2010

Change We Can Fight Over: The Relationship between Arable Land Supply and Substate Conflict; Strategic Insights, v. 9, issue 1 (Spring-Summer 2010) ; pp. 65-89

Black, Nathan

Monterey, California. Naval Postgraduate School

Strategic Insights, v.9, issue 1 (Spring-Summer 2010
http://hdl.handle.net/10945/11514

STRATEGIC INSIGHTS
E-journal published by the Center on Contemporary Conflict

Change We Can Fight Over: The Relationship between Arable Land Supply and Substate Conflict

Nathan Black

Introduction

After decades of debate, most natural scientists have now acknowledged that the earth's temperature is rising. These scientists also predict that the environmental consequences of global climate change over the next 20-100 years will be significant.[1] This gradual realization of the existence and environmental impact of global warming has spurred a parallel discussion among national security academics and policymakers about the security consequences of climate change. Roughly speaking, there are two camps in this discussion—one that ominously predicts the potential for global warming to spark violent resource-related conflicts all over the world,[2] and one that views the link between climate change and conflict as ambiguous and unproven.[3]

This debate between alarmists and skeptics (of the security consequences of climate change, not of climate change itself) has clear consequences for great power security policy in the coming decades. In recent years the great powers have begun to take slow steps toward the prevention and mitigation of future climate change, but the stark reality is that global warming is already upon us. Thus, policymakers need to know—both now and in the coming decades—whether climate change can be expected to touch off the resource conflicts that some analysts have predicted. If the answer is in the affirmative, then considerably more resources need to be put against the prevention and mitigation of climate change-related violence, and not simply against the prevention and mitigation of global warming itself.

But the resolution of this debate has proved difficult, because the alleged link between climate change and violent conflict is not direct—the weather does not reach down and start wars. Rather, what is being proposed by the alarmist camp is a multi-step process. First, global warming will cause environmental degradation in many parts of the world, such as Africa and Latin America, that are already prone to conflict.[4] Second, environmental degradation will result in natural resource scarcities. Third, these resource scarcities will supposedly lead to armed violence between competing non-state actors and/or states. Each of the steps in this process must be validated conclusively in order for us to predict that climate change will increase the frequency of armed conflict in the future. Thus, recent empirical work that has shown a direct statistical association between changes in rainfall or temperature and conflict gives us little sense of the mechanisms by which these environmental changes are actually associated with conflict, and therefore gives us only limited confidence that these statistical associations will persist in the future.[5]

This article attempts to move this important climate change and conflict debate forward by focusing in on one step—the final one—in the alleged climate change to conflict process. The article explores the relationship between supply-side changes to a single but critical natural resource, arable land, and the likelihood of both civil war and substate armed conflict in general between 1965 and 1999. In so doing, the article speculates on the effect of one likely outcome of climate change, rather than attempting to directly estimate the future effect of climate change itself (see Figure 1). The Intergovernmental Panel on Climate Change predicted in 2007 that "agricultural land" would decrease as a result of global warming, particularly in Africa and Latin America.[6] Logically, then, if reductions in agricultural land supply—here measured as "arable land" supply (on definitions, see below)—and substate conflict have been linked in the past, then climate change, to the extent that it exacerbates such supply reductions, will probably increase the likelihood of conflict in the future.[7]

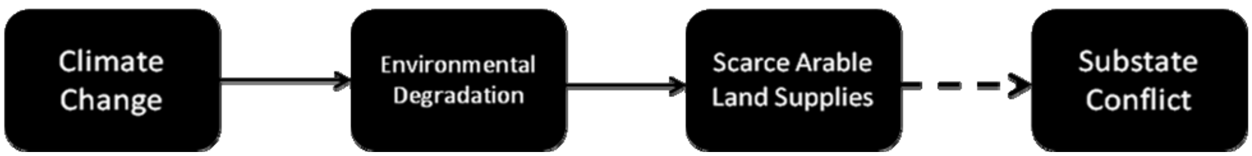

Figure 1. Possible causal pathway from climate change to substate conflict, with the link to be explored in this article represented by the dotted line.

Beyond its salience to the climate change debate, this article's focus on the land-conflict link specifically represents a needed addition to the existing academic literature. Prior empirical work on renewable resources and substate conflict has frequently attempted to measure the link between land scarcity and conflict, but has not done so using the most intuitive and theoretically consistent explanatory variable. As a result, the findings obtained by these studies are inconclusive and often contradictory.

This article, in contrast, finds an unambiguous and robust relationship between arable land supply and substate conflict. Using a more intuitive and theoretically consistent specification of the explanatory variable—measuring changes in arable land supply over time, rather than capturing the resource endowment at a single time-point—this article shows that changes to that supply are, in fact, significantly associated with the likelihood of civil war. These results therefore suggest that, at least with respect to one key natural resource, the final alleged link in the causal chain from climate change to conflict is valid, and that arable land supply changes arising from future climate change should be of concern to security policymakers. To achieve a fuller understanding of the mechanisms underlying this robust statistical association, this article then proposes a preliminary theory of the way in which arable land scarcity causes substate conflict. This theory is based on the finding that positive changes to arable land supply decrease the probability of war much more than negative changes increase the probability, leading to a view of arable land supply change as a direct brake on conflict and only an indirect gas pedal. In the end, then, this article comes down in between the alarmists and the skeptics in the climate change and conflict debate. The article predicts that climate change, to the extent that it diminishes arable land supplies, will marginally increase the likelihood of civil war—but the article emphasizes that we should only expect to see such resource wars where the difficult task of popular mobilization by insurgent or counterinsurgent elites is successfully completed.

The next section reviews the past empirical tests of the relationship between land and substate conflict, and identifies an important specification of the explanatory variable that has not yet been tried. In the third section, the consistency of this new specification with major theories of scarcity and conflict is demonstrated. The fourth section details the article's own empirical test, which aims to overcome the shortcomings of the prior literature. The large-N results, presented next, show strong and robust support for an arable land supply-civil war relationship, and suggest the preliminary theory that is then detailed. The case of Darfur is then used to illustrate this theory. The concluding section considers the implications of these results for the climate change-conflict debate and identifies directions for future research.

Past Empirical Tests of the Land-Conflict Relationship

Table 1 summarizes the specifications and findings of seven major tests of the relationship between land and substate conflict, with publication dates spanning from 1998 to 2008. These seven articles do not examine land in particular but rather the general link between renewable resources and substate conflict; the table shows the tests and results that pertain specifically to land. In this section the indeterminacy of these tests is shown, and it is postulated that the indeterminacy arises from a counter-intuitively specified explanatory variable.

The large-N literature on land and substate conflict is widely acknowledged to have begun with the competing findings of Hauge and Ellingsen (1998) and Esty *et al.* (1999). Hauge and Ellingsen claim to find direct associations between the extent of soil degradation in a state and the likelihood of both civil war and lower-grade substate conflict in that state, while Esty *et al.* find no such direct relationship. Instead, the closest Esty *et al.* come is correlating "soil degradation" (severity times "rate") with infant mortality, which is in turn correlated with the likelihood of "state failure." (State failure encompasses civil war but includes other phenomena, including "adverse or disruptive regime transitions," "genocides" and "politicides."[9])

The empirical debate over whether a land-conflict link exists, and over whether that link is direct or mediated by socioeconomic or institutional factors, has continued intermittently for the subsequent decade with mixed and often contradictory results. For example, Hendrix and Glaser (2007) agree with Esty *et al.* that land degradation and armed conflict onset are not directly related, but in the same year Raleigh and Urdal (2007) found a positive association between soil degradation and armed conflict. Most recently, Theisen (2008) attempted a resolution of this debate by replicating the original Hauge and Ellingsen model. Among his other findings, he discovered that contrary to Hauge and Ellingsen's original claim, soil degradation severity and civil war onset were *not* significantly related. Furthermore, the relationship between soil degradation severity and armed conflict in general was shown to be rather weak.

Table 1: Summary of Previous Tests of the Land-Substate Conflict Relationship

Article	Dependent Variable	Proxy for Land	Finding
Hauge and Ellingsen 1998	Onset of civil war (Correlates of War definition), 1980-1992 and onset of armed conflict (PRIO definition), 1989-1992	Soil degradation severity (ordinal), as measured by the UNEP in 1990	"Moderate" and "high" soil degradation positively and significantly associated with both civil war onset and armed conflict onset
Esty *et al.* 1999	State failure, 1957-1996; infant mortality as an intervening dependent variable	Ordinal soil degradation severity (UNEP) and ordinal estimates of rate of degradation over past 5-10 years; "land burden" (farmers per unit cropland multiplied by ratio of farmers to total workers) and rate of change in land burden	No significant relationship between either proxy and state failure; soil degradation (severity times rate) is positively associated with infant mortality, which in turn is associated with state failure
De Soysa 2002	Onset of armed conflict (PRIO definition), 1989-2000	Arable land as percentage of total land at a single time-point	Negative and significant relationship between arable land percentage and armed conflict onset
Urdal 2005	Onset of armed conflict (PRIO definition), 1950-2000	None, but considers "population density" with respect to cropland (population divided by cropland area in country); cropland measured at a single time-point	No significant relationship between an interaction term (population growth multiplied by "population density") and conflict; weakly significant negative association between "population density" itself and conflict
Hendrix and Glaser 2007	Onset of armed conflict (PRIO definition)[8] in Sub-Saharan Africa, 1981-2002	Percentage of land degraded as measured by the FAO at a single time-point	No significant coefficients on land degradation in any of the models
Raleigh and Urdal 2007	Onset of armed conflict (PRIO definition), 1990-2004	Soil degradation severity (ordinal), as measured by the UNEP in 1990	"Medium" and "high" soil degradation positively and significantly associated with armed conflict onset
Theisen 2008	Onset of civil war (Correlates of War definition), 1980-1992 and onset of armed conflict (PRIO definition), 1989-1992	Soil degradation severity (ordinal), as measured by the UNEP in 1990	"High" soil degradation positively and significantly associated with armed conflict onset but "medium" soil degradation only weakly associated; soil degradation and civil war onset not significantly associated

The balance of these empirical works might suggest, at first glance, a null hypothesis that there is no consistent relationship between land supply and substate conflict. This, in turn, would suggest that in the vast universe of worries on the minds of great power security policymakers, the impact of climate change on states' land supplies should perhaps be a small concern. However, this conclusion would be premature, because the land-conflict relationship has not yet been tested with a more intuitive specification of land supply.

