Climate Wars? Assessing the Claim That Drought Breeds Conflict

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Drought, Political Exclusion, and Civil War

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ABSTRACT

Dominant climate models suggest that large parts of Africa will experience greater climatic variability and increasing rates of drought in coming decades. This could have severe societal consequences as the economies and food supplies of most African countries depend on rain-fed agriculture. According to leading environmental security scholars, policy makers, and NGOs, an increase in scarcity-driven armed conflicts should also be expected. Drawing on these arguments, we present a conditional theory of environmental conflict predicting that drought increases the risk of civil war primarily when it strikes vulnerable and politically marginalized populations in agrarian societies. This general proposition is evaluated empirically through a unique gridded dataset of post-colonial Africa that combines high-resolution meteorological data with geo-referenced data on civil war onset and the local ethno-political context. Despite popular conception, we find little evidence of a drought-conflict connection. Instead, the local risk of civil war can be explained by sociopolitical and geographic factors: a politically marginalized population, high infant mortality, proximity to international borders, and high local population density.

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Climate change is hot. Twice in recent years, the Nobel Peace Prize has been awarded to environmental activism: in 2004 to Wangari Maathai and in 2007 to the United Nations' Intergovernmental Panel on Climate Change (IPCC) and former U.S. Vice President Al Gore. In April 2007, the UN Security Council held its first ever debate on climate security. The chair of that debate, then British Foreign Secretary Margaret Becket, left no doubt as to the connection between climate and conflict: "What makes wars start? Fights over water. Changing patterns of rainfall. Fights over food production, land use."[1] In the same year, a report by eleven retired U.S. generals and admirals testified that environmental security is no longer soft politics, concluding that climate change is a "threat multiplier" for instability and conflict that will have repercussions

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[1] See Paul Reynolds, "Security Council Takes on Global Warming," *BBC News*, April 18, 2007, http://news.bbc.co.uk/2/hi/6559211.stm.

for all.[2] And in a speech to the UN on September 22, 2009, U.S. President and Nobel laureate Barack Obama made it clear that climate change is an “urgent, serious, and growing threat” as more frequent droughts and crop failures “breed hunger and conflict.”[3] Surely, such statements must be based on solid scientific evidence – much in the same manner as the natural sciences inform the debate on likely physical changes? Not so. As a matter of fact, the policy debate on the security implications of climate change has run far ahead of the scientific evidence base. This study represents one scholarly attempt to catch up with rhetoric.

At the heart of the climate security discourse lies the issue of water scarcity. A key characteristic of the world’s poorest and most vulnerable societies is their dependence on rain-fed agriculture for income and food supply. Global warming is likely to affect precipitation patterns and increase the unpredictability of extreme weather events, thereby probably having a negative impact on health and food security in many parts of the world.[4] Some argue that these developments might also have implications for peace and security in a stricter sense. The environmental security literature offers several case-based accounts of armed conflict within the

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[2] CNA Corporation, *National Security and the Threat of Climate Change* (Alexandria, Va.: CNA Corporation, 2007), p. 6. See also Dan Smith and Janani Vivekananda, *A Climate of Conflict: The Links between Climate Change, Peace and War* (London: International Alert, 2007).

[3] “TEXT: Obama’s U.N. Speech on Climate Change,” Reuters, September 22, 2009, http://www.reuters.com/article/idUSTRE58L2PR20090922.

[4] J.H. Christensen, B. Hewitson, A. Busuioc, A. Chen, X. Gao, I. Held, R. Jones, R.K. Kolli, W.-T. Kwon, R. Laprise, V. Magaña Rueda, L. Mearns, C.G. Menéndez, J. Räisänen, A. Rinke, A. Sarr, and P. Whetton, “Regional Climate Projections,” in S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. 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* (New York: Cambridge University Press, 2007), pp. 847–940.

context of competition over scarce resources.[5] Yet, it remains unclear whether these cases are exceptions or whether they epitomize a more systematic pattern of resource scarcity and conflict, in general, and drought and violent conflict, in particular.[6]

This study offers a rigorous assessment of the claim that drought and water shortages increase the risk of civil war.[7] In contrast to earlier attempts to study the scarcity-conflict nexus in

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[5] Prominent environmental security contributions include Günther Baechler, *Violence through Environmental Discrimination* (Dordrecht: Kluwer Academic, 1999); Thomas Homer-Dixon, "On the Threshold. Environmental Changes as Causes of Acute Conflict," *International Security*, Vol. 16, No. 2 (Fall 1991), pp. 76–116; Thomas Homer-Dixon, *Environment, Scarcity, and Violence* (Princeton, N.J.: Princeton University Press, 1999); and Colin Kahl, *States, Scarcity, and Civil Strife in the Developing World* (Princeton, N.J.: Princeton University Press, 2006).

[6] Previous comparative studies on the statistical relationship between climate factors and violent conflict include Halvard Buhaug, "Climate Not to Blame for African Civil Wars," *Proceedings of the National Academy of Sciences of the USA*, Vol. 107, No. 38 (September 2010), pp. 16477–16482; Marshall B. Burke, Edward Miguel, Shanker Satyanath, John A. Dykema, and David B. Lobell, "Warming Increases the Risk of Civil War in Africa," *Proceedings of the National Academy of Sciences*, Vol. 106, No. 49 (December 2009), pp. 20670–20674; Hsiang, Solomon M., Kyle C. Meng, and Mark A. Cane, "Civil Conflicts Are Associated with the Global Climate," *Nature* Vol. 476, No. 7361 (August 2011), pp. 438–441; Edward Miguel, Shanker Satyanath, and Ernest Sergenti, "Economic Shocks and Civil Conflict: An Instrumental Variable Approach," *Journal of Political Economy*, Vol. 112, No. 4 (August 2004), pp. 725–753; Richard S. J. Tol and Sebastian Wagner, "Climate Change and Violent Conflict in Europe over the Past Millennium," *Climatic Change*, Vol. 99, Nos. 1-2 (March 2010), pp. 65–79; David D. Zhang, Peter Brecke, Harry F. Lee, Yuan-Qing He, and Jane Zhang, "Global Climate Change, War, and Population Decline in Recent Human History," *Proceedings of the National Academy of Sciences of the USA*, Vol. 104, No. 49 (December 2007), pp. 19214–19219; and contributions to the special issues on "Climate Change and Conflict" in *Political Geography*, Vol. 26, No. 6 (August 2007) and *Journal of Peace Research*, Vol. 49, No. 1 (January 2012) .

a comparative manner, we explicitly incorporate the role of ethnopolitical structures. Not all groups in a society are equally vulnerable to environmental shocks. Almost all accounts of land and water conflicts in Africa concern peripheral and neglected groups in weak or oppressive regimes – even though the nature of the political system in these narratives often remains implicit. Environmental hardships, such as prolonged drought, tend to accentuate societal divides, as marginalized groups lack alternative means of livelihood and income and are less likely to be at the receiving end of government-sponsored redistribution programs and relief aid. This leads to a second significant improvement of this study: its geographically disaggregated design. Grievances and human suffering will emerge first, and be most acute, in locations where drought coincides with political and economic marginalization. Local, short-term implications could be lowered opportunity cost of rebel recruitment and a higher motivation for using violence to redress grievances. Therefore, if leading politicians, think tanks, and environmental security scholars are correct – if a regular pattern of increasing water scarcity and increasing risk of violent conflict truly exists – this should be observed where drought strikes marginalized populations in poor, agrarian, nondemocratic societies.

To evaluate the empirical validity of this general proposition, we employ a high-resolution gridded dataset of Africa from 1960 to 2004 that combines georeferenced and annualized precipitation data with new data on the point location of civil war onset and the location and political status of ethnic groups.[8] We test a large selection of alternative location-

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[7] A drought is normally defined as deficiency of precipitation over an extended period of time, usually a season or more. See *Drought Risk Reduction Framework and Practices: Contributing to the Implementation of the Hyogo Framework for Action* (Geneva, Switzerland: International Strategy for Disaster Reduction, 2008).

[8] This study focuses on civil wars, the dominant and most severe form of contemporary armed conflict, to which much of the climate security discourse refers. We consider alternative forms of conflict in the conclusion. We follow

specific drought measures and allow for both direct and conditional relationships, where the effect of drought is contingent on various sociopolitical characteristics at the local as well as the national level. In contrast to popular conception, the analysis reveals little evidence of a drought-conflict connection. Although we find strong support for the exclusion perspective – African civil wars break out disproportionately in politically marginalized areas – this statistical regularity is unaffected by abrupt local water shortages. This finding calls for moderation when discussing security implications of climate change, particularly within the context of policy advice and practice.

