Civil conflict sensitivity to growing-season drought

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To date, the research community has failed to reach a consensus on the nature and significance of the relationship between climate variability and armed conflict. We argue that progress has been hampered by insufficient attention paid to the context in which droughts and other climatic extremes may increase the risk of violent mobilization. Addressing this shortcoming, this study presents an actor-oriented analysis of the drought–conflict relationship, focusing specifically on politically relevant ethnic groups and their sensitivity to growing-season drought under various political and socioeconomic contexts. To this end, we draw on new conflict event data that cover Asia and Africa, 1989–2014, updated spatial ethnic settlement data, and remote sensing data on agricultural land use. Our procedure allows quantifying, for each ethnic group, drought conditions during the growing season of the locally dominant crop. A comprehensive set of multilevel mixed effects models that account for the groups' livelihood, economic, and political vulnerabilities reveals that a drought under most conditions has little effect on the short-term risk that a group challenges the state by military means. However, for agriculturally dependent groups as well as politically excluded groups in very poor countries, a local drought is found to increase the likelihood of sustained violence. We interpret this as evidence of the reciprocal relationship between drought and conflict, whereby each phenomenon makes a group more vulnerable to the other.

armed conflict | climate variability | drought | ethnicity | georeferenced event data

There is increasing acceptance within policy and national security circles that climate change and extreme weather events constitute a significant threat to societal stability and peace (1, 2). Despite evidence provided by a few idiographic studies (3, 4), the conflict research community has yet to agree on a statistical pattern consistent with a general causal climate–conflict connection (5–7). One reason for the scientific conundrum may be the failure to properly specify the socioeconomic and political context within which climatic extremes can undermine social stability and increase conflict risk. Drawing on insights from theoretical and single-case empirical research, we propose a conditional model of climate–security connections that explicitly considers the affected population's socioeconomic context. Specifically, we examine how growing-season drought across the agricultural lands of spatially defined ethnic groups affects the risk that the groups engage in conflict against the state and the extent to which this effect is conditioned on the groups' livelihood vulnerability, political status, and economic development. In doing so, our study provides the most appropriate large-scale test to date of dominant environmental security thinking (8).

In brief, a group's vulnerability to climatic extremes can be considered a function of its dependence on renewable resources, the sensitivity of that ecosystem to environmental changes, and the group's coping capacity (9). The livelihoods of farming communities living off nonirrigated lands are often identified as particularly vulnerable (10, 11). Central factors restricting coping capacity include a low level of socioeconomic development, a history of conflict, and limited access to economic and social capital that could facilitate alternate modes of livelihood (12, 13). In addition, societal groups that are excluded from political processes are much less likely to be on the receiving end of government-sponsored relief aid and compensation programs in the wake of disaster (14, 15).

Climate-induced crop failure or loss of pasture may imply a dramatic income loss, and limited material and human capital will aggravate the situation by narrowing the range of outside options. However, this process by itself does not explain how organized violent conflict might erupt or be sustained. Organizing unrest requires agency, a perception of common identity, and in the case of civil conflict, a belief that the government is to blame for the misery (16). Preexisting social structures, oftentimes in the form of ethnonational identities, constitute a key element necessary to solve the collective action problem for mobilization (17). In large parts of the developing world, particularly in Africa and Asia, ethnicity constitutes the predominant societal cleavage around which social identity and political preferences are formed and play out (18–20). Indeed, most contemporary civil conflicts are fought along ethnic lines, and ethnic conflicts have increased markedly since the end of the Cold War (21). For these reasons, the conflict potential of economic hardships is considered especially high where these coincide with distinct ethnic identities (22, 23).