Looking down the "proxy for land" column of **Table 1**, it quickly becomes evident that almost every land-related explanatory variable is static—it measures the quantity of land or the extent of land degradation at a single point in time. For instance, the frequently-used ordinal indicator of "soil degradation" severity was published by the United Nations Environmental Program in 1991, and considers only soil degradation as assessed in 1990.[10] The measures of Hendrix and Glaser (2007) are similarly time-invariant; that used by de Soysa (2002) appears to be as well. Some of the measures of land used by Esty *et al.* (1999) can be considered measures of the change in land supply over time, but even these are tenuous. (The "rate" of soil degradation is an ordinal estimate of the one-time change from 1980-1990 or 1985-1990; the rate of change in "land burden" is mainly a measure of the change in *demand* for land, not in the change to *supply* of land.) As for Urdal (2005), although he does measure the extent to which a state's population's demand for land changes over time, he does so while measuring a state's cropland area at a single time-point.[11] (In other words, population varies over time in his model, but not land supply.)

These static specifications of the explanatory variable, land supply, do not seem directly related to the postulated climate change to conflict process that is of substantive interest in this article. In that process, environmental degradation is alleged to decrease a given state's agricultural land supply, leading to violent resource conflicts. But decreases (or increases) in a state's land supply are not measured in these previous empirical works; only a snapshot of a state's land at one time-point is known. From these works we might be able to conclude that countries with less or lower-quality land than other countries are more likely to experience substate conflict—although the indeterminacy of the results shown above do not fully support that conclusion—but we cannot conclude that countries which experience a negative shock to their land supply are more likely to experience conflict.

Hence, given the recent context of the climate change and conflict debate, there is a need for a study which examines the relationship between the *change* in a state's arable land supply and the likelihood of both civil war and violent substate conflict in general. This article fills that gap, using data on arable land supply collected at the state level by the Food and Agriculture Organization (more on these data below). Measures of hectares of arable land are available in time-series for almost every country in the world from 1961 to 1999.[12] Thus we have rich data to link over-time abundance changes to conflict propensity.

The Importance of a Dynamic Explanatory Variable to Scarcity and Conflict Theories

In addition to fitting more intuitively in the "climate change to conflict" debate that this article engages, a dynamic specification of the arable land supply explanatory variable is also more consistent with major theoretical perspectives on scarcity and substate conflict. Several of these theoretical perspectives are discussed in this section, and the importance of a dynamic independent variable to each of these perspectives is demonstrated. It should be noted that these theoretical perspectives are not mutually exclusive and are often combined in empirical studies; likewise, they will be combined in the preliminary theory of arable land scarcity and conflict that is proposed below.

Homer-Dixon and "Supply-Induced Scarcity"

The major contemporary theory of natural resource scarcity and substate conflict comes from Thomas Homer-Dixon (1999). Homer-Dixon's basic argument is that "environmental scarcity" is causally linked to substate conflict through two mechanisms. The first mechanism, "resource capture," "occurs when powerful elites use their power in order to grab resources they anticipate will become scarce in the near future."[13] This results in a spiral of hostilities between elites and masses, in which the masses are aggrieved by the even greater scarcities and the elites weaken the political institutions that might otherwise alleviate the tensions. The second mechanism, "ecological marginalization," "takes place when population groups faced with scarcity of resources migrate into an area with a fragile ecosystem, in turn creating greater scarcities in that area and deprivation conflicts between natives and newcomers."[14] The importance of a dynamic explanatory variable is evident from this short exposition of Homer-Dixon's theory. It is the *changes* over-time to the natural resources in this theory, and elite and mass responses to those changes, that set in motion the mechanisms that lead to conflict. Two additional potential mechanisms by which environmental scarcity might lead to substate conflict are described by Kahl (2006): "state failure," by which scarcities erode the state, and "state exploitation," by which elites foment scarcity-based conflicts that benefit them politically. Again, a time-variant explanatory variable would be required to test the presence of either of these mechanisms.

Homer-Dixon also introduces a useful typology of "environmental scarcity" that helps us state more precisely what the explanatory variable in this study consists of. There are three types of environmental scarcity, he writes. "Supply-induced scarcity" is scarcity brought on by shrinking resource pools. "Demand-induced scarcity" results from more people wanting to draw from a given resource pool; population pressure is a common proxy for demand-induced scarcity. "Structure-induced scarcity" results from an uneven distribution of a resource pool; in this sense, even a resource-rich country such as the United States could suffer from environmental scarcity.[15] In the empirical works discussed above, some scholars focus on supply-induced scarcity,[16] some focus on demand-induced scarcity,[17] and some focus on a combination of the two.[18] Because my interest is ultimately in the impact of climate change on the likelihood of substate conflict, this article will focus on the supply-induced scarcity of arable land. Global warming will not directly affect the demand for arable land or the distribution of arable land; it will impact its supply, and thus it is changes to arable land supply that are of greatest interest in this article.

Relative Deprivation

Another, older theory which postulates a relationship between scarcity and substate conflict—and which, incidentally, is not confined to the scarcity of environmental assets—is the Relative Deprivation (RD) theory articulated by Gurr (1968a, 1968b, 1970). Gurr defines RD as "actors' perceptions of discrepancy between their value expectations … and their value capabilities,"[19] where "value expectations" are "the goods and conditions of life to which people believe they are rightfully entitled" and "value capabilities" are "the goods and conditions they think they are capable of attaining or maintaining, given the social means available to them."[20] The key insight here is that absolute well-being is not as great an explanatory factor as is an individual's assessment of his or her relative well-being.[21] The relationship Gurr posits between RD and substate violence is direct and straightforward: "The more severe is relative deprivation, the greater the likelihood and intensity of civil violence."[22]

RD was and is an important theoretical contribution to the civil war literature, yet in general only one particular variety of RD has been tested empirically. Most RD research has considered as the explanatory variable the differences in well-being between social groups at a given point in time. This is *intergroup* RD, and thus would be concerned with structure-induced scarcity within Homer-Dixon's framework. For example, Morrison and Stevenson (1972) look at the difference between "elite" secondary school enrollment and "mass" secondary school enrollment as one of their explanatory variables in their study of African "communal instability." Intergroup RD research can only occasionally be found in modern political science, and now as then, as an explanatory variable it has only limited empirical support.[243]

But RD need not be intergroup, as Gurr and contemporary theorists were quick to point out. Gurr writes, "An individual's point of reference may be *his own past condition*, an abstract ideal, or the standards articulated by a leader as well as a 'reference group.'"[24] Thus RD can be temporal as well—the worsening of a person's or a group's condition over time, rather than relative to other people or groups, could be a cause of armed violence. Several other social scientists have invoked some form of "temporal RD," as I will call it, in their own theories of civil conflict. James Davies (1962), in his well-known "theory of revolution," adapts an insight from Alexis de Tocqueville to hypothesize that "revolutions are most likely to occur when a prolonged period of objective economic and social development is followed by a short period of sharp reversal."[25] His (and Tocqueville's) most compelling example is the French Revolution, which followed centuries of abject poverty, one century of relative improvement, and a brief period of relative decline (in that order).

Clearly temporal RD, as a theoretical mechanism linking scarcity and conflict, also requires a dynamic explanatory variable. Simply knowing how much arable land a state had at some time-

point is not sufficient to determine whether the temporal RD mechanism is at work. To know whether individuals or groups are going to feel deprived of a resource, we must also know what their baseline endowment of the resource was, because this baseline endowment will determine, in large part, the “value expectations” that Gurr discusses.
(Note: Although the focus of this article is on changes in arable land supply over time—hence examining temporal RD to the exclusion of intergroup RD—intergroup RD is also considered by way of inclusion of the “land GINI” control variable, discussed in more detail below.)

The Grievance School of Civil War

The final theoretical perspective on scarcity and substate conflict comes from a more recent and well-known source than the previous two perspectives discussed, although it incorporates elements of the previous two perspectives as discussed below. That source is the “grievance” school of the civil war literature, which has risen in opposition to the “greed” school (Collier and Hoeffler 2004).[26] (However, as discussed below, a causal story told from the “greed” school’s perspective might be observationally equivalent in my test.) The basic theory of civil war proposed by the grievance school is that internal wars are most likely to break out when everyday people in a given country have something to be angry or fearful about. Political elites need rank-and-file members in order for their insurgency or counterinsurgency campaigns to even get off the ground, so they attempt to recruit ordinary people by exploiting an existing grievance. For instance, insurgent elites in El Salvador won over many fighters and passive supporters with their message that the long-standing gross misdistribution of land within the state was outrageous, not inevitable (Wood 2003). But a similar mobilization attempt in the Santa Cruz region of Bolivia, where land was abundant, failed—one observer remarked, “What was Ché going to offer these peasants, still more land they could not use?”[27] According to grievance theory, then, the greater the level of mass grievance in a state, the greater the likelihood that elites will mobilize that grievance into a successful recruitment campaign and the greater the subsequent likelihood of major armed substate conflict.