The article is organized as follows. We begin by briefly describing contemporary precipitation patterns and trends in Africa. Existing arguments linking drought to civil war are then surveyed before we explain why any measurable impact of drought is likely to be contingent on ethnopolitical power relations. Thereafter, we outline how this proposition is tested using a spatially disaggregated design, before turning to the results and our interpretation of these. We conclude by discussing some implications of our findings and point to fruitful avenues for future research.

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the UCDP/PRIO project in defining civil armed conflict as an armed conflict between a state and one or more non-state actor(s) over a clearly stated issue of incompatibility (government or a specific territory) that results in at least 25 battle-related deaths per calendar year. Nils Petter Gleditsch, Peter Wallensteen, Mikael Eriksson, Margareta Sollenberg, and Håvard Strand, "Armed Conflict 1946–2001: A New Dataset," *Journal of Peace Research*, Vol. 39, No. 5 (September 2002), pp. 615–637. Civil war is sometimes defined as an armed intrastate conflict that generates at least 1,000 annual casualties. We use the terms "armed conflict" and "war" interchangeably throughout this article.

BACKDROP: TRENDS IN PRECIPITATION PATTERNS

The world is heating up. Although the most recent years on average have been marginally cooler than the turn of the century, 2010 tied 2005 as the warmest year on record.[9] Simultaneously, we have witnessed a dramatic decrease in seasonal Arctic sea ice extent, and the global rate of hydro-meteorological natural disasters has increased exponentially over the last few decades, even if it is hard to quantify the exact contribution of global warming.[10]

Climate change is not felt equally in all corners of the world, however. Warming occurs disproportionately in the Northern Hemisphere, and particularly at higher latitudes. Precipitation patterns display similar, though not always overlapping changes, with considerable interregional and interannual variations. According to the IPCC Fourth Assessment Report, precipitation will increase in higher latitudes and decrease in the subtropics, where droughts will become more frequent and more intense.[11]

Just as climate change differs among regions, so does vulnerability to shifting environmental conditions. Africa is projected to be hit first and most extensively by a less hospitable climate, given its economic dependence on rain-fed agriculture, high environmental

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[9] See "NASA Research Finds 2010 Tied for Warmest Year on Record" (New York: NASA Goddard Institute for Space Studies, January 12, 2011), http://www.giss.nasa.gov/research/news/20110112/.

[10] National Snow and Ice Data Center (NSIDC), *Annual Report 2007* (Boulder, Colo.: NSIDC, 2007); Jose Rodriguez, Femke Vos, Regina Below, and D. Guha Sapir, *Annual Disaster Statistical Review 2009. The Numbers and Trends* (Catholic University of Louvain, Belgium: Centre for Research on the Epidemiology of Disasters, 2010).

[11] Gerald A. Meehl, Warren M. Washington, William D. Collins, Julie M. Arblaster, Aixue Hu, Lawrence E. Buja, Warren G. Strand, and Haiyan Teng, "How Much More Global Warming and Sea Level Rise?" *Science*, Vol. 307, No. 5716 (March 2005), pp. 1769–1772. See also Mike Hulme, Ruth Doherty, Todd Ngara, and Mark New, "Global Warming and African Climate Change," in Pak Sum Low, ed., *Climate Change and Africa* (New York: Cambridge University Press, 2005), pp. 29–40; and Christensen et al., "Regional Climate Projections."

vulnerability, and weak institutional coping capacity.[12] Only 4 percent of arable land in subsaharan Africa is irrigated, making the predominantly agricultural African economies poorly suited to withstand increasing drought. The result might be substantial vegetation die-off in exposed regions, with negative implications for agricultural productivity and food security.[13] One-third of the African population live in drought-prone areas today, and almost all subsaharan countries are projected to be in a state of water stress by 2025.[14] Moreover, two-thirds of the workforce in subsaharan Africa is employed in the rural sector, making this region especially sensitive to future climate changes.[15]

The direction and extent of climate change vary also within regions. As shown in figure 1, parts of East Africa and the Horn have become considerably wetter over the last half century while other areas, notably central and western Africa, have seen a decline in annual precipitation.

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[12] Two important reports on vulnerability to climate change are M. Boko, I. Niang, A. Nyong, C. Vogel, A. Githeko, M. Medany, B. Osman-Elasha, R. Tabo, and P. Yanda, "Africa," in M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson, eds., *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge, Mass.: Cambridge University Press, 2007), pp. 433–467; and the UK Treasury-commissioned assessment by Nicholas Stern, *The Economics of Climate Change: The Stern Review* (Cambridge: Cambridge University Press, 2006).

[13] David D. Breshears, Neil S. Cobb, Paul M. Rich, Kevin P. Price, Craig D. Allen, Randy G. Balice, William H. Romme, Jude H. Kastens, M. Lisa Floyd, Jayne Belnap, Jesse J. Anderson, Orrin B. Myers, and Clifton W. Meyer, "Regional Vegetation Die-Off in Response to Global-Change-Type Drought," *Proceedings of the National Academy of Sciences of the USA*, Vol. 102, No. 42 (October 2005), pp. 15144–15148.

[14] *Vital Water Graphics. An Overview of the State of the World's Fresh and Marine Waters*, 2nd ed. (Nairobi: United Nations Environment Programme, 2008).

[15] Stern, *The Economics of Climate Change*.

Results from global circulation models of various IPCC scenarios suggest that these intracontinental trends will continue.[16] It has to be noted, however, that there is considerable uncertainty in these projections, especially at the subregional level.

LINKING DROUGHT TO CIVIL WAR

The general expectation that failing precipitation could cause armed conflict draws on an influential body of work commonly referred to as the environmental security literature. Thomas Homer-Dixon’s well-known typology of supply- and demand-induced and structural scarcities of renewable resources has informed much research in this area.[17] According to this school of thought, less developed countries are most predisposed to endemic resource shortages because they lack necessary knowledge and capabilities to overcome persistent resource pressure. Likely consequences include reduced economic productivity, migration, sharpening of group demarcations, and disruption of political institutions. These problems would indicate a higher risk of armed conflict, and the environmental security literature is not short on reports of conflicts in resource-poor regions. The models, explanations, and particularly the assumptions of environmental security scholarship have been heavily criticized from a political ecology point of view.[18]

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[16] See Eleanor J. Burke, Simon J. Brown, and Nikolas Christidis, “Modelling the Recent Evolution of Global Drought and Projections for the Twenty-First Century with the Hadley Centre Climate Model,” *Journal of Hydrometeorology* Vol. 7, No. 5 (October 2006), pp. 1113–1125; and Christensen et al., “Regional Climate Projections.”

[17] A major point of reference is Homer-Dixon’s book *Environment, Scarcity, and Violence*.

[18] Recent ecology-oriented work includes Tor Arve Benjaminsen, “Does Supply-Induced Scarcity Drive Violence Conflicts in the African Sahel? The Case of the Tuareg Rebellion in Northern Mali,” *Journal of Peace Research*,

Quantitative cross-national empirical research has still not converged on a systematic and robust connection between resource scarcity and civil war,[19] although disaggregated studies of single countries appear somewhat more supportive.[20] Yet, even if endemic scarcities do not generally cause civil war, a sudden drop in resource supply might do so. For example, subsistence-based populations may be forced to relocate when environmental shocks eradicate their crops or livestock. Migration may instigate violent conflict in several ways: through resource competition between newcomers and natives; through increasing polarization and hardening of socioeconomic cleavages among identity groups; and through antagonism between host authorities and the migrants' home government caused by suspicion over the real cause or motive for displacement.[21] Indeed, migration is viewed with much concern in the emerging discourse on climate security.[22] Although there is some statistical evidence for a link between

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Vol. 45, No. 6 (November 2008), pp. 819–836; and Nancy Lee Peluso and Michael Watts, *Violent Environments* (Ithaca, N.Y.: Cornell University Press, 2001).

[19] For reviews, see Michael Brzoska, "The Securitzation of Climate Change and the Power of Conceptions of Security," *Sicherheit und Frieden (S+F)*, Vol. 27, No. 3 (September-October 2009), pp. 137–145; Ragnhild Nordås and Nils Petter Gleditsch, "Climate Change and Conflict," *Political Geography*, Vol. 26, No. 6 (August 2007), pp. 627–638; and Idean Salehyan, "From Climate Change to Conflict? No Consensus Yet," *Journal of Peace Research*, Vol. 45, No. 3 (May 2008), pp. 315–326.

[20] Notably Henrik Urdal, "Population, Resources and Violent Conflict: A Sub-National Study of India 1956–2002," *Journal of Conflict Resolution*, Vol. 52, No. 4 (August 2008), pp. 590–617.

[21] Rafael Reuveny, "Climate Change-induced Migration and Violent Conflict" *Political Geography*, Vol. 26, No. 6 (August 2007), pp. 656–673.