Analytical Approach

Earlier quantitative comparative assessments of the climate variability–armed conflict link typically rely on country-averaged data or use arbitrarily defined grid cells as units of analysis (24–27). Despite their merit, both approaches have notable limitations; country-level data mask considerable within-country variation in environmental and political conditions and may miss localized phenomena, whereas disaggregated grid analyses typically require spatial overlap between the treatment (climatic anomaly) and the

Significance

Understanding the conflict potential of drought is critical for dealing effectively with the societal implications of climate change. Using new georeferenced ethnicity and conflict data for Asia and Africa since 1989, we present an actor-oriented analysis of growing-season drought and conflict involvement among ethnic groups. Results from naive models common in previous research suggest that drought generally has little impact. However, context-sensitive models accounting for the groups' level of vulnerability reveal that drought can contribute to sustaining conflict, especially for agriculturally dependent groups and politically excluded groups in very poor countries. These results suggest a reciprocal nature–society interaction in which violent conflict and environmental shock constitute a vicious circle, each phenomenon increasing the group's vulnerability to the other.

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Data deposition: The replication data reported in this paper are available from Peace Research Institute Oslo's data repository, https://www.prio.org/Data/Replication-Data, as well as the Department of Peace and Conflict Research, Uppsala University, www.pcr.uu.se/data.

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outcome (conflict) for an effect to be detected. Neither approach is suited to capture and evaluate the group-level dynamic outlined above.

Remedying this shortcoming, we take advantage of a new generation of georeferenced data on ethnic groups (28), which we link to specific armed conflict events (29) by considering the ethnic claims and recruitment strategy of each nonstate conflict actor in each armed civil conflict (30). This linking procedure is an important innovation, because it permits considering how local drought affects ethnic groups' conflict behavior, irrespective of the actual location of fighting relative to the drought or the group's homeland. Moreover, by overlaying the spatial ethnicity layers with high-resolution land use rasters (31) and monthly remote sensing-based drought statistics (32), we are able to calculate, for each ethnic group and each calendar year, cropland-specific drought during the growing season of the dominant local crop (33). We use a group-specific Standardized Precipitation Evapotranspiration Index (SPEI) as our primary indicator of drought, because it captures both precipitation anomalies and variations in determinants of evaporation (e.g., temperature and wind speed). We focus on drought, because it is the environmental condition widely assumed to carry the largest conflict potential.

In the empirical analysis presented below, we consider both naive models, in which local drought is assumed to have a direct and general effect on conflict risk, and context-sensitive models, where the effect of drought is conditioned on the groups' livelihood vulnerability (agricultural dependence, expressed as share of the group's settlement area covered by cropland), economic vulnerability (local economic development, expressed as area average night light emission per group settlement polygon), and political vulnerability (ethnopolitical exclusion). In all, we investigate subnational climate–conflict dynamics across Africa and Asia, 1989–2014, covering a larger spatiotemporal domain than any previous study of this kind. The geographical scope not only accounts for the large majority of the world's armed conflicts, but it also encompasses the agricultural areas that are most vulnerable to drought and other extreme weather events (34–36). Additional details and alternative operationalizations are described in *SI Text*.

Figs. 1 and 2 give a visual representation of key vulnerability dimensions captured in the analysis. The extent of agricultural dependence, used as proxy for livelihood vulnerability, varies substantially between countries as well as between ethnic groups within countries (Fig. 1). The largest shares of cropland are found in South and Southeast Asia. Most groups in Africa have modest proportions of agricultural lands, where pastoral and agropastoral systems constitute a more prominent part of the rural economy. The conflict data also reveal a distinctly nonrandom spatial pattern with notable clusters in West Africa, the African Great Lakes region, and the Horn, as well as in South Asia. Fig. 2 shows country-level infant mortality rates (IMRs) assigned to the respective groups. IMR arguably constitutes the best aggregate proxy for country-level socioeconomic development, being strongly and inversely related to human welfare and positively associated with state fragility (37, 38). In contrast to gross domestic product (GDP) and other indicators of macroeconomic performance, IMR is less immediately affected by commodity price fluctuations and global market forces and also less endogenous to armed conflict. We use IMR statistics to identify a subset of "most likely" cases (i.e., ethnic groups in countries marked by chronic poverty and weak political institutions, which are conditions that can critically stunt communities' capacity to cope with agroeconomic shocks) (9, 39). Again, the