The conditions of supply-induced scarcity and temporal relative deprivation, described above, seem to be two of many potential forms of mass grievance. (Intergroup relative deprivation, demand-induced scarcity, and structure-induced scarcity are others.) With these examples in mind, it is difficult—though not impossible—to imagine measuring mass grievance with a static explanatory variable, such as a state’s arable land endowment or GDP per capita at a particular time-point. People might be aggrieved by their absolute poverty, hunger, or lack of livelihood, but they seem more likely to be aggrieved by their negative assessment of their *relative* well-being over time. The use of a dynamic explanatory variable, such as arable land growth or GDP growth, thus seems more consistent with the grievance school of civil war.

All three theoretical perspectives on scarcity and substate conflict, then, suggest that the explanatory variable of interest should capture change over time, rather than an absolute resource endowment at a single time-point. The use of a dynamic explanatory variable will thus constitute this article’s empirical approach going forward. Specifically, this article tests the hypothesis of the grievance school as it applies to arable land scarcity—arable land scarcity should increase pools of grievance within states, which should make mass recruitment into insurgencies and counterinsurgencies easier and, therefore, civil wars more likely—against the null hypothesis that there is no such causal link between arable land scarcity and substate conflict.

Specification of Empirical Test

The unit of analysis in this study is the country-year. This article used the Fearon and Laitin (2003) civil war dataset as the baseline for data collection.[28] These data cover 161 countries between 1945 and 1999. Because data on the independent variables are generally only available from 1965 onward, the baseline dataset was censored to run from 1965 to 1999. This puts the total number of country-year observations at 4,872. The dependent variable, "onset," is drawn from the Fearon and Laitin baseline dataset. It takes a value of 1 if a civil war started in a given country-year, and 0 otherwise. Of the 4,872 observations, 81 (1.7 percent) are onset country-years. As a robustness check, this article also considers the onset of armed conflict, as defined by the International Peace Research Institute, Oslo (PRIO), in the same country-years.[29] Since the annual observational bar for "armed conflict" (25 battle-related deaths) is lower than the bar for civil war (1,000 battle-related deaths), there are more positive observations—172, or 3.5 percent.

The primary independent variable is "delta-land": the three-year percentage change, from *t*-4 to *t*-1, of hectares of arable land in the country.[30]The three-year change is meant to capture a medium-term increase or decline in a state's arable land endowment—one sufficiently sustained that the population of that state would notice (but not over such a long period that the population would forget its baseline resource endowment).[31] This variable is calculated from the absolute hectares of arable land in each country-year. These data are drawn from the World Development Indicators,[32] which in turn relies on the Food and Agriculture Organization (FAO) for reporting. The FAO collects its arable land data from a mix of country's self-reports and expert estimates. The mean value of delta-land is +2 percent, with a standard deviation of 8.5 percent.

According to the FAO, arable land is defined as "land under temporary crops, … temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years)." It is contrasted with "permanent cropland," which consists of land for crops that are not replanted annually such as "cocoa, coffee and rubber," and "permanent pasture," which is "land used permanently (five years or more) for herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land)."[33] Between these three measures, I believe arable land is the best to use for this study. "Permanent cropland" seems less likely to be relevant to the causes of substate conflict, because the resources that grow on such land seem less vital. "Permanent pasture" could be relevant but the data seem less reliable. First, the FAO warns of overlap between this category and the "forests and woodland" category, which was discontinued in 1995. Secondly, an examination of the FAO data indicates that the "arable land" indicator is more likely to change from country-year to country-year and is less likely to be self-reported. Overall, arable land seems to be the most reliable and the most intuitive measure of the health of a state's agricultural land supply.

The following control variables were used:

Arable land per capita (the static value). This would be a more traditional primary independent variable in a test of renewable resources and conflict, so it is worth seeing its association with conflict as well. Data are from the World Development Indicators.

Change in the state's population from *t*-4 to *t*-1. This is the proxy for demand for arable land; since we want to know the specific association between arable land supply change and war, we need to control for the other types of scarcity defined by Homer-Dixon. This variable is transformed from raw population data in the baseline Fearon/Laitin dataset.

Land GINI coefficient (data are not sufficiently available for a delta variable). This measures proxies' structure-induced scarcity. Data are drawn from the replication dataset for Collier and Hoeffler's (2004) article, and thus are aggregated at five-year intervals.[34]

Change in the constant-dollar value of agricultural imports from *t*-4 to *t*-1. Several critics of the resource-conflict literature have pointed out that countries facing scarcities can often import their way out of the problem.[35] This article controls for that phenomenon with this variable, using import data from the FAO.[36]

The state's POLITY 2 score. This variable, which measures the democracy level of a state, is meant to capture the overall institutional health of the country—since such health may mediate the relationship between environment and conflict. Data are available for almost every country-year in the Fearon/Laitin dataset.

A dummy variable for whether the country-year is in Sub-Saharan Africa. Much of the environmental security literature draws on this region for its case evidence, so it would be useful to see if controlling for the region eliminates delta-land's marginal effect. Data are available in the Fearon/Laitin dataset.

The level of secondary male education in the state. Homer-Dixon identifies a loss of "ingenuity" as one of the intermediate mechanisms between environmental scarcity and conflict;[37] thus it makes sense to control for a broad measure of human capital. The data for this variable are drawn from Collier and Hoeffler and are aggregated at five-year intervals.

Nine "usual suspect" control variables that fit my test into the overall theoretical framework of civil war: GDP per capita—both a static and a "delta" measure from *t*-4 to *t*-1 (Fearon and Laitin), ethnic fractionalization (Fearon and Laitin), religious fractionalization (Fearon and Laitin), percent mountainous terrain (Fearon and Laitin), a political instability dummy (Fearon and Laitin), a "Cold War" dummy (1 if the country-year is pre-1990), peace years (Collier and Hoeffler, with some extrapolation from the Correlates of War list of intrastate wars[38]), and percent urban population (World Development Indicators).

Results

All empirical tests were conducted with robust standard errors clustered by country.[39] **Table 2** shows the results from the basic civil war onset model. For comparison purposes, Model I follows Hendrix and Glaser (2007) and uses the percentage of degraded land as the explanatory variable. The coefficient is in the expected direction but is nowhere close to statistical significance. As in the empirical tests reviewed above, the land degradation data are time-invariant by country—they were downloaded from the FAO's "Terrastat" website and last updated in 2003.[40] These results simply show, then, that using a static explanatory variable in a land-conflict test yields inconclusive findings.

On the other hand, the coefficients on delta-land in Models II-VI are consistently negative and statistically significant.[41] In other words, high positive growth in the quantity of arable land is negatively associated with the likelihood of civil war onset. Models II-IV were run with the entire sample. I successively dropped control variables to get a higher N, and the substantive statistical effect remains constant across these models. Models V-VI are a robustness check; instead of considering every country-year for which data are available, I censored the model to those country-years in which agricultural value added comprises 25 percent or more of the country's GDP.[42] Despite the substantial drop in N in this "agriculturally dependent" sub-sample, the coefficient on delta-land remains negative and significant.

Since raw logit coefficients can be difficult to interpret, **Table 3** shows the results of a simulation run using the "Clarify" software built by Michael Tomz, Jason Wittenberg and Gary King (version 2.0). Model II was simulated, setting all of the control variables to their medians and then varying the value of delta-land. There is an unambiguous fall in the probability of civil war as delta-land increases. Further simulations (not shown) reveal that among all the time-variant continuous variables, the average marginal effect of one- or two-standard-deviation changes from the median is second-greatest for delta-land (second only to GDP per capita). Thus, a strong, robust relationship between arable land supply and civil war onset has been identified. The previous empirical literature, which found inconsistent results on this front, was simply looking at a less intuitive specification of the explanatory variable.

When armed conflict onset, rather than civil war onset, is used as the dependent variable, the relationship between delta-land and conflict is in the expected direction but is generally non-significant (though the p-value is as low as 0.156 when land GINI and male secondary education are dropped). Thus, in direct contradiction to Theisen's (2008) findings, the relationship between land supply and conflict is most clearly manifested at the level of civil war. This means the security implications of climate change may be even grimmer than the literature has supposed.

To the extent that changes in arable land supply cause conflict—not knowable only from correlations, of course—they seem to cause wars not skirmishes. So further exploration of the land-conflict relationship should be high on both academic and policy agendas.