[22] Christian Aid, *Human Tide: The Real Migration Crisis* (London: Christian Aid, 2007).

transnational refugee flows and the outbreak of armed conflict,[23] it is far from obvious that environment-induced migration (to the extent migration can be considered monocausal) will have the same security implications. Because of a lack of conceptual clarity and a complex web of migration drivers, no empirical study has been able explore the general consequences of "environmental migration" across multiple cases. Besides, the temporal aspect of the migration-conflict link is underdeveloped and vague, as epitomized by claims that the Sahelian drought in the 1980s caused the war in Darfur more than a decade later.[24]

The recent economic literature on civil war provides an alternative explanation for a scarcity-conflict connection. In rain-fed agrarian societies, significant deviations from normal precipitation levels will have a negative impact on agricultural output, thereby reducing state income from taxation and export.[25] Such economic shocks are argued to heighten the risk of conflict in two ways. First, they can reduce the government's counterinsurgent capacity and its ability to deliver public goods, thereby increasing the opportunities and incentives for dissident organizations to take up arms. Second, they can reduce individuals' economic opportunity cost of becoming a rebel soldier. The latter argument is part of a more general theory of rebellion as

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[23] Kristian Skrede Gleditsch and Idean Salehyan, "Refugees and the Spread of Civil War," *International Organization*, Vol. 60, No. 2 (April 2006), pp. 335–366.

[24] See UN Secretary-General Ban Ki-moon, "A Climate Culprit in Darfur," *Washington Post*, June 16, 2007, http://www.washingtonpost.com/wp-dyn/content/article/2007/06/15/AR2007061501857.html. Two articles that disagree with the climate link for Darfur are Michael Kevane and Leslie Gray, "Darfur: Rainfall and Conflict," *Environmental Research Letters*, Vol. 3, No. 3 (July–September 2008), pp. 1–10; and Ian Brown, "Assessing Eco-Scarcity as a Cause of the Outbreak of Conflict in Darfur: A Remote Sensing Approach," *International Journal of Remote Sensing*, Vol. 31, No. 10 (May 2010), pp. 2513–2520.

[25] Burke et al., "Warming Increases the Risk of Civil War in Africa." A related, earlier study is Miguel et al., "Economic Shocks and Civil Conflict: An Instrumental Variable Approach."

individual criminal behavior, where the decision to rebel is based on calculations of expected private economic gains.[26]

Unlike the complex causal chains normally portrayed in the environmental security literature, the economic opportunity argument yields falsifiable statistical predictions in which climatic anomalies constitute a short-term trigger effect that should exhibit a general correlational pattern with the outbreak of armed conflict. At the same time, the state-centric national economy explanation is vague on actors and motives, so it remains unclear which groups of society would be more likely to challenge the government in response to a climate-induced economic shock. In what follows, we outline a theoretical framework of the scarcity-breeds-conflict proposition by explicitly incorporating local actors and their political context. By doing so, we provide a more refined and appropriate specification of the "most likely" scenario than what has been presented in earlier empirical research.

Political Exclusion as a Facilitating Factor

Civil war is not a random process that occurs in response to adverse environmental shocks, isolated from geopolitical and cultural realms. A drought cannot cause an armed rebellion by itself, but it could trigger a latent conflict under certain conditions. If the stories portrayed in the environmental security literature represent a widespread phenomenon, the weak empirical support from the large-*N* literature might be attributed to overly aggregated research designs and a failure to specify the conditions under which environmental scarcities lead to violence.

[26] Prominent advocates of this line of inquiry include Paul Collier's "Rebellion as a Quasi-Criminal Activity," *Journal of Conflict Resolution*, Vol. 44, No. 6 (December 2000), pp. 839–853; and Herschel I. Grossman's "A General Equilibrium Model of Insurrections," *American Economic Review*, Vol. 81, No. 4 (September 1991), pp. 912–921.

Most reports of scarcity-induced conflicts concern politically and environmentally marginalized groups.[27] Members of social groups without influence over national politics share both a common grievance and a common identity that can be utilized in overcoming collective action problems related to mobilization.[28] Colin Kahl makes this connection explicitly, arguing that the potential for demographic and environmental stress to produce violent conflict is highly contingent on the combination of exclusive political institutions and high salience of ethnic cleavages.[29] Groups that are denied access to central decisionmaking processes have few peaceful means of addressing their concerns.[30] Geographic concentration of the marginalized further facilitates coordination, mobilization, and conduct of violent opposition.[31] Among the many economically and politically disadvantaged groups that reportedly have reacted violently in

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[27] Notably, Baechler's influential book is titled *Violence through Environmental Discrimination.*

[28] Ernest Gellner, *Nations and Nationalism* (Ithaca, N.Y.: Cornell University Press, 1983); Ted Robert Gurr, *People versus States. Minorities at Risk in the New Century* (Washington, D.C.: United States Institute of Peace Press, 2000); Charles Tilly, *From Mobilization to Revolution* (New York: McGraw Hill, 1978); and Andreas Wimmer, *Nationalist Exclusion and Ethnic Conflicts. Shadows of Modernity* (Cambridge, Mass.: Cambridge University Press, 2002).

[29] Kahl, *States, Scarcity, and Civil Strife in the Developing World*.

[30] See, for example, Charles Tilly, *The Politics of Collective Violence* (New York: Cambridge University Press, 2003).

[31] Monica Duffy Toft, *The Geography of Ethnic Violence: Identity, Interests, and the Indivisibility of Territory* (Princeton, N.J.: Princeton University Press, 2003); and Nils B. Weidmann, "Geography as Motivation and Opportunity: Group Concentration and Ethnic Conflict," *Journal of Conflict Resolution*, Vol. 53, No. 4 (August 2009), pp. 526–543.

response to worsening environmental conditions are the Tuaregs in Mali, the indigenous peasants of Chiapas, Mexico, and the Bougainvilleans of Papua New Guinea.[32]

Crucially in this context, asymmetric societal structures tend to be accentuated during times of environmental crisis. A poor harvest or loss of pasture has immediate implications for local subsistence-based communities, particularly if nonagricultural sources of income are unavailable. Poor households often lack access to nonfarming economic activities and are forced to sell assets such as livestock in the face of drought.[33] State-based discrimination puts further strain on a group's resources and might have a detrimental impact on the ability to cope with a climatic shock.[34] In agrarian countries, a failing harvest season also affects the national income and reduces the amount of funding available for redistribution. The result is often a widening wealth gap between the haves and the have-nots, between those on whom the regime depends for

[32] See Kahl, *States, Scarcity, and Civil Strife in the Developing World*; Philip Howard and Thomas Homer-Dixon, "The Case of Chiapas, Mexico," in Homer-Dixon and Jessica Blitt, eds., *Ecoviolence: Links among Environment, Population, and Security* (Lanham, Md.: Rowman and Littlefield, 1998), pp. 19–54; and Volker Böge, "Mining, Environmental Degradation, and War: The Bougainville Case," in Mohamed Suliman, ed., *Ecology, Politics and Violent Conflict* (London: Zed, 1999), pp. 211–227.

[33] Jahn Lay, Ulf Narloch, and Toman Omar Mahmoud, "Shocks, Structural Change, and the Patterns of Income Diversification in Burkina Faso," *African Development Review*, Vol. 21, No. 1 (April 2009), pp. 36–58; and Thomas Reardon and J. Edward Taylor, "Agroclimatic Shock, Income Inequality, and Poverty: Evidence from Burkina Faso," *World Development*, Vol. 24, No. 5 (May 1996), pp. 901–914.

[34] Jon Barnett and W. Neil Adger, "Climate Change, Human Security, and Violent Conflict," *Political Geography*, Vol. 26, No. 6 (August 2007), pp. 639–655; Clionadh Raleigh, "Political Marginalization, Climate Change, and Conflict in African Sahel States." *International Studies Review*, Vol. 12, No. 1 (March 2010), pp. 69–86.

sustained control and those outside the sphere of political influence.[35] Accordingly, acute water shortages and drought should carry the largest potential for violent dispute when they affect marginalized populations that lack resources to pursue alternative modes of living and at the same time are likely to be ignored by the central government.

