***
				(.015)
No change	.008	.010	−.003	.044
	(.048)	(.048)	(.048)	(.048)
Population location	.013	.013	.006	.001
	(.013)	(.013)	(.013)	(.013)
Urban distance	.005	.009	.014	.003
	(.015)	(.015)	(.015)	(.015)
Border distance	−.029**	−.006	−.022	.003
	(.015)	(.015)	(.015)	(.015)
Regional poverty measure	.002	.000	.000	.002
	(.004)	(.004)	(.004)	(.004)
Country dummy Ethiopia	.118	.100	.177	.129
	(.127)	(.127)	(.127)	(.127)
Country dummy Uganda	.045	.029	.054	.019
	(.126)	(.126)	(.126)	(.126)
Country dummy other	.086	.0917	.111	.086
	(.139)	(.139)	(.139)	(.139)
Location conflict count prior month	.001	.039	.001	.044
	(.047)	(.047)	(.047)	(.047)
Location conflict count previous year (at month)	.280	.294	.229	.163
	(.303)	(.303)	(.303)	(.303)
Constant	.445	.204	.323	.059
	(.200)	(.206)	(.203)	(.207)
R^2	2.5%	2%	6%	4%
LL	−2775	−2790	−2679	−2746

Units: 3,588; Rebel count: 2,978

communal and rebel conflict patterns across the study area and the overall dispersion of events: poorer and more peripheral areas see higher levels of communal conflict, while the areas that experience rebel events are more scattered and distributed across a range of socio-economic and geographic regions.

Epoch results

Unlike the regression results, the epoch superposition analyses were aimed at determining whether periods of very high levels of conflict compared to periods of very low conflict differ in anomalous rainfall conditions and the temporal emergence of any rainfall signal. In essence this provides a distribution free test of the conflict–rainfall relationship. In Figure 4, the variation in normalized rainfall for months with low and high levels of conflict for rebel conflict and communal violence are displayed when the data is aggregated for all three countries. Conflict occurs at month zero and negative and positive months refer to the aggregate rainfall conditions for all high and low

Table IV. Communal conflict event models

	Communal			
	Month (pos.)	*Month (neg.)*	*All (pos.)*	*All (neg.)*
Positive rainfall variation	.089***		.041***	
	(.009)		(.011)	
Positive rainfall variation (month prior)			.080***	
			(.011)	
Positive rainfall variation (2 months prior)			.049***	
			(.009)	
Negative rainfall variation		−.153***		−.078***
		(.015)		(.016)
Negative rainfall variation (month prior)				−.044**
				(.018)
Negative rainfall variation (2 months prior)				−.161***
				(.015)
No change	−.020	−.039	−.000	−.039
	(.063)	(.064)	(.062)	(.063)
Population location	.013	.011	.019	.002
	(.013)	(.013)	(.013)	(.012)
Urban distance	−.038**	−.038**	−.024*	−.050***
	(.014)	(.014)	(.015)	(.014)
Border distance	.000	.013	.004	−.000
	(.014)	(.014)	(.014)	(.014)
Regional poverty measure	.011**	.009**	.009**	.008*
	(.004)	(.004)	(.004)	(.004)
Country dummy Ethiopia	.160	.119	.197	.166*
	(.089)	(.089)	(.089)	(.088)
Country dummy Uganda	−.81	−.060	−.063	−.046
	(.071)	(.071)	(.075)	(.070)
Country dummy - other	−.327	−.156	−.210	−.175
	(.182)	(.181)	(.181)	(.180)
Location conflict count prior month	.201***	.146	.234***	.172**
	(.062)	(.063)	(.062)	(.062)
Location conflict count previous year (at month)	.082	.085	.121	.103
	(.232)	(.231)	(.231)	(.228)
Constant	.205	.043	.078	.130
	(.173)	(.173)	(.175)	(.172)
R^2	3%	3%	5%	6%
LL	−1953	−1944	−1906	−1884

Units: 3,588; Communal count: 2,209

conflict samples at different times, before and after the conflict occurs. These results show that in periods of high rebel conflict, the conditions are statistically (significant at the 90% significance level) anomalously dry for the three months prior to the conflict, compared to periods of low rebel conflict; this difference in rainfall conditions starts to emerge at three months prior to the conflict. For communal violence the relationship is reversed: periods of high communal violence are statistically more likely to be wetter for the three months prior to violence than periods of low communal violence. This difference is greatest at 2 months prior to the violence where the rainfall variations for this month and the previous three months are statistically (significant at the 90% significance level) higher for high rather than low conflict levels.