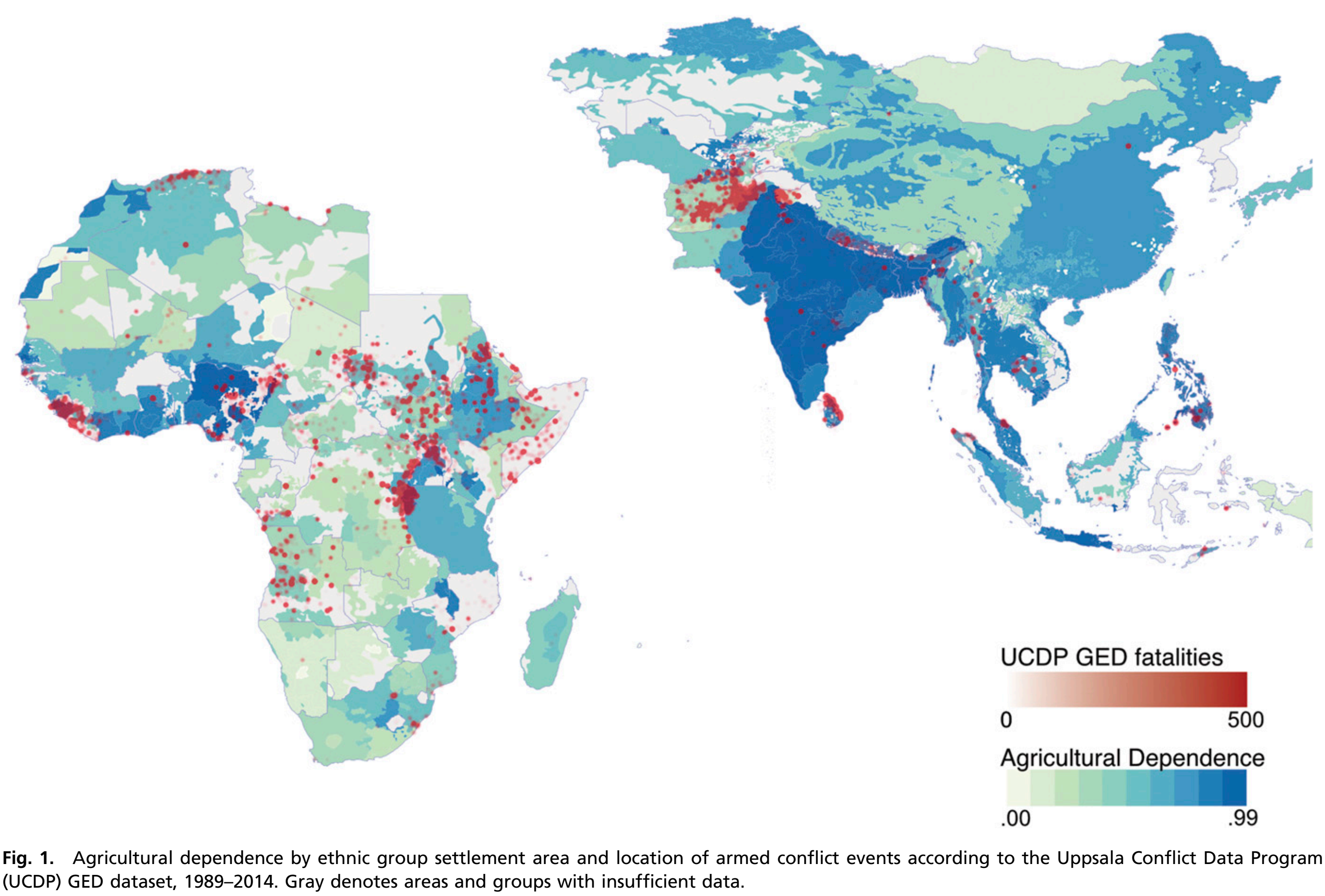

Fig. 1. Agricultural dependence by ethnic group settlement area and location of armed conflict events according to the Uppsala Conflict Data Program (UCDP) GED dataset, 1989–2014. Gray denotes areas and groups with insufficient data.