The famine in northern Ethiopia in 1984–85 illustrates how the social and political effects of drought depend on political structures and government policies. At the time of the 1984 drought, the uprising of the Tigrayan People's Liberation Front (TPLF) had been active for nearly a decade. An essential reason why the drought turned into a famine was the Derg regime's ruthless counterinsurgent policies, which included large-scale military offensives in surplus-producing areas, aerial bombardments of markets, and strong restrictions on trade and migration. The Derg's policy backfired, however; the famine made people turn to TPLF in unprecedented numbers. From 1984 to 1987 the TPLF army increased nearly threefold, and the front was turning away volunteers. This occurred mainly because ordinary Tigrayans became deeply alienated from the government, believing that they would never be free from famine as long as the junta was in power. The famine clearly made it easier for the TPLF to persuade local Tigrayans to turn against the Amhara-dominated state, and it also lowered the opportunity cost of joining the rebellion by making ordinary life insecure and miserable.[36]

Ethnopolitical exclusion is certainly not the only contextual factor that might determine whether water shortages will spark political unrest. Resilient and highly adaptive societies, which are characteristic of most developed countries, are generally well prepared to handle excessive

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[35] Jose-Miguel Albala-Bertrand, *Political Economy of Large Natural Disasters* (Oxford: Oxford University Press, 1993).

[36] For an authoritative source of the Tigray rebellion, see Alex de Waal, *Evil Days: Thirty Years of War and Famine in Ethiopia* (New York: Human Rights Watch, 1991).

climate variability and unexpected scarcities. Although the adaptive capacity of small farmers and pastoralists in African drylands often is underestimated,[37] there are limits to experience-based knowledge in the face of more dramatic and permanent changes. For this reason, developing countries directly dependent on subsistence resources are considered particularly vulnerable to climate-induced risks.[38] This is reflected in the recent empirical literature on environmental change and civil war, which focuses almost exclusively on Africa.[39] Another potential catalyst of armed conflict is access to preexisting networks, such as political parties or other interest groups.[40] Indeed, desperately poor people in search of earning opportunities are unlikely to be able to muster a potent rebel army without a significant contribution from entrepreneurs with organizational skills and ample funds.

To summarize, we argue that any measurable impact of drought on civil conflict risk is especially likely to materialize within the context of a vulnerable agricultural economy and ethnopolitical marginalization, in which the affected population is disproportionately harmed, yet

[37] See, for instance, Michael Mortimore, *Roots in the African Dust: Sustaining the Sub-Saharan Drylands* (Cambridge: Cambridge University Press, 1998).

[38] See Neil W. Adger, Saleemul Huq, Katrina Brown, Declan Conway, and Mike Hulme, "Adaptation to Climate Change in the Developing World," *Progress in Development Studies*, Vol. 3, No. 3 (July 2003), pp. 179–195; and Nick Brooks, Neil W. Adger, and P. Mick Kelly, "The Determinants of Vulnerability and Adaptive Capacity at the National Level and the Implications for Adaptation," *Global Environmental Change*, Vol 15, No. 2 (July 2005), pp. 151–163.

[39] See, for example, Buhaug, "Climate Not to Blame for African Civil Wars"; and Burke et al., "Warming Increases the Risk of Civil War in Africa."

[40] David D. Laitin, *Nations, States, and Violence* (Oxford: Oxford University Press, 2007); and Timothy P. Wickham-Crowley, *Guerrillas and Revolution in Latin America: A Comparative Study of Insurgents and Regimes since 1956* (Princeton, N.J.: Princeton University Press, 1992).

deprived of nonviolent channels of political protest. In this sense, a drought might constitute the final straw leading people to rebel. A possible counterargument is that a drought could further weaken marginalized groups, thereby constituting a temporary obstacle to mobilization. Although this reasoning might hold some merit, rebellion tends to be staged by aspiring elites that are well protected from sudden resource scarcities and are able to provide funds and arms whenever the timing is considered right.[41] Whether rebel entrepreneurs share the underlying grievances with the affected group at-large is subordinate in this context. When agrarian livelihoods dry up, prospective rebel leaders may seize the opportunity, expecting that commoners' willingness to rebel increases with deteriorating living conditions and lowered economic opportunity cost of fighting.

Why Location Matters

Before we move on to operational matters, a further specification of the theoretical framework is necessary. Above, we have argued that climate patterns and societies' ability to mitigate or adapt to changes in these patterns often vary greatly within countries. A drought might not have the same short-term impact on industrialized urban centers as it has on rain-dependent subsistence communities. Similarly, when a disaster strikes, politically important segments of society are much more likely to receive aid and compensation early on than are minorities and pastoralist groups. The logical implication of the refined environmental security proposition is straightforward; a drought constitutes a threat to security and peace primarily when it overlaps with other conflict-inducing features, notably political exclusion, economic marginalization, and cultural discrimination.

[41] Wickham-Crowley, *Guerrillas and Revolution in Latin America*.

Yet, a crucial question remains: Is any resulting violence likely to occur in the areas exposed to the drought? Strategic considerations might dictate that the locus of the initial riot or attack is set to maximize visibility or damage inflicted on the government. At the same time, a rebellion depends on local support to secure recruitment, funding, and shelter, as well as to establish a credible "just" cause. Consequently, popular uprisings and insurgencies are remarkably predictable in spatial terms. Even if rebel leaders occasionally emerge from cities outside the core insurgency area, rebel organizations usually issue demands that refer to local grievances and concerns as a justification for their actions.[42] Besides, rebels at the outset tend to be rather few and poorly equipped, and therefore lack the capability to conduct raids in distant locations. Often, conflicts start by rebel attacks on local police or army installations and nearby communications facilities such as radio and television stations. In Chiapas, the first military encounter between the local Zapatistas and state police forces occurred in San Cristóbal, the second-largest town in Chiapas. Similarly, the 1990 Tuareg uprising in Mali began with rebel attacks on government buildings in Gao Region, the heart of Tuareg territory, whereas the long-standing conflict in West Papua started with Papuan militias attacking Indonesian army headquarters in Manokwari District, West Papua.

That said, we do not disregard possible insecurity effects of drought that work through national-level mechanisms and that might have nationwide implications.[43] Rather, weakening of

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[42] An early and forceful articulation of this view can be found in Ted Robert Gurr, *Why Men Rebel* (Princeton, N.J.: Princeton University Press, 1970). See also Mahmood Mamdani, *Citizen and Subject: Contemporary Africa and the Legacy of Late Colonialism* (Princeton, N.J.: Princeton University Press, 1996).

[43] For arguments linking rainfall extremes and droughts at the national level to violent conflict see Cullen Hendrix and Idean Salehyan, "Climate change, rainfall, and social conflict in Africa," *Journal of Peace Research*, Vol. 49, No. 1 (January 2012), pp. 000–000.

the state economy and institutions, disintegration of national unity, and, potentially, state collapse should be seen as consequences of more immediate, local developments. This is evident in the current climate security discourse, in which most articulated warnings and speculations center on the vulnerability and resilience of local populations.[44]

Hypotheses

The general argument outlined above implies that increasing water scarcity and drought should have the most immediate impact on local communities. Moreover, a careful reading of relevant narratives suggests that a conflict-inducing effect of drought should be most pronounced when the drought strikes a marginalized, peripheral population. This gives the following testable propositions:

> *H1. Drought increases the local risk of civil war.*
>
> *H2. The effect of drought on civil war risk is larger in politically marginalized areas.*

RESEARCH DESIGN

Extant large-*N* studies of the general scarcity-conflict nexus offer inconclusive results.[45] Recently, a new wave of research addresses the climate-conflict link explicitly by studying short-

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[44] Boko et al., "Africa"; Stern, *The Economics of Climate Change*; United Nations Development Programme (UNDP), *Fighting Climate Change: Human Solidarity in a Divided World. Human Development Report 2007/2008* (New York: UNDP, 2007).

[45] For a review of the recent literature, see Salehyan's viewpoint article "From Climate Change to Conflict?"

term implications of climatic (precipitation, temperature) anomalies for civil war either directly[46] or via poor economic growth.[47] Although these studies reach widely different conclusions, they represent a significant step forward because they focus on rapid environmental changes rather than static conditions that shaped the first generation of relevant comparative research.[48] At the same time, they rely on a habitual country-level design and hence suffer from the same aggregation problem as earlier work. Such analyses may capture possible effects of drought that work through state institutions or have nationwide impacts (e.g., via displacement), but they are likely to miss or discount more immediate effects at the local level. Both climate and underlying factors that affect the latent risk of conflict (e.g., ethnopolitical exclusion, poverty, economic discrimination, population size, and settlement patterns) often display considerable variation

[46] Buhaug, "Climate Not to Blame for African Civil Wars"; Burke et al., "Warming Increases the Risk of Civil War in Africa"; Cullen S. Hendrix and Sarah M. Glaser, "Trends and Triggers," *Political Geography*, Vol. 26, No. 6 (August 2007), pp. 695–715; and Hendrix and Salehyan, "Climate Change, Rainfall, and Social Conflict in Africa."

[47] See Miguel et al., "Economic Shocks and Civil Conflict: An Instrumental Variable Approach," and later (critical) assessments of their analysis: Peter Sandholt Jensen and Kristian Skrede Gleditsch, "Rain, Growth, and Civil War: The Importance of Location," *Defence and Peace Economics*, Vol. 20, No. 5 (October 2009), pp. 359–372; and Antonio Ciccone, "Economic Shocks and Civil Conflict: A Comment," *American Economic Journal: Applied Economics*, Vol. 3, No. 4 (October 2011), pp. 215–227.