Conclusions

Previous studies have contested climate as a significant driver of conflict. In part this disagreement has arisen because of a concentration on large-scale conflict. In this

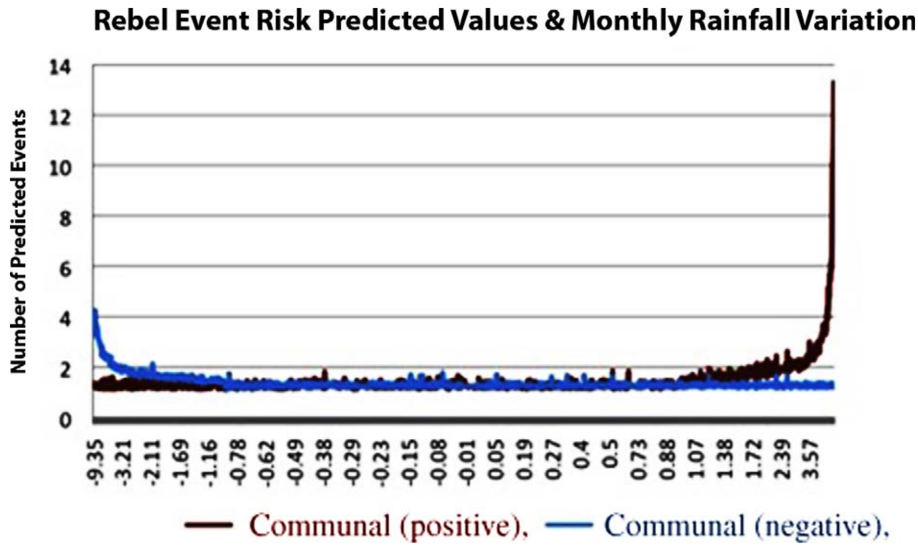

Figure 3. Communal violence: Predicted events over rainfall deviations

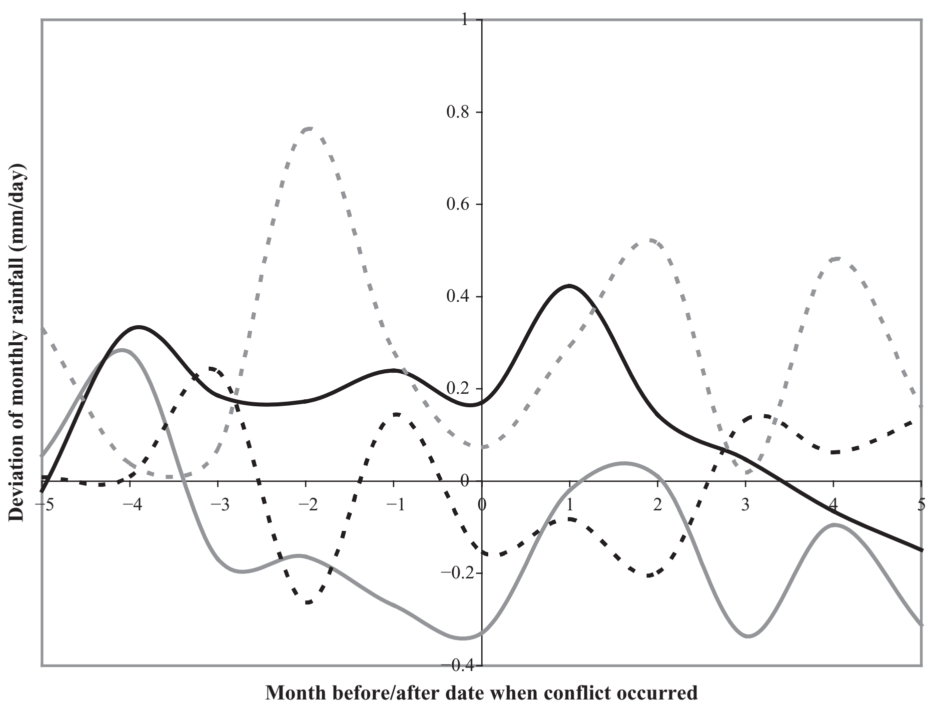

Figure 4. Variation in normalized rainfall for months with low and high levels of rebel and communal conflict in Kenya, Uganda and Ethiopia