Table 2: Logit Models (DV = Civil War Onset)

Variable	Model I (global sample)	Model II (global sample)	Model III (global sample)	Model IV (global sample)	Model V (agriculturally dependent country-years)	Model VI (agriculturally dependent country-years)
Percent Land Degraded	.0005959 (.10)	—	—	—	—	—
Delta-Land	—	-.0911545 (4.10)***	-.0565501 (2.80)***	-.0448664 (3.53)***	-.090358 (3.96)***	-.066622 (2.55)**
Land per capita	-.819302 (.83)	-.6505477 (.75)	-.8938505 (.94)	-.8092641 (1.21)	-5.671876 (1.72)*	-2.391994 (1.63)*
Delta-Population	-.0032013 (.16)	.0018099 (.08)	-.0079706 (.45)	-.0039334 (.18)	-.0183327 (1.18)	-.0103678 (.48)
Land GINI	-2.366634 (1.80)*	-2.180264 (1.55)	-2.303465 (2.01)**	—	-2.133737 (.86)	—
Delta-Imports	.0024369 (1.63)	.0022609 (1.36)	.0023311 (1.47)	-.0007436 (.35)	-.0003757 (.12)	-.0031661 (.94)
POLITY 2	.0428843 (1.60)	.0436602 (1.56)	.0450016 (1.72)*	.0322262 (1.45)	.0939393 (2.42)**	.0747583 (2.64)***
GDP per capita	-.2761675 (2.68)***	-.2920541 (2.84)***	-.3521931 (3.11)***	-.3006134 (2.75)***	-.7069593 (1.36)	-1.080279 (1.87)*
Delta-GDP per capita	-.0199643 (1.88)*	-.0200131 (1.75)*	-.0142327 (1.36)	-.0015234 (.18)	-.0165567 (1.12)	-.0006528 (.06)
Ethnic Fractionalization	1.742621 (2.09)**	2.015464 (2.50)**	2.016916 (2.75)***	.7706345 (1.31)	1.690945 (1.07)	.184915 (.21)
Religious Fractionalization	.5355985 (.76)	.8296961 (1.22)	.4589679 (.67)	.0286222 (.05)	.8988663 (.82)	1.033132 (1.17)
Sub-Saharan Africa	-1.260373 (2.20)**	-1.541034 (2.58)***	-1.037046 (2.09)**	-.3262165 (.93)	-.3525 (.32)	-.382609 (.74)
Male Secondary Education	-.0036793 (.32)	-.0074688 (.60)	—	—	.0044662 (.19)	—
Percent Mountainous Terrain	.0018729 (.26)	.0001418 (.02)	-.0003972 (.05)	.0042732 (.72)	-.004299 (.33)	.0016547 (.18)
Political Instability	.6952245 (2.05)**	.7196737 (2.06)**	.5209495 (1.47)	.6809699 (2.65)***	.7992512 (1.34)	.5467519 (1.37)
Cold War	.4753206 (1.10)	.4917849 (1.15)	.5726451 (1.59)	.096875 (.34)	.9328619 (1.62)	.3123065 (.75)
Peace Years	-.0048959 (.43)	-.0002394 (.02)	-.0003069 (.03)	-.003422 (.47)	.0042063 (.26)	.0021142 (.22)
Percent Urban Population	-.0012951 (.11)	-.002058 (.16)	.0017302 (.16)	-.0105883 (1.43)	-.0178108 (.70)	-.0123094 (.52)
N	2644	2644	2793	4195	751	1321
Pseudo R^2	0.1176	0.1376	0.1215	0.0875	0.1464	0.0873

Two-tailed tests; absolute values of Z statistics in parentheses.
* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3: Results of simulated model with global sample, holding other variables at medians.

Simulated Value of Delta-Land	Simulated Probability of Civil War	90% Confidence Interval
Median among observations used in model (+0.2%)	Baseline: 2.2%	1.2% – 3.5%
–1 standard deviation (–8.3%)	4.7%	2.2% – 8.3%
–2 standard deviations (–16.9%)	10.0%	3.8% – 19.3%
+1 standard deviation (+8.7%)	1.0%	0.5% – 1.7%
+2 standard deviations (+17.3%)	0.5%	0.2% – 1.0%

Explanatory-Variable Sample Partitions

A fruitful follow-up question is: Does the association of delta-land with civil war onset vary according to whether delta-land is negative or positive? Interestingly, it does, as shown in **Table 4**. Models run with only positive values of delta-land obtain the expected negative and significant coefficients on the explanatory variable.[43] Yet models run with only negative or zero values of delta-land do not obtain significant coefficients on the explanatory variable. These findings suggest that the results in the non-partitioned sample are driven by positive values of delta-land, and that negative and zero values of delta-land have no consistent relationship with the probability of civil war onset.[44]

Table 4: Logit Models (DV = Civil War Onset)

Variable	Model I (global sample, delta-land > 0)	Model II (global sample, delta-land ≤ 0)	Model III (global sample, delta-land > 0)	Model IV (global sample, delta-land ≤ 0)	Model V (agriculturally dependent country-years, delta-land > 0)	Model VI (agriculturally dependent country-years, delta-land ≤ 0)
Delta-Land	-.3998142 (2.91)***	-.0264969 (.36)	-.163356 (2.31)**	-.0013953 (.04)	-.6057478 (2.29)**	-.0714155 (.66)
Land per capita	-1.395064 (.61)	-.5023185 (.49)	-2.457051 (1.74)*	-.1716712 (.26)	-2.071255 (1.25)	-24.05944 (2.97)***
Delta-Population	.1497247 (1.49)	-.0204418 (.53)	.0739344 (1.03)	-.0276519 (.89)	.1681362 (1.56)	-.0728526 (2.29)**
Land GINI	4.225958 (1.32)	-5.109981 (2.36)**	—	—	3.55192 (.93)	-4.451182 (1.00)
Delta-Imports	.0066982 (2.28)**	-.0030146	.0007104 (.27)	-.001360	.0012128 (.21)	-.002385 (.45)

		(1.01)		8 (.50)		
POLITY 2	.0322357 (1.05)	.0669409 (1.39)	.0113819 (.35)	.065613 (1.82)*	.0712533 (1.86)*	.175731 (2.31)**
GDP per capita	-.3673479 (1.59)	-.3473913 (2.50)**	-.4040282 (1.95)*	-.2979984 (2.26)**	1.070755 (1.75)*	-.030545 (3.55)***
Delta-GDP per capita	-.0404624 (2.30)**	-.0081473 (.52)	-.0171146 (1.39)	.0048342 (.46)	-.0516123 (1.82)*	.0114343 (.38)
Ethnic Fractionalization	-1.375771 (1.22)	3.178884 (2.12)**	-.9329431 (1.25)	1.798141 (2.11)**	-2.375066 (1.71)*	4.452755 (1.48)
Religious Fractionalization	-1.375771 (1.28)	.794367 (.83)	.2479019 (.29)	.1320208 (.16)	.8313718 (.71)	2.073204 (1.09)
Sub-Saharan Africa	-1.055155 (.83)	-1.515843 (1.59)	-.1224978 (.25)	-.6463596 (1.36)	.1721427 (.13)	-.8104938 (.71)
Male Secondary Education	-.0143943 (.46)	-.0011118 (.06)	—	—	-.0200048 (.53)	.0270832 (.76)
Percent Mountainous Terrain	-.0220703 (1.35)	.0114268 (1.13)	-.0070688 (1.03)	.0139306 (1.75)*	-.0283339 (1.51)	.0283369 (1.34)
Political Instability	1.205262 (1.73)*	.2370905 (.36)	1.043329 (2.27)**	.3414062 (.82)	.4261286 (.34)	1.64799 (3.56)***
Cold War	1.757164 (1.26)	.4547587 (.66)	.1682935 (.36)	.2969546 (.64)	1.28901 (.66)	2.93836 (2.13)**
Peace Years	.0359157 (1.90)*	-.0121428 (.67)	.0119538 (1.08)	-.0116262 (1.12)	.0417048 (1.23)	-.0295791 (1.17)
Percent Urban Population	-.0249453 (.97)	.0091801 (.49)	-.0060332 (.38)	-.011807 (1.34)	-.0773174 (1.67)*	.0483624 (1.46)
N	1388	1256	2365	1830	458	293
Pseudo R^2	0.2414	0.2067	0.1252	0.1363	0.2244	0.3860

Two-tailed tests; absolute values of Z statistics in parentheses.
* Significant at 10%; ** significant at 5%; *** significant at 1%.

These results might be explained by the preliminary theory of arable land scarcity and conflict proposed in Figure 2. It shows positive growth in arable land as a direct “brake” on conflict, while supply shrinkage is only an *indirect* gas pedal. In other words, high arable land growth makes civil war unlikely because the opportunity for a pool of temporal relative deprivation-fueled grievance to form is very limited. If this land-growth brake is removed, temporal relative deprivation-fueled grievance arises,[45] which is sometimes mobilized by elites—whether insurgents or counterinsurgents—into a full-scale civil war and sometimes not. By this logic, positive values of delta-land would have a direct dampening effect on civil war likelihood, but negative or zero values would not have a direct upward effect on that probability because they would not be a sufficient condition for war.[46] This postulation of arable land scarcity as a *necessary* but *insufficient* condition for war along this causal pathway is similar to Kahl's (2006) view of his much broader environmental variable, "demographic and environmental stress."[47]

The significant control variables in the negative/zero models in **Table 4**—primarily land GINI, GDP per capita and ethnic fractionalization—perhaps specify conditions under which these elites are more likely to be successful at this mobilization of grievances. The ethnic fractionalization coefficients are certainly consistent with Kahl's "state exploitation" mechanism (see above).

Surprisingly, though, it appears that *low* structure-induced scarcity makes mobilization more likely to be successful, which is not consistent with either Kahl's or Homer-Dixon's theories. The exact nature of the conditions under which elite mobilization of arable land supply-related grievances is successful or unsuccessful clearly needs further exploration.

Overall, the large-N analysis has shown two facts about the association between changes in arable land supply and the probability of civil war. First, an association exists; the null hypothesis, which has received support from the extant empirical literature, is rejected when delta-land is used as the explanatory variable. Second, changes in arable land supply appear to act as a direct brake on conflict but only as an indirect gas pedal, suggesting the preliminary theory portrayed in Figure 2.