[48] See, for example, Daniel C. Esty, Jack A. Goldstone, Ted Robert Gurr, Barbara Harff, Marc Levy, Geoffrey D. Dabelko, Pamela Surko, and Alan N. Unger, *State Failure Task Force Report: Phase II Findings* (McLean, Va.: Science Applications International, 1998).

within countries, so aggregating data by country may introduce substantial measurement error and, possibly, ecological fallacy.[49]

To remedy this shortcoming, we developed a spatially disaggregated dataset for Africa, 1960–2004, derived from the PRIO-GRID database.[50] African economies are largely dependent on rain-fed agriculture, and the continent's overall high environmental vulnerability, weak institutional coping capacity, a predominantly rural population, and colonial legacy imply that our analytical design implicitly incorporates a number of important scope conditions.[51] The employed grid structure comes with a resolution of 0.5 x 0.5 decimal degrees, which corresponds to a cell size of roughly 50 × 50 kilometers. This resolution is high enough to ensure that even small countries such as Rwanda and Djibouti are represented by multiple cells, and sufficiently coarse to keep the size of the overall dataset at a manageable level. The African grid contains more than 10,000 unique cells per cross section. Each cell was observed once per year since 1960 or the year of independence of the country to which the cell belongs.[52] We excluded grid cells

[49] See Lars-Erik Cederman and Kristian Skrede Gleditsch, "Introduction to Special Issue on 'Disaggregating Civil War,'" *Journal of Conflict Resolution*, Vol. 53. No. 4 (August 2009), pp. 487–495, and subsequent articles in the same issue.

[50] Andreas Forø Tollefsen, Håvard Strand and Halvard Buhaug, "PRIO-GRID: A Unified Spatial Data Structure," *Journal of Peace Research*, Vol. 49, No. 2 (March 2012), in press

[51] In a slightly more technical jargon, the research design assumes a fixed-effects approximation by implicitly accounting for a number of (near) continent-wide features that plausibly may affect the environment's impact on civil war risk.

[52] To allow attaching country-specific features to the grid cells, each cell is assigned to one country only. Cells overlapping international borders are assigned to the country with the largest geographic share. For earlier grid-based analyses of civil war, see Halvard Buhaug and Jan Ketil Rød, "Local Determinants of African Civil Wars, 1970–2001," *Political Geography*, Vol. 25, No. 3 (March 2006), pp. 315–335; and Clionadh Raleigh and Henrik Urdal,

with little or no measurable amount of precipitation in a normal year (less than 100 millimeters); these areas are mostly uninhabited and, by definition, never experience drought.[53] The complete panel dataset includes about 350,000 valid observations.

The disaggregated research design offers a number of improvements over conventional country-level analyses; yet, there are alternative approaches to the grid structure. Perhaps the most appealing option would be to construct the data around politically relevant social groups.[54] After all, organized political violence is conducted by groups of people, not by individuals or artificial grid cells. At the same time, to capture the great within-country variation in precipitation, one would have to choose spatially distinct groups. Although there are good georeferenced ethnicity data available (see below), we decided not to let ethnic groups constitute our units of analysis, for two reasons. First, the size of ethnic group territories varies greatly, and some are large enough to introduce some of the aggregation problems that we seek to avoid. Second, focusing on ethnic groups would limit our dependent variable to ethnically based civil wars. An alternative approach would be to focus on first- or second-order administrative

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"Climate Change, Environmental Change, and Armed Conflict," *Political Geography*, Vol. 26, No. 6 (August 2007), pp. 674–694.

[53] A desert is commonly defined as an arid climate with less than 250 millimeters annual precipitation. See the Köppen climate classification as described in Tom L. McKnight and Darrel Hess, *Physical Geography: A Landscape Appreciation*, 8th ed. (Upper Saddle River, N.J.: Prentice Hall, 2004).

[54] See, for instance, Halvard Buhaug, Lars-Erik Cederman, and Jan Ketil Rød, "Disaggregating Ethno-Nationalist Civil Wars: A Dyadic Test of Exclusion Theory," *International Organization*, Vol. 62, No. 3 (July 2008), pp. 531–551.

entities.[55] Again, the heterogeneity in size is problematic. Besides, administrative boundaries may change over time, and their function varies among countries –sometimes in response to past conflict or anticipation of future unrest. To our knowledge, there is no publicly available time-series data on subnational political entities. A seeming drawback of the grid structure – its complete ignorance of sociopolitical entities and boundaries – is also a significant strength: the grid cells do not change over time; their size and outline are exogenous to past conflict and the political context; they may be aggregated or further disaggregated in a consistent manner; and they are immediately comparable across countries.

Data and Measurements

The dependent variable in all model specifications is onset of civil armed conflict, as defined by the UCDP/PRIO Armed Conflict Dataset.[56] We excluded coups d'état from the reported models; intra-government conflicts are distinct from disputes pitting state against nonstate actors and they are less relevant from a theoretical point of view.[57] To facilitate the spatially disaggregated analysis, all conflicts were pinpointed to the exact onset location (i.e., the locality of fighting on the first day of the conflict) and assigned corresponding geographical coordinates. The onset cells are coded 1 in the initial year of a new armed conflict, as well as in the first year of conflict recurrence after a peaceful intermittency of at least two calendar years. The explanatory factor of

[55] One example of this approach is Gudrun Østby, Ragnhild Nordås, and Jan Ketil Rød, "Regional Inequalities and Civil Conflict in 21 Sub-Saharan Countries, 1986–2004," *International Studies Quarterly*, Vol. 53, No. 2 (June 2009), pp. 301–324.

[56] Gleditsch et al. "Armed Conflict 1946–2001."; Lotta Themnér and Peter Wallensteen, "Armed Conflict, 1946–2010," *Journal of Peace Research*, Vol. 48, No. 4 (July 2011).

[57] The results change little if the coups are included, see supporting material

interest in this study is drought, operationalized as negative precipitation deviation. In Africa, annual rainfall is a good proxy for freshwater availability (as mentioned earlier, only 4 percent of arable land is irrigated), and precipitation-generated measures of drought are attractive given their exogenous relationship with human/societal behavior (in contrast to agricultural output, food prices, calls for international assistance, and other nonmeteorological proxies for drought).[58] Georeferenced precipitation data were derived from the Global Precipitation Climatology Centre of the UN-sponsored World Meteorological Organization (GPCC).[59] The GPCC data contain annual gauge-based estimates of total precipitation (millimeter) for the global land surface at 0.5 x 0.5 degree resolution for all years, 1951–2004. From the GPCC data, we constructed several alternative measures of drought, all calculated specifically for each cell year. The simplest indicator is a measure of proportional change, or growth, in annual rainfall (R) since the previous year $(R_{it} - R_{it-1})/R_{it-1}$).[60] We also included a variable that captures rainfall anomaly, or the relative deviation (%) from the long-term average annual precipitation in the cell. In addition, we tested a binary drought indicator from the United Nations Environmental Programme (UNEP/GRID Europe), based on precipitation data from the Climate Research Unit at the University of East Anglia. The UNEP data are available only for the period 1980–2001.

[58] Precipitation is certainly not the sole determinant of drought; lack of rainfall can be compensated for by irrigation, lakes, rivers, marshes, desalination of sea water, and drilling of water holes. Moreover, extreme temperatures dramatically increase soil evaporation and can offset otherwise favorable climatic conditions.

[59] A description of these data are provided in Bruno Rudolf and Udo Schneider, "Calculation of Gridded Precipitation Data for the Global Land-Surface Using In-Situ Gauge Observations," *Proceedings of the 2nd Workshop of the International Precipitation Working Group IPWG* (2005), pp. 231–247.

[60] Miguel et al., "Economic Shocks and Civil Conflict."

