Climate not to blame for African civil wars

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Vocal actors within policy and practice contend that environmental variability and shocks, such as drought and prolonged heat waves, drive civil wars in Africa. Recently, a widely publicized scientific article appears to substantiate this claim. This paper investigates the empirical foundation for the claimed relationship in detail. Using a host of different model specifications and alternative measures of drought, heat, and civil war, the paper concludes that climate variability is a poor predictor of armed conflict. Instead, African civil wars can be explained by generic structural and contextual conditions: prevalent ethno-political exclusion, poor national economy, and the collapse of the Cold War system.

Africa | climate change | conflict | security

Although the causes of climate change remain under debate and the accuracy of future predictions is questioned, another aspect of global warming, less contested but equally controversial, lurks in the background. Research on security implications of climate change is still in its infancy, and contemporary discourse is shaped by conjectures and idiographic evidence. Absence of a solid research tradition notwithstanding, key actors do not shy away from projecting that future wars will be fought over diminishing resources (1–4). Recently, the notion of "climate breeds conflict" also has received some support within academic research (5, 6). This paper investigates the scientific evidence base for the claimed relationship. Using a host of alternative measures of drought, heat, and civil war, under various model specifications, the paper concludes that climate variability is a poor predictor of armed conflict. Instead, African civil wars can be explained by generic structural and contextual conditions: widespread ethno-political exclusion, poor national economy, and the collapse of the Cold War system.

Results

There has been a significant warming of the globe over the past half-century (7). Although changes in temperature and precipitation patterns vary between regions, the African continent as a whole has become notably dryer and hotter, as illustrated in Fig. 1. Most of this drying has occurred along the Mediterranean, northern Sahara, and southern Africa, whereas parts of East Africa and the Horn have become wetter. According to most Intergovernmental Panel on Climate Change scenarios, this trend will continue (7). The same 50-y period has seen significant changes in civil war occurrence, with a gradual accumulation of conflicts extending beyond the Cold War period, followed by a rapid drop since the late 1990s. The time trend in war deaths displays a slightly different pattern, with the highest peak in annual casualties in the initial postcolonial years and another less severe peak in the mid-1980s. The first decade of the 21st century has been comparatively peaceful (8, 9). More generally, Fig. 1 demonstrates a rarely acknowledged fact: the opposing trends in climate and conflict over the past 15 y.

Recently, a PNAS article by Burke et al. received wide publicity for its reported strong empirical connection between civil war and temperature in Africa (6, 10). In fact, Burke et al. concluded that adverse impacts of future warming will outweigh any likely positive effects of economic growth and democratization in the region. Assuming constant growth in per capita income and democracy, we should expect a 54% increase in civil war incidence by 2030.

There are good reasons to be skeptical about such categorical claims. First, the study is limited to major civil wars and fails to distinguish between lesser war episodes (<1,000 annual casualties) and peace. The stringent inclusion criterion excludes a number of recent violent uprisings in the Sahel—the classic region of claimed scarcity-induced conflicts—including in Chad, Niger, Mali, and Senegal. It remains unclear whether the results hold up if alternative and more inclusive definitions of conflict are applied. Second, the Burke et al. (6) study applies an unconventional operationalization of the dependent variable, focusing on prevalence rather than outbreak of violence, yet counting only conflict years that caused a minimum of 1,000 direct casualties. This has some unfortunate consequences. For example, consider the civil war in Sierra Leone. This conflict is widely accepted as lasting from March 1991 until the ceasefire and resulting Abuja Agreement in late 2000.* However, the Burke et al. article considers Sierra Leone at war in 1998–1999 only, the only 2 y in which direct annual casualty estimates crossed the 1,000 deaths threshold. Using climate statistics for 1997–1998 to explain a war that had caused somewhere between 2,000 and 5,500 battle deaths by 1998 (14), however, makes little sense. Third, the empirical analysis by Burke et al. is limited to the period from 1981 to 2002. Since 2002, civil war incidence and severity in Africa have decreased further while the warming and drying of the continent have persisted (Fig. 1). Fourth, the study replaces conventional time-varying covariates with country fixed effects and time trends in response to certain methodological concerns. However, the methodological rationale and theoretical justification for these fixes can be questioned, and their inclusion introduces other problems.