The problem with this story is that this article is trying to illustrate a micro-level theory with macro-level data. Though hardly an uncommon sin in the civil war literature, it is nevertheless a serious one. To prove the theory correct will require substantially different research methods, which this article begins to undertake below with a plausibility probe into a single case: this decade's deadly counterinsurgency in western Sudan.

Background

The recent human tragedy in Darfur is a telling illustration of the preliminary theory proposed in Figure 2. In some sense this case is selected on both the dependent and the independent variable, because virtually every scholar and practitioner who has studied the current situation in Darfur agrees that the conflict has been motivated at least in part by land disputes.[48] However, the particular mechanism suggested here has yet to be illustrated in the limited academic literature on the conflict. Furthermore, as we shall see, there is a good deal more variation on both dependent and independent variables in this case than many have acknowledged.

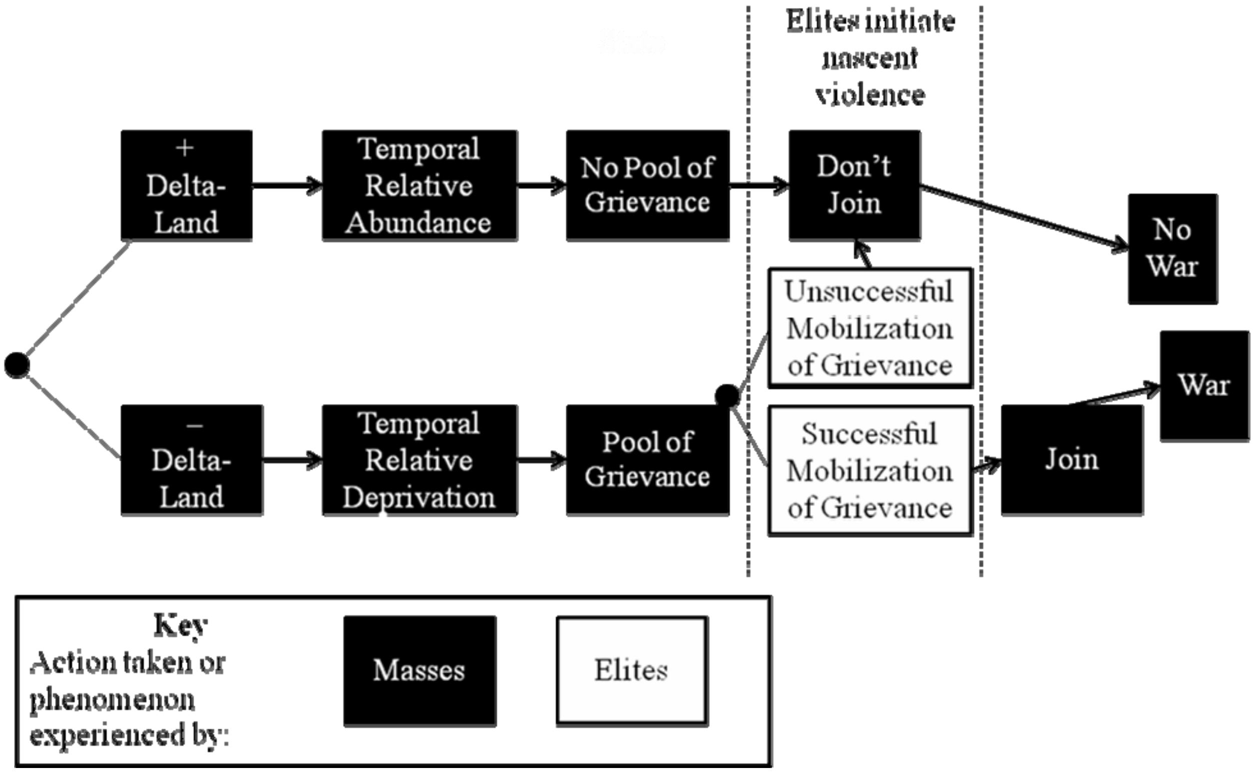

Figure 2: Preliminary theory of arable land scarcity-fueled civil war.

Illustrative Case: Darfur

This case illustration will seek to suggest that changes in arable land growth were a major, though not exclusive, cause of the unprecedented human tragedy in Darfur. To make this illustration I will demonstrate two facts. First, it makes sense temporally to claim that positive land supply growth acted as a fairly direct brake on the catastrophic conflict potential of the region, and that major conflict followed the removal of this brake in the late 1990s. (To make this claim more convincing, I show that land supply changes operated independently from several other potential causes of the violence, including demand-induced scarcity, structure-induced scarcity and the general political conditions of western Sudan just prior to 2003.) Secondly, negative changes to land supply seem to have increased the recruiting efficacy of Government of Sudan (GoS) and Janjawiid elites through a temporal RD-fueled, micro-level mechanism. Thus these shocks acted as an indirect gas pedal; they happened to be mobilized successfully by elites, but might not have been.

Before these specific claims are advanced, some general background follows. On the ground, the Darfur conflict has looked like the continuation of long-standing disputes between pastoralists, who are mostly Arab, and farmers, who are mostly African. The pastoralists need land for their camels, cattle and other animals to graze and the farmers need land for crops; herein lies the root of the disputes. Though violent conflict was surely not absent prior to 1970, during that time these disputes were generally mediated by tribal authorities. That changed in 1970 when the GoS did away with the "Native Administration" put in place by the British colonists, and in 1971 when the GoS' Unregistered Lands Act declared all untitled land government property for them to distribute as they wished. Every account of Darfur's troubled past mentions these two actions as the beginning of serious land conflict in western Sudan, because these central government actions effectively destroyed the prior institutional order.

Conditions were worsened by a severe drought in the mid-1980s, which was accompanied by famine and low-level violent conflicts. An Arab-African clash of medium intensity (about 5,400 deaths[49]) erupted between 1987 and 1989, and the terms of the peace agreement ending the conflict were never enforced. This clash was largely a proxy conflict between Libya (supporting the Arabs as part of Qaddafi's irredentist vision) and Chad (supporting the Africans), although this element of the tension eased somewhat in 1991 as Qaddafi's influence waned in western Sudan.[50] It was in this conflict that the so-called "Janjawiid" militants were first named—Arabs, often on horseback, attacking villages, forcing out farmers and "laying claim to their land."[51]

As this conflict was winding down, Omar al-Bashir came to power in Khartoum. His Arab supremacist outlook spelled trouble for the Africans in the west. In 1994 the GoS divided the Darfur region into three states, which were gerrymandered to reduce African political influence. Nevertheless, the situation on the ground seems to have been fairly quiet throughout most of the 1990s. That changed between 1997 and 1999, as local-level violent conflicts between pastoralists and farmers began to resurge.[52] Then, in 2000, an Arab supremacist general—Abdallah al-Safi al-Nur—became governor of the state of North Darfur. The governor promptly disbanded the non-Arab police and handed their weapons over to Musa Hilal. Hilal is a member of one of the pastoralist Arab tribes, and is considered the commander of the Janjawiid militias. In 2000 he was actively recruiting and training men for these militias, and by 2002 Janjawiid attacks on African villages had significantly intensified.

The present conflict in Darfur mainly erupted on April 25, 2003, when anti-Khartoum rebels largely from the African tribes mounted a brazen attack on an airbase in the region. After initial efforts to suppress the rebellion using the regular army proved ineffective—due in large part to defections—Bashir authorized the rearming and additional recruitment of Janjawiid militants, in order to fight, as Alex De Waal has called it, a "counterinsurgency on the cheap."[53] Thereafter chaos reigned, as Janjawiid swept through the villages, killing, raping and pillaging with impunity. According to the International Criminal Court, this wave of violence spiked in mid-2003, hit a trough toward the end of that year, and then spiked again in early 2004. By mid-2004 the killing had dropped to lower levels, where it has stayed up to the present.[54] By February 2006 the estimated death toll stood at 200,000, in addition to 2.5 million refugees (in Chad) or internally displaced persons (in Sudan)—far surpassing any violence the troubled region had seen in the 1970s, 1980s or 1990s.[55]

Supply Growth Acted Independently as a Direct Brake

The greatest mystery about Darfur is why 2003? As the chronology indicates, conditions for a catastrophic substate conflict in western Sudan had been ripe since 1970—so what caused the outbreak of major violence in the early 2000s, not before or after? It is this puzzle that changes in the supply of arable land seem to explain. Figure 3 shows Sudan's arable land supply and population between 1961 and 2005. The general story is: Arable land increased slowly through about 1992, and then rapidly through about 1996. Starting in 1997, land growth stagnated, and briefly went negative. This stagnation abated in 2003, when growth resumed. Meanwhile, population growth—though unhealthily high, with an annual rate of 5.2 percent—remained fairly steady throughout this period. The land GINI coefficient for Sudan (not shown) also held relatively steady, not deviating from 0.64 between 1980 and 1999.

Thus the data imply that while the proxies demand for growth and structure stayed fairly constant, arable land supply hit a plateau in the years just prior to the onset of major violence in 2003. This suggests that arable land growth in prior years—particularly the early- to mid-1990s, when, as noted in the case background, Darfur seems to have been fairly quiet—was acting as a direct brake on the conflict-prone situation, just as we saw in the large-N portion of this study. When that brake was removed, violence followed fairly soon after.