Rainfall for events with high (low) rebel conflict are shown in solid grey (black) while for high (low) communal violence these are shown in dashed grey (black)

article, we analyze disaggregated conflict events where, while still politically determined, the linkages with the physical environment are considered to be more immediate and direct. In particular, the article looks at the influence of one climate parameter, rainfall, and uses the analogy of rainfall variability (e.g. monthly and seasonal changes) to assess the climate–conflict nexus. The results of this analysis for conflict over East Africa support a theoretical linkage between the climate and conflict that focuses rainfall variability as a marginal driver of conflict frequencies. The results show that disaggregated conflict frequencies are exacerbated by both extreme wet and dry conditions. In the setting of East Africa, rainfall provides an indicator of resource availability through its impact on natural and agricultural resources. Therefore, these findings moderately support both a 'zero-sum' narrative, where conflicting groups use force and violence to compete for ever-scarcer resources, and an 'abundance' narrative, where an abundance of resources spur rent-seeking/wealth-seeking and recruitment of people to participate in violence. In both cases, there is clearly a prerequisite of economic and political instabilities for such narratives to be played out. Key to the discovery of this climate–conflict link is the separation of conflict into rebel and communal types. Within this general framework, anomalous rainfall conditions, irrespective of sign, are likely to enhance the probability of conflict. However, when looking in more detail, the highest incidence of rebel conflict appears to occur in extreme dry rather than wet conditions. By contrast, it is shown that the highest incidences of communal violence appear to occur in extreme wet rather than dry conditions.

Given the geographic focus of the study, the conclusions of this work are applicable mainly in East Africa. However, they are arguably generalizable to other countries across the Sahel belt where high rates of communal and rebel violence occur in arid and semi-arid lands (ASAL). The primary rebel group in this study is the Lord's Resistance Army, which has a unique spatial signature compared to other rebel groups, in that the LRA has significant operations in and around Uganda and has more diffusive campaigns. However, the results from both Ethiopia and Uganda are applicable to other rebel contexts and complement a growing recognition of how rebels use the environments in which they operate for resources, tactical manoeuvring and possibly recruitment. The differences in control variables coefficients for the communal and rebel sample indicate a critically understudied aspect of the environmental security literature: the locations, which have both extreme climate variability and very high rates of communal conflict, are poorer relative to the remainder of the state. This conclusion supports a wider case-based literature on communal and pastoral violence in the Sahel belt which suggests that conflict is a competition for power and access to resources in areas of government absence and a dearth of public goods. Due to the narrow margin of sustainability for the livelihoods across the Sahel, groups again manipulate environmental conditions in order to control territory, resources and aggregate wealth through raiding behaviour.

The implications of this work are that conflicts do not occur in a political vacuum. There is a lack of attention to how the politically marginal become highly vulnerable to ecological variation. The people living in ASAL are frequently victims of poverty and political manoeuvring including elites who encourage groups to 'ethnicize' land claims, leading to contests over access and occupation of communal lands, water and migration rights (see Hagmann & Mulugeta, 2008). The changing economic landscapes in African states – including the gradual incorporation of land for agricultural activities – create contests over livelihoods. This is frequently the basis for blunt assumptions of farmer–herder contests. However, this is a larger issue about 'pastoralist spaces' and their continued existence within modern states (Mulugeta & Hagmann, 2008).