The present paper provides a more comprehensive evaluation of short-term climate variations and civil war risk in Sub-Saharan Africa.† It offers a number of key improvements on earlier research. First, it departs from a fixed, narrow definition of civil war by applying multiple complementary measures of armed intrastate conflict, including those that fall below the 1,000 annual deaths threshold. Notably, an inclusive definition (minimum threshold at 25 annual battle deaths) corresponds better with narratives of violent conflict within contexts of environmental marginalization (16–18). Second, the analysis models the outbreak and incidence of civil war as distinct processes and devotes particular attention to climatic conditions before the initiation of

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Data deposition: Replication data are available from PRIO's data repository at http://www.prio.no/CSCW/Datasets/.

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*The UCDP/PRIO Armed Conflict Dataset (11), Fearon and Laitin's (12) replication dataset, and Nicholas Sambanis' list of civil wars (13)—the three dominant sources of civil war data—all code 1991 as the initial year of the civil war in Sierra Leone.

†Sub-Saharan Africa is particularly relevant in this context due to the region's high dependence on rain-fed agriculture, high environmental vulnerability, and weak institutional coping capacity (15).

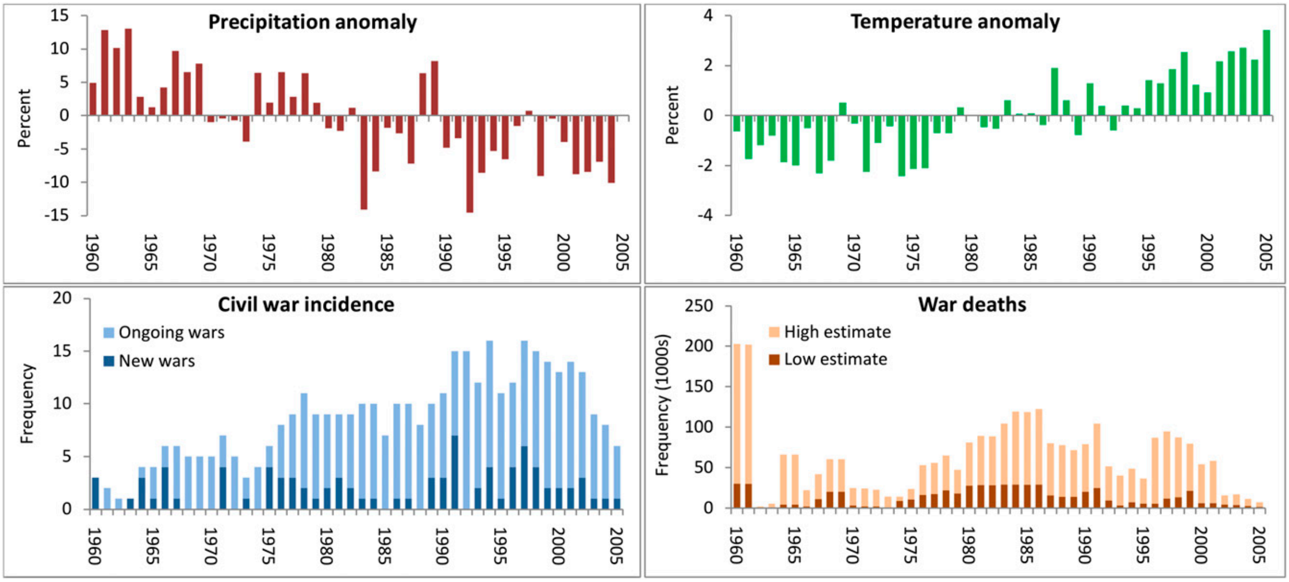

Fig. 1. Trends in climate and civil war in Africa (1960–2005). (*Upper Left*) Deviation from mean annual precipitation in the period, calculated from precipitation data from the Global Precipitation Climatology Centre (19). (*Upper Right*) Deviation from mean annual temperature in the period based on statistics from the Climate Research Unit, University of East Anglia (20). (*Lower Left*) Frequency of countries with outbreak and incidence of civil wars (at least 25 battle-related deaths per year) in Africa, as defined by the UCDP/PRIO Armed Conflict Dataset v.4–2009 (11). (*Lower Right*) Low and high estimates of annual war deaths in Africa derived from the PRIO Battle Deaths Dataset v.3 (14).