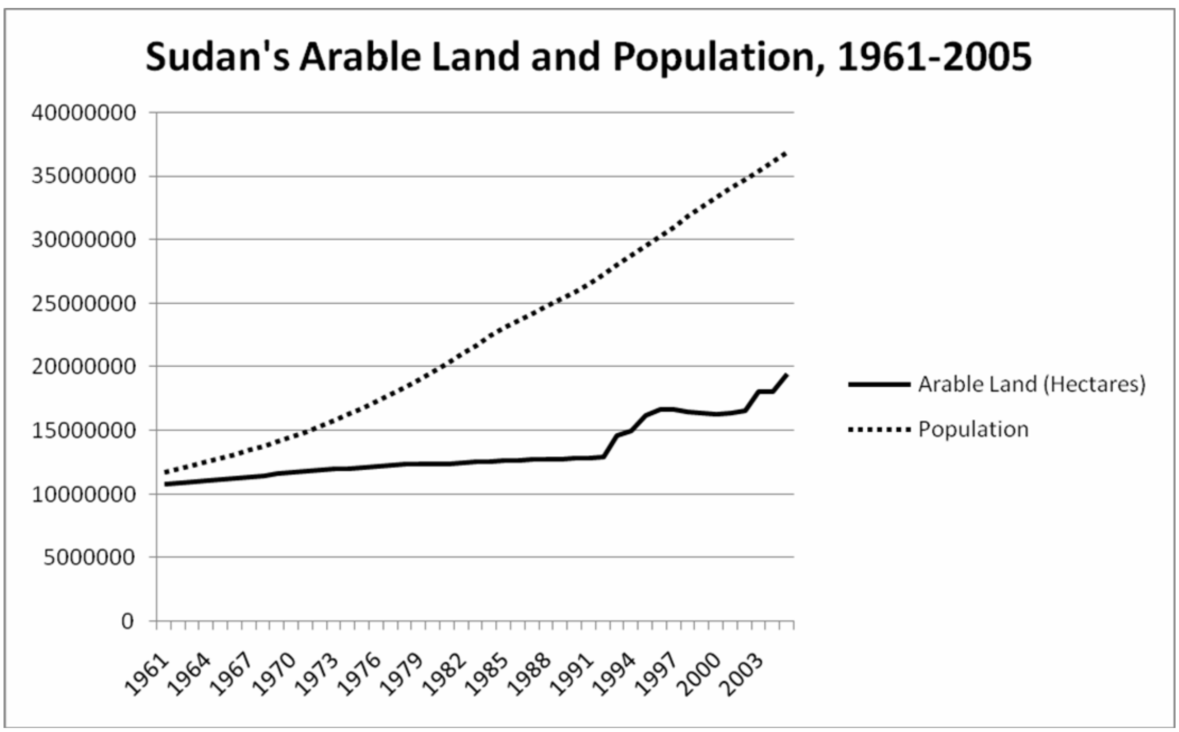

Figure 3: Arable land and population in Sudan, according to the World Development Indicators.

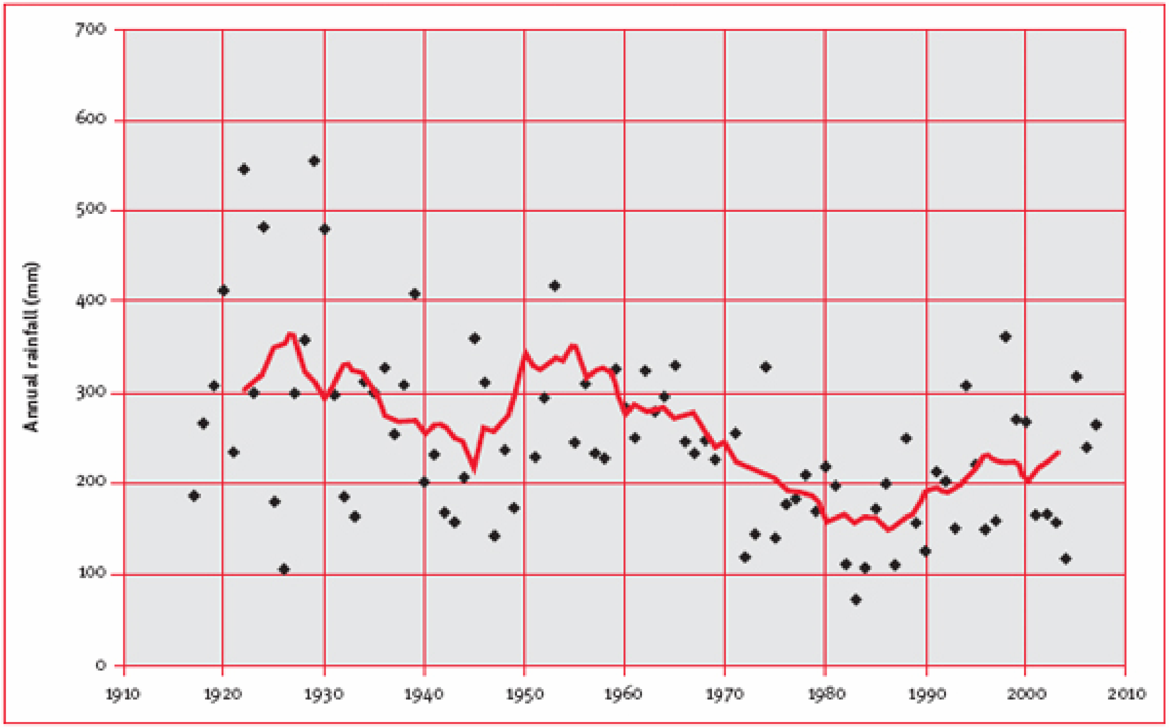

Figure 4: Rainfall data for El Fasher, North Darfur (reproduced from Bromwich, "Environmental Degradation and Conflict in Darfur"). The points represent individual years; the line represents the ten-year moving average.

Since Sudan is Africa's largest country, it would be ideal to see this story mirrored in Darfur itself. Not surprisingly, the sub-national data available for such comparisons are limited; nevertheless, the data available seem reasonably supportive of the observations made at the national level. Figure 4, taken from Brendan Bromwich's (2008) article, shows annual rainfall in El Fasher, the capital of North Darfur, between 1917 and 2007. There is a slow decline in the ten-year average between Sudanese independence (1956) and the mid-1980s—a decline not reflected in the national-level data discussed above. For the most part this decline was unaccompanied by major conflict; even the 1987 war saw only about one-fortieth of the deaths of the 2003 war. Thus these long, scarce years should likely be viewed as a case of temporal relative deprivation but mobilization failure; the causes of this failure merit further exploration.

Thereafter average rainfall rises, hitting a peak in the mid-1990s. Next average rainfall declines, hitting another low in 2000. Though the ten-year average goes back up thereafter, the points representing 2001-2004 also show relatively poor rain years. Thus changes in rainfall in North Darfur correspond fairly closely to changes in arable land in late 1990s Sudan; in both cases, resource supply seems to have been backing off from a fairly peaceful growth period in the years just prior to the 2003 conflict. It is worth asking how well rainfall and arable land are actually correlated; based on the entire dataset their correlation is very low, as will be discussed in the conclusion (nor does rainfall have more explanatory power than arable land in the entire dataset, as also discussed). However, in Sudan the correlation is fairly strong—0.32, according to the national-level data.[56] Other rough proxies for renewable resource supply in Darfur tell a similar story. A recent article using remote sensing to estimate vegetation "greenness" in Darfur also shows an improvement in ecological conditions in the early 1990s, followed by a drop-off in the late 1990s—though these data suggest another improvement in 1999 and the early 2000s (perhaps too late to stave off the temporal RD-related grievance already fomented).[57]

Meanwhile, the growth of resource demand in Darfur seems not only to have not been increasing, but in fact *decreasing*. According to official census data (which admittedly is likely to undercount pastoralists), Darfur's population grew rapidly between 1973 and 1983 (at an annualized rate of 16.1 percent) but more slowly between 1983 and 1993 (6 percent per year) and even more slowly between 1993 and 2003 (1.6 percent per year).[58]

Also, based on a review of histories of late twentieth century Darfur, it seems unlikely that structure-induced scarcity or the general political-military climate of western Darfur worsened or improved much just prior to 2003. This is not to suggest that the structure of the region stayed completely constant in western Sudan during this time period, for there are plenty of individual instances of detrimental central or local government actions to cite.[59] At the same time, one does not get the sense that daily life was worsening in the late 1990s and early 2000s for the pastoralists, who came to form the core of the deadly counterinsurgency, except through the land supply mechanism. Analysts have pointed out that Darfur was awash in arms when the 2003 conflict broke out, but this had been the case since Qaddafi's irredentist adventures of the 1980s—in 1990, it was estimated that there were "more than 50,000 modern small weapons available in Darfur."[60] So if, as Julie Flint and De Waal claim, "the Kalashnikov transformed the moral order of Darfur,"[61] then that transformation happened some time ago. Furthermore, to the extent that sociopolitical changes were afoot in this time period—such as al-Nur's accession in El Fasher—these changes were largely working in favor of the Arabs.

Thus there is evidence, strongest at the national level but reasonably mirrored in Darfur itself, that a detrimental change in the growth of land supply closely preceded the 2003 violence, and that this change was independent of the demand, structural, and political-military context. The 2003 war, then, seemingly was a case of temporal relative deprivation—brought on by removal of the direct supply-growth brake—combined with mobilization success.

Supply Changes Help Explain Janjawiid Recruitment

As supportive as these data are, one wonders if the individual participants in the deadly Janjawiid militias—"Khartoum's main weapon against Darfurian [*sic*] rebels" despite supplemental air and regular army support[62]—were really motivated by negative arable land supply changes to undertake their actions. It will likely be many years before a scientific survey can be undertaken among the Janjawiid, but in the meantime, it does appear that the stagnated supply of land in the late 1990s and early 2000s provided significant motivation.[63]

As with the violence itself, the puzzle of Janjawiid recruitment is to explain a sudden, sharp uptick. When al-Nur handed police weaponry over to Hilal in 2000, Hilal had recruited 2,000 Janjawiid. By October 2002 this number had swelled to 5,000.[64] By "the height of the war" (2003 and 2004) the count was at 20,000.[65] So what caused militia membership to increase tenfold in less than four years?