The policy implications of these findings are that greater attention should be paid to communal conflict management, particularly in periods of high rainfall variability. This fits well with current climate change projections which are largely uncertain in terms of the sign of change in mean rainfall for large parts of the tropics but agree that the magnitude of rainfall variability is likely to increase with human-induced climate change. However it should be noted that the assumption of increased conflict with increased rainfall variability has not been shown in this study to be independent of changes in mean rainfall conditions.

Replication data

Replication files for this article are found at www.prio.no/jpr/datasets. All data are publically available and collected from a range of secondary sources at www.acleddata.com. Data on nonviolent events (approximately 7% of the total data) are not included in the analysis conducted here.

Acknowledgements

Both authors would like to thank Caitriona Dowd for research assistance.

Funding

Clionadh Raleigh's research was funded by the US government's Minerva Grant on Climate Change and African Political Stability.

References

Adano, Wario R & Karen Witsenburg (2005) *Surviving Pastoral Decline: Pastoral Sedentarisation, Natural Resource Management and Livelihood Diversification in the Marsabit District, Northern Kenya*. Vol II. Amsterdam: Faculty of Social and Behavioural Sciences, University of Amsterdam.

Barnett, Jon (2000) Destabilizing the environment–conflict thesis. *Review of International Studies* 26(2): 271–288.

Buhaug, Halvard (2010) Climate not to blame for African civil wars. *PNAS* 107(38): 16477–16482.

Buhaug, Halvard & Jan Ketil Rød (2006) Local determinants of African civil wars, 1970–2001. *Political Geography* 25(3): 315–335.

Burke, Marshall B; Edward Miguel, Shanker Satyanath, John A Dykema & David B Lobell (2009) Warming increases the risk of conflict in Africa. *PNAS* 106(49): 20670–20674.

Butler, Colin D (2007) Globalisation, population, ecology and conflict. *Health Promotion Journal of Australia* 18(2): 87–91.

CIESIN (2005a) *Gridded Population of the World, Version 3 (GPWv3) Data Collection*. Palisades, NY: Center for International Earth Science Information Network, Columbia University (http://sedac.ciesin.columbia.edu/gpw/index.jsp).

IESIN (2005b) *Global Subnational Infant Mortality Rates*. Palisades, NY: Center for International Earth Science Information Network, Columbia University (http://sedac.ciesin.columbia.edu/gpw/index.jsp).

CIESIN (2005c) *Prevalence of Child Malnutrition*. Palisades, NY: Center for International Earth Science Information Network, Columbia University (http://sedac.ciesin.columbia.edu/gpw/index.jsp).

Hagmann, Tobias & Alemmaya Mulugeta (2008) Pastoral conflicts and state-building in the Ethiopian lowlands. *Afrika Spectrum* 43(1): 19–37.

Hegre, Håvard; Gudrun Østby & Clionadh Raleigh (2009) Poverty and civil war events: A disaggregated study of Liberia. *Journal of Conflict Resolution* 53(4): 298–623.

Herbst, Jeffrey (2000) *States and Power in Africa: Comparative Lessons in Authority and Control.* Princeton, NJ: Princeton University Press.

Homer-Dixon, Thomas (2007) Terror in the weather forecast. *New York Times*, 24 April: 1.

IPCC (2007) *Climate Change 2007: Synthesis Report*. Geneva: Intergovernmental Panel on Climate Change.

Kevane, Michael & Leslie Gray (2008) Darfur: Rainfall and conflict. *Environmental Research Letters* 3(3): 1–10.

Kimble, Shell & Patrick O'Sullivan (2002) Terrain and guerrilla warfare in Navarre, 1808–1814. In: Peter Doyle & Matthew Bennett (eds) *Fields of Battle: Terrain in Military History*. London: Kluwer Academic, 71–89.

Krätli, Saverio & Jeremy Swift (1999) *Understanding and Managing Pastoral Conflict in Kenya: A Literature Review*. Brighton: Institute of Development Studies, University of Sussex.

Meehl, Gerald A; Thomas F Stocker, William D Collins, Pierre Friedlingstein, Amadou T Gaye, Jonathan M Gregory, Akui Kitoh, Reto Knutti, James M Murphy, Akira Noda, Sarah CB Raper, Ian G Watterson, Andrew J Weaver & Zong-Ci Zhao (2007) Global climate projections. In: S Solomon, D Qin, M Manning, Z Chen, M Marquis, KB Avery, M Tignor & HL Miller (eds) *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press, 747–845.