violence (as opposed to the peak years of the wars). Third, this paper goes beyond studying only levels of temperature and precipitation. Two alternative sets of climate parameters are offered: interannual growth, i.e., the proportional change since the previous year; and climate anomaly, i.e., the proportional deviation from long-term mean annual levels of temperature and precipitation. Finally, it compares the climate parameters with benchmark explanations of civil war risk: ethno-political exclusion, economic level of development, conflict history, and the post-Cold War period.

A preliminary inspection of the data appears to give some support to claims that temperature drives African civil wars in that they tend to be concentrated in warmer countries, including the Democratic Republic of the Congo, Ethiopia, Somalia, and Sudan. The mean annual temperature for countries with at least one civil war outbreak in the sample period (1981–2002) is 24.9 °C, compared with 23.4 °C for the control group. The conflict sample is also wetter (1,055 mm vs. 943 mm), reflecting the concentration of armed conflicts in the tropical zone of Africa.

A more systematic assessment of climate variability and civil war risk is provided in Tables 1–3. The sample dataset contains annual observations of all countries in Sub-Saharan Africa—the presumed most environmentally vulnerable region—from 1981 through 2002. The analysis starts by replicating the most recent finding that higher temperature is associated with a higher civil war risk (6). Accordingly, model 1 adopts linear regression with country fixed effects and time trends. The dependent variable (DV) is coded 1 if at least 1,000 battle deaths were reported in the country year; the independent variables (IDVs) give current and previous-year estimates of temperature and precipitation. As

Table 1. Alternative model specifications

	Model 1: war years 1,000+	Model 2: war years 1,000+	Model 3: war years 1,000+	Model 4: war years 1,000+
Temperature	0.043*	−0.001	0.013	0.011
	(0.022)	(0.019)	(0.030)	(0.016)
Temperature$_{t-1}$	0.013	−0.021	−0.014	−0.019
	(0.023)	(0.018)	(0.029)	(0.017)
Precipitation	−0.023	−0.072	−0.028	−0.012
	(0.052)	(0.050)	(0.059)	(0.042)
Precipitation$_{t-1}$	0.025	−0.056	−0.030	−0.022
	(0.049)	(0.041)	(0.053)	(0.035)
Intercept	−1.581*	0.807	0.023	0.342
	(0.854)	(0.520)	(1.414)	(0.226)
Country fixed effects	Yes	No	Yes	No
Country time trends	Yes	Yes	No	No
R^2	0.66	0.34	0.46	0.01
Civil war observations	98	98	98	98
Observations	889	889	889	889

Data are OLS regression estimates with and without fixed effects and time trends; SEs are in parentheses.
$^{**}P < 0.05$, $^{*}P < 0.1$.

Table 2. Alternative measures of civil war

	Model 5: incidence 1,000+	Model 6: outbreak 1,000+	Model 7: incidence 25+	Model 8: outbreak 25+	Model 9: outbreak 100+
Temperature	−0.006	−0.005	0.015	−0.009	0.016
	(0.021)	(0.013)	(0.040)	(0.026)	(0.024)
Temperature_{t-1}	−0.025	−0.009	−0.031	−0.004	−0.018
	(0.028)	(0.015)	(0.032)	(0.026)	(0.017)
Precipitation	0.062	−0.012	0.129*	0.055	−0.014
	(0.061)	(0.052)	(0.072)	(0.068)	(0.074)
$\text{Precipitation}_{t-1}$	0.056	0.003	0.024	0.018	−0.010
	(0.062)	(0.035)	(0.069)	(0.071)	(0.060)
Intercept	0.358	0.448	−0.112	0.214	0.138
	(1.231)	(0.531)	(1.521)	(0.891)	(0.911)
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Country time trends	Yes	Yes	Yes	Yes	Yes
R^2	0.76	0.09	0.65	0.13	0.10
Civil war observations	169	11	226	46	23
Observations	889	889	889	889	769

Data are OLS regression estimates with country fixed effects and country-specific linear time trends; SEs are in parentheses. Models 5–8 apply different operationalizations of civil war from the same conflict database (11); model 9 uses civil war data from an alternative source (12).
$^{**}P < 0.05$, $^{*}P < 0.1$.

expected, the claimed positive and significant effect for temperature (current year) is reproduced.