Though Janjawiid militiamen are diverse, ranging from common criminals to Chadian thrill-seekers, the bulk of the new recruits in and around 2003 seem to have come from the camel-herding pastoralist tribes of northern and western Darfur. Flint and De Waal give a sense of the scale, reporting that at one point in 2003 "6,000 volunteers raised by tribal leaders in West Darfur" arrived at an army post to be armed. (Some were non-Arabs and were turned away by the GoS.)[66] One tribal amalgamation in particular, the Northern Rizaygat (NR), has been a particularly prolific contributor; a focus group in Young *et al.*'s (2009) field study of the NR reported a post-2003 rise in military salary-drawers from 0 percent to 60 percent.[67] And Young *et al.*'s field study reveals additional information about the NR that supports the story told by the national and sub-national data. They write:

> The leadership of the Northern Rizaygat tribes … broadly supported the call [to arms by the GoS in 2003] and were quick to respond. … In North and West Darfur, many interviewees justified the rapid response of support for the government by the accumulation of grievances over the years by the Arab pastoralists against the Zaghawa in the north (who continually raided Arab camel herds) and also against the Masalit, particularly in terms of blocking of migration and fencing of pastures. … These fears [of further antagonism] were a result of a long history of tribal tensions and conflict, and those [NR] interviewed remember well a catalogue of incidents and killings, which, in West Darfur, date back to 1997.[68]

Of note here is that the local-level antagonism of the NR by the African tribes seems to have begun around the same time that rainfall in Darfur (and arable land growth in Sudan writ large) began to taper off. Robert Collins tells a similar story in North Darfur, where Masalit started anti-Islamist guerilla warfare in 1998 after a different group of pastoralist tribes "began to move south much earlier than usual with their herds and flocks, which frequently trampled the crops of Masalit farmers."[69] Since stagnated arable land growth likely spurred temporal relative deprivation among the farmers, it makes sense that they would resort to more antagonistic measures to secure resources, such as fencing pastoral land and retaliating against crop trampling.[70] Thus it is reasonable to suppose that in several parts of Darfur, stagnating arable land supply incited low-level, temporal RD-driven farmer-pastoralist conflict, which created anger and fear among the pastoralists—a pool of grievance—that GoS and Janjawiid leaders were able to transform into a surge in recruitment. If these emotions existed in 1987, they were not as successfully transformed.

This is not the orthodox narrative of Janjawiid recruitment, which prefers to place the blame for the rapid mobilization more squarely on the shoulders of the GoS. For instance, Flint and De

Waal point out: “Without friends in high places in the capital, Musa Hilal’s recruitment and training center … could not have expanded as it did after … 1996.”[71] This narrative should not be dismissed, not least because it implies criminal responsibility for Bashir but also because there are numerous anecdotal accounts of the rapid uptick in the Janjawiid’s capabilities after Khartoum’s decision to employ “counterinsurgency on the cheap.”[72] Indeed, on the surface it might make sense simply to assert that the April 2003 airbase attack “transformed Darfur’s war from provincial discontent into a front-rank military danger to Khartoum,”[73] and that the number of deaths beginning in 2003 is simply a function of the extent to which the GoS was paying attention to the region.

The preliminary theory proposed in Figure 2 helps sort out these competing stories—it suggests, in essence, that they are both right but that neither explains everything. The necessary but insufficient pool of grievance, which seems to have spurred individual pastoralists to join the Janjawiid, appears best attributed to local-level land conflicts brought on by negative supply shocks in the late 1990s. The necessary and sufficient successful exploitation of these grievances is probably due at least in part to Khartoum’s more direct involvement in Janjawiid recruitment after April 25, 2003. Hence we have both a “climate culprit” (in the words of UN Secretary-General Ban Ki Moon)[74] and a “Khartoum culprit.”[75]

Therefore, both data and narrative support the supposition that a drop in the arable land growth rate in the late 1990s and early 2000s created temporal relative deprivation, which in turn incited local land conflicts, which formed a pool of grievance that tribal, Janjawiid and GoS elites successfully exploited. The resultant surge in Janjawiid manpower led to the worst armed conflict ever seen in western Sudan—indeed, the worst manmade humanitarian disaster on Earth in the first decade of the 21st century. Thus we see tendencies identified in the large-N section—mainly, arable land supply change as a direct brake but indirect gas pedal on conflict—borne out in this case.

Conclusion

This article is part of a recent surge of interest in the security consequences of climate change, focused specifically on whether climate change should be expected to lead to an increase in the frequency of armed substate conflict. Unlike most recent work on this issue, however, the article has focused in on one link in the climate change to conflict causal chain—the relationship between arable land scarcity and conflict (see Figure 1). And unlike most of the work on the land-conflict link specifically, this work has made use of a dynamic explanatory variable that captures changes in arable land supply over time rather than at a single time-point. The result has been a rigorous, intuitive, and theoretically consistent engagement with the question of whether great power security policymakers should worry about climate change’s repercussions for substate conflict in the world.

The short answer is yes. A robust and statistically significant negative association between arable land growth and civil war onset between 1965 and 1999 suggests that, on average, climate change's postulated negative effect on future arable land growth should lead to an increased likelihood of civil war in the coming decades—particularly in Africa and Latin America, where arable land stocks are expected to be affected most significantly. But the short answer is not the whole answer. The preliminary theory presented in this article, which was formulated to explain the curious discontinuity between the effects of positive "delta-land" and negative "delta-land," casts negative arable land growth as a necessary but *insufficient* condition for civil war along the arable land scarcity causal pathway. As appears to have been the case in Darfur, local and individual grievances appear to be in relatively short supply as long as arable land endowment grows. Once that growth slows or is reversed, local-level grievances significantly increase due to the temporal relative deprivation incurred. These grievances may then be parlayed by elites into insurgency or counterinsurgency support, or there may be no such mobilization success. Mobilization is hard, and as a result, we should not expect to see an unstoppable wave of climate change-related conflicts in the coming decades—a trickle seems more likely.

Nevertheless, the severity of the Darfur conflict suggests that it would be worth policymakers' energy to keep this trickle as intermittent as possible, by predicting the sites of future scarcity-related conflicts and making an effort—through development or security assistance—to prevent them from breaking out. Predictive work of this kind is theoretically possible, but will require substantial additional research into the causes of scarcity-driven substate conflicts.

Foremost among future research requirements is the need to prove and generalize the preliminary theory proposed here. Ultimately, proving an individual-level theory (rather than just suggesting one) involves talking to individuals. Thus, a valuable extension of this inquiry would be survey research in countries, which experienced a period of arable land growth, followed by a sudden plateau (or cliff) in that trajectory. One could imagine a study structured quite similarly to the large-N work here: asking ex-combatants, those in war-afflicted countries who decided not to fight, and similar people in most-likely but non-war-afflicted countries, the role that arable land supply change, population pressure, distribution of arable land, changes in their income, and so forth played in their decisions to fight or not to fight. One contribution of the current article is that it has yielded a vast set of potential such conflicts and non-conflicts to study; these country-years can now be described with a continuous and highly variable measure of land supply change rather than the largely ordinal measures used in the past.

It would be also worthwhile to consider arable land supply change as a *dependent* variable. There are countless potential causes of such supply changes, and environmental degradation is just one subset of them. In fact, **Table 5** shows that changes in annual rainfall (also from *t*-4 to *t*-1) were not well correlated with delta-land globally between 1965 and 1999, making Sudan the exception not the rule.[76] (Adding a delta-rainfall variable to the models above generally does not yield a significant coefficient on delta-rainfall, nor does it substantially reduce the significance of delta-land.) Though the IPCC seemingly expects these two variables to be correlated in the future, it remains a mystery what non-environmental factors might also contribute to changes in arable land supply.

Table 5: Fixed-Effects OLS Models (DV = Delta-Land)

Variable	Model I (global sample)	Model II (global sample)	Model III (global sample)	Model IV (agriculturally dependent country-years)	Model V (agriculturally dependent country-years)
Delta-Rainfall	.001881 (.47)	.0024495 (.63)	.0133346 (1.32)	.0059446 (.66)	.0036997 (.56)
Delta-Population	-.1044234 (.58)	-.1755649 (1.14)	.0021798 (.03)	.0238725 (.51)	.0762028 (.99)
Land GINI	9.915084 (1.23)	9.566422 (1.23)	—	41.69921 (1.66)*	—
Delta-Imports	-.0111251 (3.20)***	-.0113 (3.29)***	-.000621 (1.44)	-.0116495 (2.18)**	-.0073268 (1.91)*
Avg. POLITY, *t*-4 to *t*-1	.0307511 (.32)	.0315805 (.34)	.0506414 (.70)	.3697581 (1.24)	.2149498 (1.11)
Delta-GDP per capita	.0076198 (.37)	.0186251 (.83)	.0265637 (1.38)	.0009786 (.03)	.0238294 (1.01)
Male Secondary Education	-.0306447 (.75)	—	—	.0169965 (.14)	—
Delta-Urban Population	.1107672 (.51)	.1664114 (.80)	.3343979 (1.74)*	.4468638 (.66)	.6509963 (1.25)
Year	.049432 (1.02)	.0096842 (.32)	-.0076301 (.28)	.1476447 (1.51)	.0741308 (1.40)
N	2649	2798	4199	752	1318
R^2 (within)	0.0130	0.0149	0.0067	0.0923	0.0379

Two-tailed tests; absolute values of t statistics in parentheses. Clustering standard errors by country is not necessary for these models, but robust standard errors are still used.
* Significant at 10%; ** significant at 5%; *** significant at 1%.