Meier, Patrick; Doug Bond & Joe Bond (2007) Environmental influences on pastoral conflict in the horn of Africa. *Political Geography* 26(6): 716–735.

Mulugeta, Alemmaya & Tobias Hagmann (2008) Governing violence in the pastoralist space: Karrayu and state notions of cattle raiding in the Ethiopian Awash Valley. *Afrika Focus* 21(2): 71–87.

Nel, Philip & Marjolein Righarts (2008) Natural disasters and the risk of violent civil conflict. *International Studies Quarterly* 52(1): 159–185.

Nordås, Ragnhild & Nils Petter Gleditsch (2007) Climate change and conflict. *Political Geography* 26(6): 627–638.

Raleigh, Clionadh (2010) Political vulnerability to climate change in the African Sahel states. *International Studies Review* 12(1): 69–89.

Raleigh, Clionadh & Håvard Hegre (2009) Population size, concentration, and civil war: A geographically disaggregated analysis. *Political Geography* 28(4): 224–238.

Raleigh, Clionadh & Henrik Urdal (2007) Climate change, environmental degradation and armed conflict. *Political Geography* 26(6): 674–694.

Raleigh, Clionadh; Andrew Linke, Håvard Hegre & Joakim Carlsen (2010) Introducing ACLED: Armed Conflict Location & Event Data. *Journal of Peace Research* 47(5): 651–660.

Sachs, Jeffrey (2005) *The End of Poverty: Economic Possibilities for Our Time.* New York: Penguin.

Salehyan, Idean (2008) From climate change to conflict? No consensus yet. *Journal of Peace Research* 45(3): 315–326.

Stern, Nicholas (2007) *The Economics of Climate Change: The Stern Review*. London: Cambridge University Press.

Swart, Rob (1996) Security risks of global environmental changes. *Global Environmental Change* 6(3): 187–192.

Theisen, Ole Magnus (2008) Blood and soil? Resource scarcity and internal armed conflict revisited. *Journal of Peace Research* 45(6): 801–818.

Todd, Michael & Dominic Kniveton (2001) Changes in cloud cover associated with Forbush decreases of galactic cosmic rays. *Journal of Geophysical Research- Atmospheres* 106(D23): 32031–32041.

Turner, Matthew D (2004) Political ecology and the moral dimensions of 'resource conflicts': The case of farmer–herder conflicts in the Sahel. *Political Geography* 23(7): 863–889.

UNEP (2006) *Population and Cities*. Nairobi: United Nations Environment Programme (http://geodata.grid.unep.ch).

Witsenburg, Karen & Wario R Adano (2007) The use and management of water sources in Kenya's drylands: Is there a link between scarcity and violent conflict? In: Bill Derman, Rie Odgaard & Espen Sjaastad (eds) *Conflicts Over Land and Water in Africa*. Oxford: James Currey, 215–238.
Wolf, Aaron T (1998) Conflict and cooperation along international waterways. *Water Policy* 1(2): 251–265.
Wolf, Aaron T (2000) Indigenous approaches to water conflict negotiations and implications for international waters. *International Negotiation* 5(2): 357–373.
Xie, Pingping & Philip A Arkin (1996) Analyses of global monthly precipitation using gauge observations, satellite estimates and numerical model prediction. *Journal of Climate* 9(4): 840–858.
Ziemke, Jen (2008) From battles to massacres. Manuscript, University of Wisconsin (http://www.yale.edu/macmillan/ocvprogram/conf_papers/Ziemke.pdf).

CLIONADH RALEIGH, b. 1978, PhD in Geography (University of Colorado, Boulder, 2007); Assistant Professor, Trinity College Dublin (2008–); external researcher at Peace Research Institute Oslo (PRIO). Interests in political geography and conflict.

DOMINIC KNIVETON, b. 1966, PhD in Geography (University of Bristol, 1995); Reader, School of Global Studies, University of Sussex. Interests in climatology and migration.