The remaining models in Table 1 evaluate the sensitivity of this result to changes to the model specification. Model 1 (and some earlier research) applies country fixed effects and time trends as substitutes for possible endogenous explanatory variables, to account for unmeasured heterogeneity, and to capture temporal fluctuations in the underlying conflict propensity. To avoid perfect prediction (and hence exclusion) of countries without variation on the DV, the linear ordinary least squares (OLS) estimator is chosen instead of the logit/probit model. This procedure is not without problems, however. First, it is obviously theoretically unsatisfactory to replace possible societal explanations for variations in civil war risk with crude country dummies (21). The masking of third factors also prevents assessment of interactive effects, which play a fundamental role in the environmental security literature (22, 23). Second, an explicit modeling of unit-specific time trends may be important in some settings but makes little sense in the current application. There simply is no reason why we should expect, a priori, a particular time trend in conflict propensity that has the exact same functional form (linear, quadratic, etc.) for all units. Moreover, the joint inclusion of cross-sectional dummies and time trends implies that model 1 contains 86 parameters to explain the 98 failures on the outcome variable.

In response to these concerns, model 2 is estimated without country fixed effects, model 3 excludes the time trends, and model 4 drops both fixed effects and time trends.[‡] The results are striking. Evidently, the widely held notion that warming increases civil war risk in Africa hinges crucially on the joint inclusion of these methodological fixes. Moreover, even in model 1 less than 1% of the explained variance is due to the climate parameters. From a policy advice perspective, then, it seems that we should focus on other, more pressing causes of contemporary civil wars.

Despite the seemingly fragile effect of climate presented in Table 1, it would be premature to dismiss the "warming breeds conflict" hypothesis without further tests. Next, alternative operationalizations of the dependent variable are considered. Models 1–4 share with the earlier PNAS article an unorthodox and narrow definition of civil war, counting only the most severe war years rather than all conflict years or years of conflict outbreak. Table 2 presents five models that adopt more intuitive and accepted DVs:

- Major civil war incidence: all active conflict years in wars that generated at least 1,000 battle deaths in total (model 5);
- Major civil war outbreak: the first year of recorded battles in wars that generated at least 1,000 battle deaths in total (model 6);
- Civil war incidence: all conflict years that generated at least 25 battle deaths (model 7);
- Civil war outbreak: the first year of recorded battles in wars that generated at least 25 deaths per year (model 8);
- Civil war outbreak: the first year of recorded battles in wars that generated at least 1,000 deaths in total, a yearly average of at least 100, and at least 100 killed on each side. The source for this variable covers only the years through 1999 (model 9).

The first four DVs are generated from the Uppsala Conflict Data Program/Peace Research Institute Oslo (UCDP/PRIO) Armed Conflict Dataset (11) whereas the final variant is derived from the most-used alternative source of civil war data (12). For reasons of comparability, models 5–9 retain the same model specification as model 1 with fixed effects and country-specific time trends; the only difference is the choice of DV. Again, as seen in Table 2, the claimed relationship disappears completely when alterations are made to the original setup. None of the climate variables obtain significant effects in the expected direction, and even the parameter signs vary between models.

The third stage of the empirical evaluation concerns the IDVs. So far only static climatic conditions have been explored, but some earlier work suggests that the perils of the climate are all about shocks, i.e., significant temporal changes in weather patterns (5). Models 10 and 11 in Table 3 introduce two climate variability measures: interannual growth and deviation from annual mean precipitation and temperature.[§] These models discard the fixed-

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[‡] The exogenous nature of the climate parameters, the simplicity of the political economy argument, and the conscious focus on the relatively homogenous Sub-Saharan Africa suggest that additional controls might not be necessary.