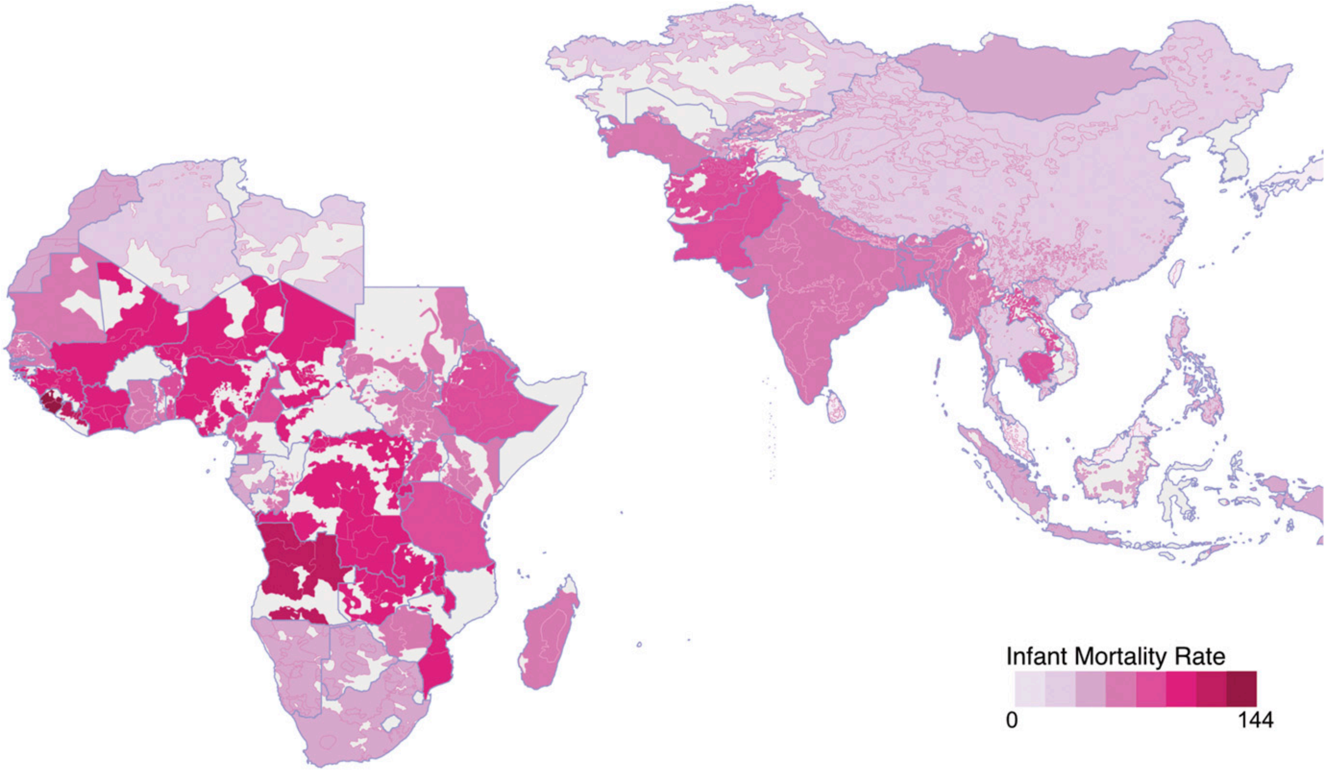

Fig. 2. Country-level IMRs assigned to respective ethnic groups in 2000. Gray denotes areas and groups with insufficient data.

data reveal large cross-sectional variation, with sub-Saharan Africa being the region of particular concern.

Results

Fig. 3 presents the main results from the statistical analysis. The marginal effects displayed are derived from a comprehensive set of multilevel random effects models of group-specific armed conflict onset and incidence as a function of observed growing-season drought in each group's agricultural areas. We estimated both direct drought effects and effects conditional on the groups' local socioeconomic and political context. Furthermore, we alternated between models containing the complete Africa–Asia sample and models covering a subset of ethnic groups in countries where socioeconomic development is especially low (IMR > sample median).