Aggregated data on annual rainfall correlate well with severe drought events; yet, such statistics could potentially mask drought events caused by the rain falling at the wrong time of the year. Hence, our preferred operationalization of drought is a more comprehensive measure that captures intra-annual deviations from normal precipitation. The Standardized Precipitation Index, SPI6, is the measure that corresponds best to nonmeteorological drought statistics, such as the EM-DAT database by the Centre for Research on the Epidemiology of Disasters. For each month, the SPI6 index measures negative deviation from normal rainfall during the six preceding months. The values are standardized where SPI6 estimates below 1 indicate near normal rainfall (or wetter); 1 to 1.49 indicate moderately dry; 1.5 to 1.99 indicate severely dry; and values in excess of 2 standard deviations indicate extremely dry. The monthly data are then aggregated to a yearly format and categorized to indicate drought events. The annualized SPI6 is coded 1 if there were at least three consecutive months with SPI6 ≥ 1 in the given grid cell during the year (moderate drought); 1.5 if the SPI6 was ≥ 1.5 for at least two consecutive months (severe drought); and 2.5 if both of the above criteria are met (extreme drought). If no drought event occurred during the year, the SPI6 is assigned the value 0. To ease interpretation and because the categorized SPI6 variable is an ordinal rather than interval scale, we employ a dichotomous variant of the SPI6 where all positive values are recoded 1. All drought measures are created in multiple variants to account for various time lags, reference periods, and cumulative scores. In addition, we include a spatially lagged SPI term that gives the cell-specific distance (log km) to the nearest drought event to capture potential displacement effects.[61]

[61] Recent case research suggests that migration in response to rapid environmental change tend to take the form of short-distance displacement, often to the nearest urban center (see contributions to special issue of *Population and Environment* (December 2010) on “Human Migration and the Environment”).

Spatial data on political marginalization of ethnic groups is generated from two recent and compatible data projects, the Geo-Referencing of Ethnic Groups (GREG) dataset and the Ethnic Power Relations (EPR) dataset.[62] The GREG project stores information on all significant ethnic groups in a geographic information systems (GIS) format, where each group is represented by one or more polygons that denote their settlement area. To obtain group-specific information on political status, we then linked the group polygons to the political status data from EPR. Note that EPR, in contrast to the GREG project, identifies politically relevant ethnic groups, so in some instances a GREG group was dropped or had to be merged with other groups to match the more inclusive delineation of the EPR data.

When adapted to the grid structure, each cell is coded in accordance with the status of the majority group within the corresponding geographic area. The variable for marginalized ethnic groups (MEG) takes on the value 1 in cell-years where the majority group in the cell is excluded from central governmental positions.[63] Reflecting the salience of ethnicity in African politics, a majority of observations contain excluded populations; only about one-third (36 percent) of the cell-years host ethnic groups in power (EGIPs). The MEG indicator is time-variant and captures

[62] A presentation of the GREG data can be found at Nils B. Weidmann, Jan Ketil Rød, and Lars-Erik Cederman, "Representing Ethnic Groups in Space: A New Dataset," *Journal of Peace Research*, Vol. 47, No. 4 (July 2010), pp. 491–499. The EPR data are described in Andreas Wimmer, Lars-Erik Cederman, and Brian Min, "Ethnic Politics and Armed Conflict: A Configurational Analysis of a New Global Dataset," *American Sociological Review*, Vol. 74, No. 2 (April 2009), pp. 316–337. Note that since work on this article was concluded, a georeferenced version of the EPR data has been released: Julian Wucherpfennig, Nils B. Weidmann, Luc Girardin, Lars-Erik Cederman, and Andreas Wimmer, "Politically Relevant Ethnic Groups across Space and Time," *Conflict Management and Peace Science*, Vol. 00, No. 00 (0000) pp. 000–000, in press.

[63] For a similar GIS-based application of the ethnicity data, see Buhaug et al., "Disaggregating Ethno-Nationalist Civil Wars."

important shifts in the national political structure of countries. In contrast to the strictly exogenous drought measures, however, the political status of ethnic groups may to some extent be a function of past power struggles as well as the regime's anticipation of future aspirations. The nature of the EPR data does not allow us to distinguish among marginalized groups based on the reason for their exclusion. We do, however, apply a one-year time lag to the MEG indicator to limit the potential for reverse causality, and as a sensitivity test we exclude subsequent civil wars for areas with a history of conflict, with little discernible impact on the results.

Contextual factors are controlled for by the following: (1) cell- and year-specific estimates of (log) population size, derived from the Gridded Population of the World, v. 3 data;[64] (2) a dummy marking off cells that contain the capital city; (3) distance to the nearest international border (log km); and country-level controls for (4) democracy, represented by the Polity 2 index of the Polity IV project;[65] (5) infant mortality rate from the UN's Population Division, supplemented by data from Henrik Urdal;[66] and (6) conflict history, represented by a

[64] Socioeconomic Data and Applications Center (SEDAC), "Gridded Population of the World Version 3 (GPWv3): Population Grids" (New York: SEDAC, Columbia University, 2005), http://sedac.ciesin.columbia.edu/gpw.

[65] Monty G. Marshall and Keith Jaggers, *Polity IV Dataset* (Columbia: Center for International Development and Conflict Management, University of Maryland, 2002). As an alternative measure of regime type, responding to concerns that the composite Polity scale is endogenous to civil war, we used the Scalar Index of Polities (SIP) developed by Scott Gates, Håvard Hegre, Mark P. Jones, and Håvard Strand, "Institutional Inconsistency and Political Instability: Polity Duration, 1800-2000," *American Journal of Political Science*, Vol. 50, No. 4 (October 2006), pp. 893–908. The results do not change, see supporting material.

[66] See Henrik Urdal, "People vs. Malthus: Population Pressure, Environmental Degradation, and Armed Conflict Revisited," *Journal of Peace Research*, Vol. 42, No. 4 (July 2005), pp. 417–434.

decay function of the time since the previous conflict in the country, using a half-life parameter of two years.[67]

All results reported below are based on regressions on a reduced sample to limit computation time and to avoid spatial autocorrelation.[68] The subsample contains all onset cell-years and a randomly drawn selection of 5 percent of the nonconflict observations, 1960–2004. The case control design is an efficient procedure to study excessively large datasets where most observations carry little information, and the logit estimator is unaffected by the relative share of 1s and 0s in the sample**.** For sensitivity tests, we employed rare events logit (relogit) and estimated the models on the full sample and on alternative, randomly drawn subsamples, all of which yielded virtually identical results to those reported here. Lastly, to better account for unit heterogeneity and correct for possible omitted variable bias, all models were reestimated with country fixed effects. The results do not change.[69]

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[67] The decay function acts as a control for temporal patterns in the data, where the risk of civil war outbreak is highest immediately after independence or the end of a previous armed conflict and decays over time for each peaceful year. The decay is given by $2^{-(\frac{T}{\alpha})}$, where T represents the number of years since the previous civil war or independence and α is the half-life parameter. Tests showed that α=2 (i.e., the conflict risk is halved every two years) gave the best model performance.

[68] To be precise, random sampling of nonconflict observations removes spatial correlation among the independent variables but does not address possible dependence among conflict observations. Yet, as each conflict is represented by a single observation (as opposed to considering all cells within the conflict zone or all cells that hosted battle events), we have little reason to suspect strong spatial dependence in the data.

[69] Michael D. Ward and Kristian Skrede Gleditsch, *Spatial Regression Models* (Thousand Oaks, Calif.: Sage, 2008) provide a useful introduction to spatial regression models. See the supporting material at http://www.prio.no/CSCW/Datasets/Replication-Data-List/ for a full documentation of the most important sensitivity analyses.

RESULTS

Climatic conditions, including rainfall patterns and temperature, vary considerably within most countries, and Africa is no exception. Figure 2 illustrates the distribution of normal annual precipitation across the continent. Evidently, large parts of the Sahara and Namib deserts have virtually no precipitation. Other regions are characterized by a tropical climate with distinct wet and dry seasons and where any drought is relative. More generally, figure 2 illustrates how climate zones tend to cross, rather than follow, national boundaries, thereby effectively pointing to the limitations of using aggregate statistics of country climate.

An initial assessment of the hypotheses offers little support for the propositions (table 1). The table shows a trivariate cross-tabulation of drought, ethnopolitical status, and onset of civil war. With such a high-resolution research design and point data for conflict outbreak, there is no surprise that civil war is a rare event indeed. Yet, conflict is not distributed completely at random. About one-third of all observations are represented by ethnic groups in power whereas only 9 of 59 conflicts (15 percent) break out in these areas. Drought exhibits a much weaker covariation with civil war. The conflict rate among the drought observations is 0.014 percent; the corresponding rate for nondrought observations is 0.018 percent (i.e., slightly higher). Still, the lower right cell, which represents the interaction between exclusion and drought, provides tentative, if weak, support for hypothesis 2. The relative increase in the proportion of onsets between EGIP observations and MEG observations is twice as large for drought observations as for non-drought observations. The limited number of conflict onsets, however, implies that these differences are not statistically significant with a reasonable margin of error.

Next, we ran a series of multivariate regression models. Table 2 presents three models: the baseline model with controls only (model 1), a model that adds a measure of local drought (model 2), and a model with the interaction between political exclusion and drought (model 3). In line with earlier research, model 1 shows that conflict is significantly more likely in areas dominated by marginalized ethnic groups (MEG). Proximity to the border, the capital city, high population density, and high infant mortality rate are other factors that are associated with a significantly higher risk of civil war onset. Although the result for local population density would seem to support notions of population pressure and demographic stress,[70] we interpret this finding as a consequence of two phenomena: the tendency for local governmental bodies and assets – typical targets of initial rebel assaults – to be located in urban centers such as towns and regional capitals, and the "urban bias" in media coverage. The coefficient for democracy is small and not significantly different from zero.