[§] The indicator in model 11 is clearly the more satisfactory measure. Despite their seeming popularity (5, 24–26), the interannual growth measures may give a false impression of extreme weather conditions in near-normal years that follow years with large deviations from normal levels of precipitation and temperature.

Table 3. Alternative climate parameters and controls

	Model 10: outbreak 25+	Model 11: outbreak 25+	Model 12: outbreak 25+	Model 13: outbreak 25+
Temperature deviation	−3.917	−12.631	−18.977	−130.35
	(10.146)	(12.144)	(12.899)	(113.69)
Temperature deviation$_{t-1}$	3.112	−6.180		
	(12.635)	(11.517)		
Precipitation deviation	−0.238	0.509		
	(0.519)	(0.578)		
Precipitation deviation$_{t-1}$	−0.792	−0.169		
	(1.674)	(0.915)		
Political exclusion$_{t-1}$	0.760*	0.820**	0.774*	0.823**
	(0.409)	(0.396)	(0.399)	(0.399)
Temperature deviation × political exclusion$_{t-1}$			11.519	
			(12.382)	
Ln GDP capita$_{t-1}$	−0.482**	−0.547**	−0.532**	−0.557**
	(0.236)	(0.263)	(0.243)	(0.265)
Temperature deviation × ln GDP capita$_{t-1}$				−15.932
				(14.559)
Post-Cold War	0.893**	1.017**	1.013**	1.066**
	(0.381)	(0.423)	(0.407)	(0.418)
Intrastate conflict$_{t-1}$	−0.726	−0.690	−0.718	−0.690
	(0.552)	(0.549)	(0.555)	(0.528)
Intercept	−0.122	0.295	0.188	0.327
	(1.768)	(1.978)	(1.794)	(1.923)
Pseudo R^2	0.05	0.05	0.05	0.05
Civil war observations	45	45	45	45
Observations	866	867	867	867

Data are logit regression estimates; robust SEs clustered on countries in parentheses. The climate parameters measure deviation from previous year's estimate (model 10) and deviation from the long-tem normal annual level (models 11–13). Ln indicates natural logarithm of values.

$^{**}P < 0.05$, $^{*}P < 0.1$.

effects OLS estimator in favor of robust logit regression, which is designed to handle binary response variables. The models use the most inclusive indicator of civil war outbreak, similar to the one used in model 8. All models also include a parsimonious selection of plausible alternative explanations of civil war outbreak—ethno-political exclusion, national income (natural logarithm of GDP per capita), a post-Cold War dummy, and a lagged conflict incidence indicator—because recent violence may affect the likelihood of a new conflict breaking out. In addition, models 12 and 13 explore possible interaction effects between temperature anomaly and political exclusion and poverty, respectively. These changes notwithstanding, temperature and precipitation patterns still fail to exhibit a significant and substantive effect on civil war risk in Sub-Saharan Africa. Accordingly, earlier reports of a direct connection between warming and civil war risk (6) represent an anomaly, not a general statistical regularity underlying a causal relationship.

So what explains the variation in civil war risk, then? In line with earlier research (12, 27, 28), the measures of ethno-political context, economic development, and time period all display significant and substantive effects on civil war outbreak. Countries with a larger share of the population excluded from influence over national power are more at risk for civil war. Similarly, civil war risk is found to be inversely related to GDP per capita. Finally, we see that the baseline risk of civil war in Sub-Saharan Africa increased with the systemic change imposed by the collapse of the Cold War system.

The results for ethno-political exclusion and income per capita should be interpreted with some care. The relationship between the national economy and civil war is likely to be multidirectional, where (anticipation of future) violence may affect investment, trade, the labor market, etc., as well as individuals' calculation of expected private economic gains, in addition to the conventional view, that poverty spurs opportunities and motives for violent behavior. Similarly, a regime may decide to restrict institutional openness and limit minority rights in the face of an emerging security crisis, and vice versa. Using lagged IDVs reduces, but probably not completely eradicates, the influence of such reciprocal relationships. Studying outbreak rather than prevalence of violence further reduces the endogeneity problem.[¶] In sum, these modifications are both more revealing and simpler than the fixes habitually specified in earlier studies of climate patterns and civil war risk. Furthermore, they offer valuable insights into where conflict prevention and peace-building efforts should be invested.