Overall, the plots reveal a mixed pattern; the point estimates for most effects are positive, indicating that the occurrence of drought is more likely to be associated with an increase than a decrease in local civil conflict risk. At the same time, most coefficients fail to obtain statistical significance at conventional confidence levels. However, some models are better approximations of the proposed conditional relationships than others, and therefore, it would be a mistake to draw conclusions merely on the basis of the median or mean marginal effect among all models shown in Fig. 3. In particular, we note that drought has a stronger association with conflict when it is modeled as a function of the group's agricultural dependence. In other words, the occurrence of drought during the growing season of the main local crop increases the risk of conflict involvement for groups with large shares of cropland but not necessarily for predominantly nonagrarian groups. Moreover, across nearly all specifications, the estimated conflict-inducing effect of drought is larger for the subsample of groups located in the least developed countries—precisely where we would expect a causal link to be most likely to materialize. The analysis further suggests that drought has a larger and more systematic effect on civil conflict incidence than on onset. We return to the implication of this insight in *Discussion*.

In terms of marginal impact, Fig. 4*A* shows how the effect of drought on conflict incidence increases with the group's share of agricultural land. The positive effect is especially pronounced for the subset of groups in low-development countries, although the shape of the slope is determined by a modest fraction of the sample (Fig. 4*B*). For most groups, the estimated effect of drought is not significantly different from zero. Fig. 4*C* shows that conflict risk increases for each additional year of growing-season drought. For the average politically excluded group, an increase from no drought to 5 consecutive years of drought during the local growing season increases the estimated likelihood of conflict incidence from 12 to 15% ceteris paribus.

The main analysis, depicted in Fig. 3, captures a variety of plausible combinations of local environmental conditions and conflict outcomes. Next, we carried out a set of sensitivity tests to explore the robustness of these patterns. First, we replaced the SPEI indicators with simpler group-specific measures of negative precipitation deviation. The results for agricultural-dependent groups remain substantively unchanged. Second, we relaxed the ethnic link criterion and consider all conflict events occurring within each ethnic group's settlement area by means of a simpler spatial overlay procedure, analogous to the approach of earlier research. This test yielded more mixed results, which may be partly because the alternative conflict variables ignore relevant events occurring outside each groups' homeland and partly because of noise introduced by additionally accounting for conflict events not involving the local population. Moreover, we found that the significant relationship between drought and conflict incidence is robust to replacing the two-level mixed effects logit estimator with ordinary least squares regression with group-level fixed effects. Details are in Tables S1 and S7–S9.