Model 2 introduces our preferred drought measure, the standardized precipitation index (SPI) dummy that captures within-year as well as between-year precipitation anomalies. Contrary to hypothesis 1, the SPI parameter estimate has a negative sign, suggesting a slightly lower risk of conflict onset in areas with drought. The coefficient comes with quite a large standard error, however, so one should be careful about drawing any conclusion regarding the direction of the relationship. Other testimonies to the trivial impact of drought on conflict risk are the virtually unaffected log likelihood and the similar coefficients for the other variables in model 2 compared to the baseline model.[71]

Model 3 offers an empirical evaluation of the proposed conditional effect of drought (hypothesis 2) by including an interaction term between SPI and the dichotomous measure of

[70] See, for example, Homer-Dixon, *Environment, Scarcity, and Violence*; and Kahl, *States, Scarcity, and Civil Strife in the Developing World*.

[71] In fact, model 2 performs worse than model 1 in terms of predicting new civil war onsets out of sample, see supporting material.

political exclusion, MEG. Again, the results counter the notion that acute water shortages increase the local risk of violent conflict. Instead, the location of civil war in Africa can be explained by generic political, socioeconomic, and geographic factors: a politically marginalized local population, high local population density, the country capital, proximity to an international border, and high infant mortality.

Overall, the results presented in table 2 provide little evidence that popular narratives of drought-induced conflict represent a widespread phenomenon. Even though the analysis has been designed to capture the conditions most conducive to violence (agriculture-dependent poor, local political exclusion) and thereby constitutes a more appropriate large-*N* test of environmental security arguments than earlier investigations, there are nevertheless reasons to caution against a hasty rejection of the hypotheses. Most critically, the results are based on a single operationalization of the key independent variable and only one possible interaction effect has been explored. Hence, we decided to run a comprehensive series of sensitivity tests to check whether our results are robust to changes in measurements and time lags, sample inclusion criteria, and model specifications.

Figure 3 offers a graphic illustration of the estimated impact of alternative drought measures, expressed as relative risks. A relative risk of 2 means that an increase in drought from the 10^{th} percentile to the 90^{th} percentile corresponds to a doubling of the estimated civil war risk, all else held constant. Relative risk ratios below 1 indicate a negative association. None of the twenty-one alternative drought variables obtain statistical significance with a 5 percent level of uncertainty; the confidence band crosses the line of no effect (relative risk equals 1) for all operationalizations. What is more, the parameter estimates fail to indicate a consistent direction of the relationship; we find both positive and negative signs of the point estimates, depending on the chosen variable. In contrast, we see that the 95 percent confidence interval for the relative risk of political exclusion is well outside the line of no effect. In words, areas inhabited by politically marginalized populations are between 1.8 and 9 times more likely to host a civil war than are core areas of the state.

We also tested interactions between the alternative drought measures and all control variables, with various time lags. A limited selection of these results is visualized in figure 4. All but one of the interaction terms returned insignificant coefficients (the interaction between population density and change in rainfall since the previous year suggests a negative relationship). Further sensitivity tests included replacing the dichotomous drought proxies with proximity measures, limiting the sample to subsaharan Africa, choosing alternative operationalizations of the conflict indicator (e.g., major wars only), and estimating country fixed effects regression. Lastly, we ran a series of country-level regressions on the effect of drought prevalence and severity on civil war risk. None of these tests yielded results that differ substantively and systematically from those reported here. Although some drought estimates obtain weak statistical significance under certain conditions, they do not warrant a modification of the overarching conclusion: drought is historically unrelated to the short-term risk of civil war in Africa. We refer to the supporting material for further details.

DISCUSSION

This study has focused on Africa for deliberate reasons. Most African countries are highly dependent on rain-fed agriculture for state income and distribution, employment, and food security.[72] They are typically characterized by poverty, weak state organizations, and ethnically

[72] See, for example, Boko et al., "Africa."

discriminatory, neopatrimonial regimes.[73] The continent also has a heterogeneous and highly variable climate, which is projected to become increasingly adverse in coming decades.[74] And Africa has hosted more armed conflicts than any other continent over the past decades.[75] In sum, Africa constitutes the ideal test bed for the "climate wars" thesis – the most-likely setting where a systematic covariance pattern of drought and armed conflict should be observed. That we do not find support for a drought-conflict relationship, then, is all the more damaging for the widely accepted drought-breeds-conflict proposition. Before concluding, let us offer a few remarks on the significance of this "nonfinding."

Drought, however defined, is a prevalent and recurring phenomenon, whereas civil war outbreak is a rare event. There is a tendency to ignore or underestimate the large number of false positives (i.e., occurrences of drought without conflict, for every instance where both phenomena are present). And although our finding is at odds with the rationale for at least two recent Nobel Peace Prize awards, other recent research comes to the same conclusion.[76] Besides, the case-

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[73] Paul Collier, *The Bottom Billion: Why the Poorest Countries are Failing and What Can Be Done about It* (Oxford: Oxford University Press, 2007). Strikingly, *The Bottom Billion* is devoid of any discussion of development challenges imposed by adverse and deteriorating environmental conditions. See also Michael Bratton and Nicolas Van de Walle, "Neopatrimonial Regimes and Political Transitions in Africa," *World Politics*, Vol. 46, No. 4 (July 1994), pp. 453-489.

[74] Christensen et al., "Regional Climate Projections."

[75] For the latest update of the UCDP/PRIO database, see Lotta Harbom and Peter Wallensteen, "Armed Conflicts, 1946–2009," *Journal of Peace Research*, Vol. 47, No. 4 (July 2010), pp. 501–509.

[76] Notably Buhaug, "Climate Not to Blame for African Civil Wars," though see also Thomas Bernauer, Anna Kalbhenn, Vally Koubi, and Gabriele Spilker, "Climate Change, Economic Growth, and Conflict," *Journal of Peace Research*, Vol. 49, No. 1 (January 2012) pp. 000–000; and,Ole Magnus Theisen, "Blood and Soil? Resource Scarcity

based environmental security literature, which generally is more supportive of an environment-conflict connection, covers many forms of scarcity, including human-induced environmental degradation. Only a handful of these studies concern water shortages directly. This literature is also vague on the type of collective violence, as well as the temporal dimension of the causal chain, and contributions rarely attempt to rank the importance of the environment relative to socioeconomic and political factors. Also, we should not ignore case studies that find little evidence of a causal connection between environmental scarcity and armed conflict.[77]

One caveat is in order: although drought does not seem to increase the short-term risk of civil war onset, it may affect its dynamics. The escalation processes during the drought in Tigray in the 1980s discussed above illustrates this well. Moreover, our empirical analysis says little about possible long-term implications of rainfall anomalies (i.e., how particular climates and variability patterns influence investment, economic activities, strategic political planning, demographic mobility, and other features that affect societal consolidation, nation building, and human security).[78] At the same time, if the claimed causal connection between climate and conflict is so subtle and complex that it cannot be traced in a quantitative and comparative

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and Internal Armed Conflict Revisited," *Journal of Peace Research*, Vol. 45, No. 6 (November 2008), pp. 801–818, which focuses on resource scarcity more generally.

[77] Benjaminsen, "Does Supply-Induced Scarcity Drive Violence Conflicts in the African Sahel"; and Peluso and Watts, *Violent Environments*.

[78] That said, two recent longitudinal studies report that periods with adverse climatic conditions, notably cooling, were associated with higher frequencies of war in the pre-industrial era; see Tol and Wagner, "Climate Change and Violent Conflict in Europe over the Past Millennium"; and Zhang et al., "Global Climate Change, War, and Population Decline in Recent Human History."

framework, then we are unable to offer meaningful, general policy advice that refer specifically to security implications of climate change.

CONCLUSION

In his acceptance lecture on the occasion of the Nobel Peace Prize award, President Barack Obama stated that "There is little scientific dispute that if we do nothing, we will face more drought, more famine, more mass displacement – all of which will fuel more conflict for decades."[79] So far, there is little scientific evidence to support this claim. The results presented in this article demonstrate that there is no direct, short-term relationship between drought and civil war onset, even within contexts presumed most conducive to violence. At the same time, the analysis solidifies claims of recent scholarship on the importance of ethnically inclusive institutions for maintaining peace. Ethnopolitical exclusion is strongly and robustly related to the local risk of civil war. These findings contrast efforts to blame violent conflict and atrocities on exogenous non-anthropogenic events, such as drought or desertification. The primary causes of intrastate armed conflict and civil war are political, not environmental. Consequently, the future security of Africa depends not on climate mitigation but on political and socioeconomic development.