Discussion

Scientific claims about a robust correlational link between climate variability and civil war do not hold up to closer inspection. A visualization of the short-term impact of climate on conflict risk is presented in Fig. 2. The graph shows change in the estimated probability of civil war (five variants) for six alternative climate measures, based on 1,000 simulations for each model specification. Given the feeble impact of climate, illustrating the range of uncertainty is more meaningful than plotting point estimates of predicted probabilities. In all but one of the specifications, the 95% confidence bands for the climate variables include both positive and negative effects. Moreover, neither temperature nor precipitation performs consistently across models as even the sign of the mean first difference estimate for a given variable is sensitive to model specification. Only the final model (5f in Fig. 2) returns a statistically significant climate parameter estimate; apparently, major civil war years (i.e., years with at least

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[¶] The fact that the sample mean of interannual growth in GDP for outbreak observations is slightly *higher* than the mean economic growth rate for country years at peace suggests that reverse causality is not a significant problem here.

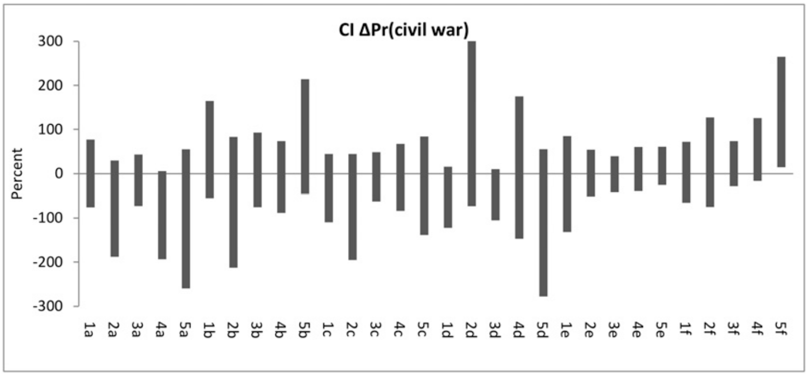

Fig. 2. Ninety-five percent confidence interval bands for change in the estimated probability of civil war with a shift from the 10th to the 90th percentile value on the selected climate variable, all other parameters held at median values. Results for six alternative climate measures in five sets of regressions are shown: 1a–f represent models with civil war outbreak as the dependent variable; 2a–f represent major civil war outbreaks; 3a–f represent civil war incidence; 4a–f represent major civil war incidence; and 5a–f represent major civil war years only. Model suffix reflects climate parameter: a is absolute temperature (*t*–1); b is temperature growth since previous year (*t*–1); c is temperature anomaly (*t*–1); d is absolute precipitation (*t*–1); e is precipitation growth since previous year (*t*–1); and f is precipitation anomaly, i.e., deviation from normal (*t*–1). All models are estimated through robust logit regression with controls for ethno-political exclusion, GDP per capita, post-Cold War period, and past conflict.

1,000 battle deaths) are more frequent in years following unusually wet periods—a result that directly contradicts the notion of scarcity-induced conflicts.

Does this mean that environmental conditions are irrelevant for conflict risk? Although this study shows that aggregate statistics on climate variability do not have a systematic, direct bearing on the short-term risk of civil war, a few caveats deserve mentioning. First, almost all relevant empirical research applies country-level analytical designs that are unable to tap subnational variations in climate and conflict. For larger countries, average measures of, e.g., annual rainfall may mask severe local anomalies. Similarly, most civil wars are quite limited in spatial extent so aggregate statistics may not be representative of the conflict zones. The first generation of spatially disaggregated time-series analyses of climate variability and local conflict come to different conclusions (29, 30). With the rapid development of appropriate geographic information systems (GIS) and high-resolution environmental and conflict data, systematic investigation of the local climate–conflict nexus is an obvious research priority.