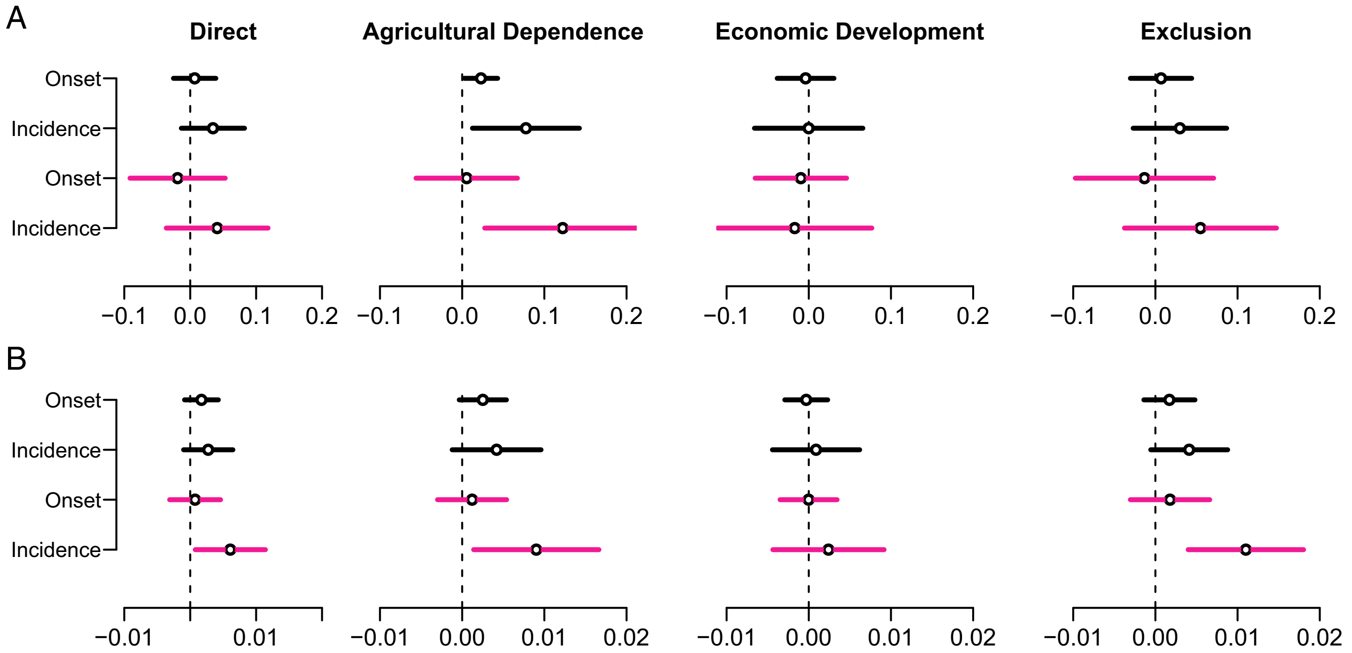

Fig. 3. Marginal effects of (*A*) growing-season drought and (*B*) cumulative years of growing-season drought on civil conflict onset and incidence for full sample (black) and high-IMR subsample (pink). Direct effects of drought are estimated in column 1; columns 2–4 show effects conditional on high agricultural dependence (85th percentile), low development (15th percentile), and ethnopolitical exclusion, respectively. Whiskers represent 95% confidence intervals. Tables S3–S6 have details on the estimated models.

Discussion

This study has investigated the extent to which the conflict behavior of spatially defined ethnic groups is sensitive to agro-economic shocks. Although ethnicity is not the only marker of identity conducive to violent mobilization and collective action, it is the dominant societal cleavage in most countries in the developing world today (21). However, not all politically relevant ethnic groups are equally vulnerable to an environmental shock. Some groups constitute a crucial part of a regime's "winning coalition" (40) and thereby enjoy economic benefits and political privileges. Even more important, groups vary in their dependence on agricultural production for income and livelihood. Accordingly, it should not come as a surprise that the majority of groups in this analysis seem relatively resilient to drought. However, for politically marginalized and agriculturally dependent groups—and especially those residing in countries characterized by very low socioeconomic development—the analysis has detected a consistent statistical pattern, whereby the occurrence and duration of drought increase the likelihood of sustained conflict involvement.

Overall, the models that estimated conflict incidence are more supportive of the drought hypothesis than the onset models. Although this result may partly be a consequence of the rare nature of conflict outbreak and consequently, few non-zero observations, we interpret this as evidence of a powerful reciprocal relationship between armed conflict and local drought, whereby each phenomenon makes a group more vulnerable to the other. Sustained fighting and insecurity deter investments, trigger capital flight, undermine public goods delivery, and have negative health implications (41, 42), all of which may decrease the local population's ability to cope with increased environmental hardship and increase their incentives to sustain ongoing resistance (43, 44). The Tigrayan rebellion in Ethiopia and the Maoist insurgency in India are two examples where such a dynamic reportedly played out (45, 46). We find less evidence that the occurrence or duration of drought significantly affects the risk of new conflict breaking out, even in the most likely subset of agriculturally dependent or politically marginalized ethnic groups in countries with very low economic development. Accordingly, although some research has suggested