A likely objection to this conclusion relates to the magnitude of things to come; the rate and extent of past warming and drying will increase manifold in coming decades, so we cannot use historical data to project future trends. This may hold some truth, as there are limits to the coping capacity of any (agrarian) society. Crops grow only under given climatic conditions, and

[79] Barack H. Obama, "Nobel Peace Prize Lecture" (Oslo: Norwegian Nobel Committee, December 10, 2010), http://nobelpeaceprize.org/en_GB/laureates/laureates-2009/obama-lecture/.

livestock perish in the absence of water and pasture. At the same time, gloomy interjections tend to ignore technological, societal, and political developments that might mediate (or accentuate) adverse environmental change. Increasing urbanization relieves some of the pressure on rural lands; technological innovation, DNA manipulation, irrigation, and desalination plantations promise significant increases in agricultural productivity (even though implementing such technologies successfully may prove challenging); and increasing economic interdependence and spread of liberal democratic values would suggest a more equitable distribution of resources and better disaster preparedness and response. The last ten to fifteen years have seen a striking drop in the frequency of civil wars in Africa, at a time when temperature has risen to unprecedented levels and drying has prevailed across much of the continent.

Although a drought is unlikely to directly cause civil war, climate change will affect human security in a broader sense. Drought and other climatic shocks frequently cause dismay and poverty, and more extreme weather in the years to come suggests more human suffering. For this reason alone, we should invest more in solid research on the social dimensions of climate change. But to raise alarm about coming "climate wars"[80] may do more harm than good, as it could lead to a militarization of the issue and raising of barriers to prevent immigration, thereby harming those who are most in need of assistance.

Finally, future research needs to apply a broader understanding of political violence and armed conflict than is normally the case today. Given data limitations and a perception that major, state-based conflicts carry greater potential for political instability and state collapse than small-scale interethnic skirmishes, recent scholarship has focused almost exclusively on civil

[80] Recent publications with a strongly alarmist tone include Gwynne Dyer, *Climate Wars* (Canada: Random House, 2009); James R. Lee, *Climate Change and Armed Conflict* (New York: Routledge, 2009); and Joseph Romm, *Hell and High Water* (New York: HarperCollins, 2007).

wars.[81] This is reflected in the contemporary discourse on climate security, which is dominated by a state-centric approach. In contrast, narratives and news reports of conflict over diminishing resources frequently concern clashes between rivaling ethnic groups or between pastoralists and sedentary farmers. The conflicts in Assam in India, Darfur in Sudan, Kenya, Mali, and Mauritania, all central cases in the environmental security literature, were at least initially interethnic conflicts without explicit state involvement. A key question in this regard is how environmental conditions and rapid environmental change affect intercommunal relations and local land use disputes, and what role the state plays in ending or fuelling these conflicts.

[81] Exceptions include Raleigh, "Political Marginalization, Climate Change, and Conflict in African Sahel States"; Karen Witsenburg and Wario Adano, "Of Rain and Raids: Violent Livestock Raiding in Northern Kenya," *Civil Wars,* Vol. 11, No. 4 (December 2009), pp. 514–538; as well as several contributions to the special issue on climate change and conflict in *Journal of Peace Research*, Vol. 49, No. 6 (January 2012), in press. See also the Uppsala Conflict Data Program's Non-State Conflict dataset, http://www.pcr.uu.se/research/ucdp/datasets/, and a new database on social conflicts in Africa from the University of Texas at Austin, http://www.scaddata.org/.

FIGURES AND TABLES

Figure 1. Changes in Mean Annual Precipitation from 1952–61 to 1995–2004

Note: The map shows changes in mean annual precipitation from the first to the most recent decade of precipitation data (1952–61 and 1995–2004, respectively). White areas are deserts with mean annual precipitation below 100 millimeters. See data and measurements section for further details.

Figure 2. Average Annual Precipitation in Africa, 1952–2004

Note: The map shows the spatial distribution of precipitation across Africa, based on high-resolution data from the Global Precipitation Climatology Centre. White areas are deserts with less than 100 millimeters precipitation per year whereas the wettest parts of Africa recieve more than 3,500 millimeters of rain in a normal year.

Figure 3. Relative Risk for Alternative Drought Measures

Note: The plot shows estimated change in the risk of civil war onset when the value of the drought measure shifts from the 10th percentile to the 90th percentile (from 0 to 1 for dichotomous measures), holding all control variables at their means. The mean point estimate is marked with a dot and 95 percent confidence bands with lines. Relative risk is calculated by dividing the estimated probability of conflict given high drought value by the probability of conflict given low drought value. Relative risk above 1 indicates an increase in civil war risk with higher drought values while values below 1 indicate a reduction in conflict risk with higher drought values. The marginalized ethnic group (MEG) indicator denotes areas hosting politically excluded ethnic groups.

Sources: Georeferenced precipitation data were derived from the Global Precipitation Climatology Centre of the UN-sponsored World Meteorological Organization, see Bruno Rudolf and Udo Schneider, "Calculation of Gridded Precipitation Data for the Global Land-Surface Using In-Situ Gauge Observations," *Proceedings of the 2nd Workshop of the International Precipitation Working Group IPWG* (2005), pp. 231–247. The SPI indicator was calculated from the same source. UNEP's drought data are from UNEP/GRID-Europe (2009), "Droughts events 1980-2001." Available at http://preview.grid.unep.ch (last accessed October 5 2011). For the MEG-data see Weidmann et al., "Representing Ethnic Groups in Space"; and Wimmer et al., "Ethnic Politics and Armed Conflict."

Figure 4. Relative Risk for Selected Interaction Terms

Note: The plot shows estimated change in the risk of civil war onset when the value of the drought measure shifts from the 10^{th} percentile to the 90^{th} percentile (from 0 to 1 for dichotomous measures), holding interacting contextual variables at the 90^{th} percentile (MEG, IMR, population) or the 10^{th} percentile value (Polity); all other variables are held at their means. The mean point estimate is marked with a dot and 95 percent confidence bands with lines. The MEG indicator denotes areas hosting politically excluded ethnic groups; IMR is infant mortality rate.

Sources: For the MEG-data see Weidmann et al., "Representing Ethnic Groups in Space"; and Wimmer et al., "Ethnic Politics and Armed Conflict"; for the Infant mortality data (IMR) see Urdal, "People vs. Malthus"; for the Polity-data see Marshall and Jaggers, *Polity IV Dataset*; and for the population data see SEDAC, "Gridded Population of the World Version 3."

Table 1. Cross Tabulation of Drought, Political Exclusion, and Civil War Onset

	Ethnic Group in Power (EGIP)		Marginalized Ethnic Group (MEG)	
	No Drought	Drought	No Drought	Drought
No onset	98,277 (99.992%)	22,844 (99.997%)	186,079 (99.977%)	42,855 (99.981%)
Onset	8 (0.008%)	1 (0.003%)	42 (0.023%)	8 (0.019%)
Total	98,285 (100%)	22,845 (100%)	186,121 (100%)	42,863 (100%)

Note: Relative frequencies by column are given in parentheses. EGIP represents cells where the local population is part of the national government; MEG observations are excluded from the national government. Drought is represented by the annualized, dichotomous SPI6 statistic. See data section for further details.

Table 2. Logit Regression of Local Civil War Onset, 1960–2004

Variables	Model 1	Model 2	Model 3
Drought (SPI)		–0.303	–0.419
		(0.333)	(1.095)
Marginalized Ethnic Group	1.394*	1.407*	1.390*
	(0.426)	(0.428)	(0.460)
Marginalized Ethnic Group × Drought			0.133
			(1.148)
Distance to border (ln)	–0.268*	–0.268*	–0.268*
	(0.100)	(0.099)	(0.099)
Capital city	1.947*	1.974*	1.971*
	(0.473)	(0.465)	(0.467)
Cell population (ln)	0.483*	0.484*	0.484*
	(0.095)	(0.095)	(0.095)
Infant Mortality Rate $_{t-1}$	0.010*	0.010*	0.010*
	(0.004)	(0.004)	(0.004)
Democracy $_{t-1}$	0.013	0.014	0.014
	(0.022)	(0.022)	(0.022)
Conflict history	–0.127	–0.122	–0.122
	(0.350)	(0.354)	(0.355)
Constant	–11.79*	–11.72*	–11.70*
	(1.361)	(1.365)	(1.360)
N (grid cell)	17,393	17,393	17,393
N (civil war onset)	59	59	59
Log pseudolikelihood	–351.633	–351.275	–351.268

Robust standard errors clustered on country in parentheses. * $p<0.05$.