Second, this study does not explore possible long-term security implications of environmental change that might work through, e.g., sustained economic underperformance, lack of investments and long-term planning, and poorly developed political institutions. Although isolating the impact of exogenous environmental factors from sociopolitical processes certainly is nontrivial, extant longitudinal studies show that war has been more prevalent during colder periods (31, 32). The historically negative association between temperature and war has weakened over time, however, possibly signifying a reversal of the relationship in the tropics (32). Short-term indirect effects of climate on conflict risk remain understudied. This article tested just two possible interactions; its nonresult mirrors that of a recent comprehensive study on environmental change and local armed conflict (30). Although recent research suggests a significant empirical connection between climate and economic activity in poor countries (33, 34), future research should invest more in studying how environmental conditions and climate variability affect long-term economic and political development.

A final caveat concerns the scale of environmental change. Contemporary global warming has been modest and slow. Climate projections for the 21st century suggest more intense heat waves and greater uncertainty in short-term weather patterns, and recent observed greenhouse gas emissions are at or above the level modeled in the worst-case Special Report on Emissions Scenarios A1F1 scenario (35). An analysis of societal responses to past climate variability may be of limited value if some of the more extreme projections, including tipping point behavior of the El Niño/Southern Oscillation and the collapse of the Asian monsoon system, become realities.

Climate change and its associated physical effects, such as higher temperatures and evaporation, more erratic weather patterns, melting of glaciers, and sea level rise, may well constitute the defining challenge of our time (36). Exposed societies that lack necessary capacity and knowledge to adapt successfully may face increasing asymmetries between demand and supply of subsistence resources (e.g., freshwater, pasture, crops) as well as basic public goods (sanitation, health, electricity) (37, 38). Some have also raised concerns about an associated rise in violent conflict. The present analysis gives little support to such speculation. The simple fact is this: climate characteristics and variability are unrelated to short-term variations in civil war risk in Sub-Saharan Africa. The primary causes of civil war are political, not environmental, and although environmental conditions may change with future warming, general correlates of conflicts and wars are likely to prevail.

Targeted climate adaptation initiatives, such as those outlined in various United Nations Framework Convention on Climate Change-sponsored National Adaptation Programs of Action (39), can have significant positive implications for social well-being and human security (40). But these initiatives should not be considered a replacement for traditional peace-building strategies. The challenges imposed by future global warming are too daunting to let the debate on social effects and required countermeasures be sidetracked by atypical, nonrobust scientific findings and actors with vested interests.

Methods

Models 1–9 are estimated through OLS regression. To account for unmeasured country characteristics, some models include country fixed effects and linear country-specific time trends. Models 10–13 are estimated through logit regression with robust SEs, clustered on countries, and a temporally lagged conflict indicator to account for first-order serial correlation (AR1).

The various measures of civil war are derived from the UCDP/PRIO Armed Conflict Dataset v.4–2009 (11, 41) and Fearon and Laitin's civil war dataset (12). Country-level precipitation data were generated from gauge-based estimates of total annual precipitation (in millimeters) for the global land surface at 0.5° × 0.5° resolution, derived from the Global Precipitation Climatology Centre (19). Annual gridded temperature estimates (°C) were aggregated in a similar manner on the basis of the CRU TS 3.0 dataset of the Climate Research Unit, University of East Anglia (Norwich, UK) (20). The country-specific normal annual precipitation and temperature values were estimated by taking the country mean values for the 1960–2004 period. Data on ethno-political exclusion are represented by an updated version of the *N** index (27), based on the Ethnic Power Relations dataset (42). Put simply, the *N** index is an expression of the share of the total population that is excluded from access to national power; higher values within the bounded interval [0, 1] denote a relatively larger excluded population. Data on gross domestic product per capita were log-transformed to account for a right-skewed distribution and because of assumed diminishing returns with higher values (43). The interaction term in model 13 uses negative GDP values as a measure of poverty. The GDP and political exclusion variables were lagged one time period to limit endogeneity. The post-Cold War dummy is coded 1 for 1990 and subsequent years.

The regression analysis was conducted using the Stata 10 statistical package. Estimates of marginal impact were generated through Clarify, a Stata module that uses Monte Carlo simulations to calculate the first difference of probabilities. Replication data are available from PRIO's data repository at www.prio.no/cscw/datasets.

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