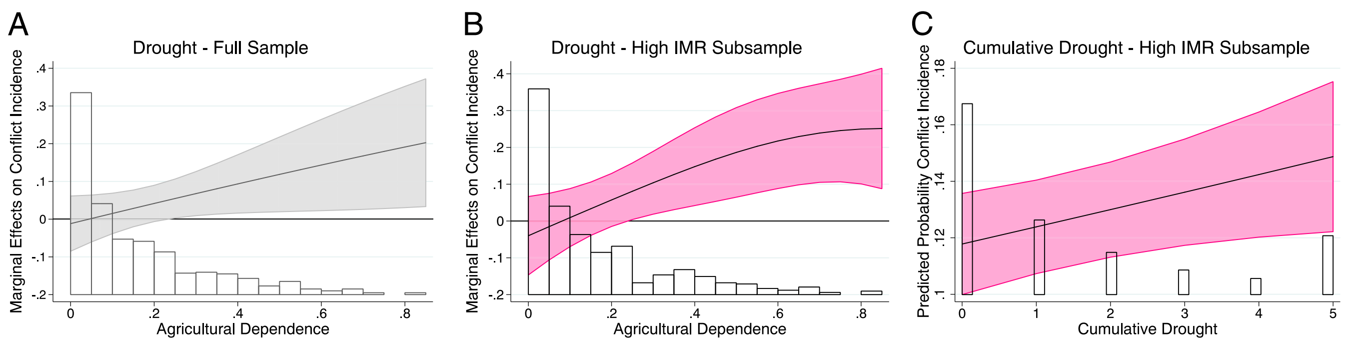

Fig. 4. Marginal effects as a function of agricultural dependence for (*A*) the full sample (n = 5,381) and (*B*) the high-IMR subsample (n = 2,733). *C* shows the predicted risk of conflict incidence for each additional year of growing-season drought for groups in the high-IMR subsample (n = 2,733). Superimposed bars represent the distributions of observations. Details are in Tables S3 and S4.

that a severe drought contributed to the onset of the Syrian civil war (3), our results do not indicate that this case is representative of a large number of contemporary conflicts.

Although this study provides insight regarding a more nuanced and conditional climate–conflict dynamic, it is clear that drought explains a small share of the observed variation in conflict involvement, implying that the substantive effect is modest compared with central drivers of conflict, such as ethnopolitical exclusion, temporal and spatial proximity to violence, and various country-specific risk factors. That said, this study has focused on only one theorized causal pathway. More research is needed to properly evaluate alternative mechanisms through which drought may translate into societal instability (e.g., forced displacement and consumer price shocks) as well as the impact on other manifestations of collective action (e.g., communal conflict and urban rioting but also, increased cooperation and conflict resolution).

Based on the most comprehensive and theoretically consistent assessment of its kind to date, we conclude that the impact of drought on conflict under most circumstances is limited. However, for segments of the population that are particularly vulnerable to natural forces because of their dependence on agriculture, drought does significantly increase the likelihood of sustained conflict, especially among groups in the least developed states. A severe drought threatens local food security, aggravates humanitarian conditions, often triggers large-scale human displacement, and as our results indicate, may also provide the breeding ground for sustained fighting. These results speak to the importance of strengthening adaptive capacities of agriculturally dependent communities, in particular in areas already affected by conflict. Conflict is development in reverse (47, 48), and the adverse impact of intense violence on environmental vulnerability is probably many times greater than the effect of environmental shock on conflict risk. The international community should, thus, be especially attentive to climatic disasters striking zones of chronic conflict.

Materials and Methods

We estimate a series of two-level mixed effects logistic regression models, which allows examining both spatial and temporal variations in conflict risk across our observations, while taking into account dependence between observations within countries and groups over time. We specify random intercepts to account for systematic differences in baseline conflict risk between groups belonging to different countries, whereas the slopes or variable effect sizes are assumed constant across all groups.

The units of analysis are yearly observations of politically relevant ethnic groups with a geographical base drawn from the Ethnic Power Relations dataset (17, 49). A group is politically relevant if at least one political organization claims to represent it in national politics or its members are subjected to state-led political discrimination. We exclude from our sample ethnic groups that dominate or have monopoly over governmental power, because these cannot simultaneously constitute a nonstate opposition actor.

Data on civil conflict events are taken from the Uppsala Conflict Data Program Georeferenced Event Dataset (UCDP GED), version 4.0., which records all lethal events in armed conflicts between state and nonstate actors that claim at least 25 battle-related deaths during at least one calendar year (29). We combine the conflict data with information on the ethnic claims and recruitment profiles of the nonstate actors from the ACD2EPR dataset (30). For each group-year, we code two alternative binary dependent variables. Onset is coded one in the first year that a lethal event can be linked to the ethnic group (recording a new onset after two calendar years of inactivity). Subsequent years of fighting are coded as missing, because groups involved in ongoing conflict are not at risk for experiencing a new onset. In addition, we consider conflict incidence, which is assigned the value of one in all years with at least one lethal event involving the group. Both variables are otherwise coded zero.

The independent variable is the severity of growing-season drought for crops cultivated within the group settlement areas. We first overlay ethnic settlement polygons (Geo-EPR-ETH v.2.0) with 0.5×0.5-decimal degrees grid cells using the PRIO-GRID structure (50). For each grid cell, we identify the primary crop [i.e., the crop covering the largest physical surface based on data from the Spatial Production Allocation Model (SPAM) 2005 (31)]. Growing seasons for each primary crop are identified using the Monthly Irrigated and Rainfed Crop Areas (MIRCA) cropping calendars (33) complemented by the SAGE Crop Calendar Dataset (51). This information is combined with monthly drought data by means of the SPEI, which considers the joint effect of precipitation and potential evapotranspiration compared with historical normal conditions (52). The severity of the growing-season drought is measured as the share of the growing season where the SPEI index is at least 1 SD below normal levels. The cell-specific drought index is then aggregated to the ethnic group level by taking the mean of all cells falling within each settlement polygon. We also construct a cumulative drought measure, which counts the number of consecutive years (up to 5 y) with growing-season drought values above the sample median. Additional details on the drought indices are in *SI Text* and Fig. S1.

We construct three different group-level measures of vulnerability. First, we calculate agricultural dependence defined as the proportion of each ethnic group's settlement area that overlaps with cropland according to the SPAM 2005 dataset (31). Second, we include a group-based measure of economic development, taking the mean yearly pixel value of night light emissions for each group's settlement area from the Defense Meteorological Satellite Program—Operational Linescan System (53). The variable is log-transformed before use. Third, we measure ethnopolitical exclusion as a binary indicator based on the Ethnic Power Relations dataset (17).

Because we anticipate systematic differences in groups' vulnerability to environmental shocks between countries, we account for the host countries' level of socioeconomic development represented by IMRs from the World Development Indicators (48). IMR measures the number of infants dying before reaching 1 y of age per 1,000 live births in a given year. Some models are estimated on a subset of the full sample, where we only include groups in the least developed countries [i.e., where the IMR score is above the sample median score (IMR > 60)].

As control variables, we include the size of the population living in the ethnic group settlement areas from the Center for International Earth Science Information Network (CIESIN) obtained via the Geographical Research on War, United Platform (GROW^{up}) database (53, 54). We also include an indicator of country-level gross domestic product per capita (GDPpc) from the World Development Indicators (55). Both variables are log-transformed before use. We account for temporal dependence in conflict risk through a decay function of time since the ethnic group last was involved in an armed conflict with the state. The risk of spillover effects from nearby conflict is accounted for by including a dummy variable indicating whether at least one other ethnic group in the same country was engaged in armed conflict against the state during the previous year. Finally, we include a group-specific time trend to account for possible trending patterns in, for example, climate variability and agricultural productivity (56). All independent variables are entered into the models at $t - 1$ to ensure the correct sequence of events. Replication data are available from PRIO's data repository at https://www.prio.org/Data/Replication-Data as well as from www.pcr.uu.se/data.

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