The data collected in this article tell us little with respect to this question; we see agricultural import growth negatively correlated with arable land growth, which makes little intuitive sense, and weak positive coefficients on urban population growth and land GINI. More broadly, the environmental science literature appears not to have reached a satisfactory consensus on the causes of delta-land, whether social or environmental.[77] This indeterminacy raises the specter of omitted variable bias for the results presented in this article, although it is difficult to conceive of a sociopolitical phenomenon causing both arable land supply change and civil war that is not already accounted for in the models above. More to the point, it highlights the fact that more work needs to be done in both the social and natural sciences on the factors driving arable land supply change. It also raises the question of whether environmentally-caused supply changes are more or less conflict-prone than changes arising from other sources. Now that the first link in the climate change to conflict casual chain (see Figure 1) has been suggested as valid by both large-N analysis and an examination of the Darfur tragedy, work on these questions is even more necessary.

These two research directions alone are vast, and there are potentially many more— for instance, what have states that have faced sudden shocks to arable land supply growth done about it; what has prevented war and what has not? Given the policy relevance and the amount of uncharted territory, further explorations of the arable land-conflict relationship, as well as the resource scarcity-conflict relationship more generally, seem suited for a central place on the civil war research agenda.

References

1. See the Intergovernmental Panel on Climate Change report (Adger *et al.* 2007).

2. See, for instance, a Center for a New American Security report on the security repercussions of climate change titled "The Age of Consequences" (Campbell *et al.* 2007); also see Ban Ki Moon's claim that climate change has contributed to the civil war in Darfur (*Washington Post*, June 16, 2007, A15)—a claim examined in more detail below.

3. See, for instance, Salehyan 2008.

4. Adger *et al.* 2007.

5. Buhaug *et al.* 2008; Hendrix and Glaser 2007; Levy *et al.* 2005.

6. Adger *et al.* 2007, 8, 10.

7. Note that this article does not assume that all arable land supply changes between 1965 and 1999 were the result of climate change, nor even that they were the result of environmental forces in general. The causes of arable land supply change are quite mysterious, as discussed in the conclusion, but we can safely state that both humans and nature play a role. This article only argues that if arable land supply and substate conflict shared a certain causal link in the recent past, we can expect that link to persist in the future. Furthermore, this article argues that this link is important to bring to the attention of policymakers, since we have been told by scientific experts that future climate change will have a downward impact on the explanatory variable.

8. Hendrix and Glaser also claim to perform robustness checks with the Fearon/Laitin civil war dependent variable but do not show these robustness checks; presumably, then, the same results were obtained.

9. Esty *et al.* 1999, 51.

10. United Nations 1991.

11. Urdal 2005, 424.

12. I focus for the time being on land quantity, since this is the most basic measure of resource supply. However, contrary to what the frequent use of the soil degradation data might suggest, there are numerous time-variant, continuous proxies for land quality (e.g., cereal yield) available from the Food and Agriculture Organization that could be explored in future research. As a first

cut, I found that changes in cereal yield had no significant association with civil war likelihood; a quality-quantity interaction term was negative and weakly significant.

13. Quoting Theisen's (2008, 803) synthesis of Homer-Dixon (1999, 14).

14. Ibid.

15. Homer-Dixon 1999, 8-9, 15, 72.

16. Hauge and Ellingsen 1998; De Soysa 2002; Hendrix and Glaser 2007; Raleigh and Urdal 2007; and Theisen 2008.

17. Urdal 2005.

18. Esty *et al.* 1999.

19. Gurr 1968a, 1104.

20. Gurr 1970, 13.

21. Ibid, 24.

22. Gurr 1968b, 254.

23. Cramer 2003; Bescançon 2005. See also Spilerman (1970), who found "racial disturbances" to be more likely in the U.S. when nonwhites were better off relative to whites, directly contradicting intergroup RD theory's predictions.

24. Gurr 1970, 25, emphasis added.

25. Davies 1962, 5.

26. Basically, the greed school postulates that civil wars break out when individuals with a low opportunity cost for fighting (usually because they live in poor economies) are recruited by opportunistic and greed-driven (rather than ideologically-driven) elites.

27. Quoted in Wickham-Crowley 1992, 117.

28. http://www.stanford.edu/group/ethnic/publicdata/publicdata.html (downloaded October 11, 2008).

29. The specific variable used is "onset2," meaning that at least two years of peace must elapse between independent successive conflicts in the same country. Data are from

http://www.prio.no/CSCW/Datasets/Armed-Conflict/UCDP-PRIO/Armed-Conflicts-Version-4-2008/ (downloaded February 17, 2009).

30. Note that both the dependent and independent variables are measured at the national level of aggregation. Many scholars have recently argued that such aggregation is not ideal, because conflicts and their causes are frequently local phenomena (see, for instance, Raleigh and Urdal 2007). I agree. However, the land data are only available for entire countries, as are data for many of the control variables used. Future work using subnational data would be highly valuable, particularly given the strong national-level findings detailed below.

31. Results similar to those presented below are obtained when using *t*-3 to *t* and *t*-6 to *t*-1 as alternate time periods. Weaker results are obtained using *t*-11 to *t*-1 and *t*-2 to *t*-1. The strongest results are obtained using *t*-4 to *t*-1.

32. http://publications.worldbank.org/WDI (downloaded February 5, 2009).

33. http://www.fao.org/waicent/faostat/agricult/landuse-e.htm (accessed August 18, 2009).

34. http://users.ox.ac.uk/~ball0144/research.htm (downloaded October 14, 2008).

35. Gleditsch 1998, 383; Le Billon 2001, 564; Deudney 1991, 26.

36. http://faostat.fao.org/site/535/DesktopDefault.aspx?PageID=535#ancor (downloaded March 19, 2009). The original data are in current U.S. dollars and were converted to constant 2005 dollars using Robert Sahr's tables at http://oregonstate.edu/cla/polisci/faculty/sahr-robert (downloaded January 22, 2009).

37. Homer-Dixon 1999, 44, 109, 115-116.

38. Sarkees 2000.

39. Unfortunately fixed-effects models are not practicable because in many cases the outcome variable does not vary within a country; country-clustered standard errors accompanied by a control variable for peace years are the next best method for accounting for statistical non-independence within states. If fixed-effects OLS regression is used instead, the substantive results shown in **Table 2** and **Table 4** are the same.

40. http://www.fao.org/ag/agl/agll/terrastat (downloaded February 19, 2009). I counted as degraded the percentage of land listed as having suffered "very severe" or "severe" degradation.

41. Outlier values of delta-land (more than two standard deviations from the mean) were dropped as a robustness check, with no substantive effect on the results.

42. The distribution of agricultural value added as a share of GDP (from the World Development Indicators) is left-skewed in the dataset, with a mean of 22.7 percent and a median of 20.1 percent. Thus the 25 percent cutoff captures the most agriculturally dependent country-years.

43. However, when land GINI and male secondary education are dropped from Model V, the p-value on the delta-land coefficient rises to 0.204.

44. These results were also obtained using OLS regression, meaning they are not specific to the logistic functional form.

45. Although this article favors a grievance story based on the Darfur case study (below), one could tell a greed story that ends similarly. Shrinking arable land supply threatens livelihoods; it could reduce individuals' opportunity costs for violence (Collier and Hoeffler 2004) and thereby render them more likely to join insurgencies or counterinsurgencies.

46. In this article, "necessary" and "sufficient" are used with reference only to the causal pathway proposed here. It is possible, then, for civil war to break out when the "necessary" condition of temporal RD has not been met, because another causal pathway not discussed here might be dominant. Thus "necessary" and "sufficient" as used here can also be thought of as shorthand for "background condition, without which civil war is highly unlikely" and "proximate condition, which is highly likely to be correlated with civil war outbreak." Kahl (2006, 58-59) comes to a similar conclusion about his "demographic and environmental stress" variable.

47. Kahl 2006, 58-59.

48. See, for instance, Prunier 2005; De Waal 2007; and Tubiana 2007.

49. http://www.sudanupdate.org/REPORTS/PEOPLES/Darf.htm (accessed March 14, 2009).

50. Collins 2008, 279-284.

51. Tubiana 2007, 70-71.

52. Collins 2008, 284-285.

53. De Waal 2004.

54. ICC data shown in Flint and De Waal 2008, 151.

55. Collins 2008, 295.

56. The correlation coefficient is derived from annual rainfall data in Africa, collected by Edward Miguel *et al.*, at http://www.econ.berkeley.edu/~emiguel/template.php?page=data, the GPCP series (downloaded March 9, 2009). These data allow construction of a "delta-rainfall" (*t*-

4 to *t*-1) measure from 1983-1999. If different, more comprehensive data are used (see note 76), the correlation coefficient is lower, at 0.13. Between the two datasets, however, Miguel *et al.*'s is more cited—Miguel *et al.* 2004 is a well-known contribution to the literature—and likely more trustworthy for analysis within Africa alone.

57. Brown 2010.

58. Author's calculations based on Fadul 2006, 35.

59. For example: Khartoum's 1993 grant of 439,000 hectares in southern Darfur—"an area half the size of Lebanon"—to a single absentee landlord (Suliman 2005, 13); the establishment of a national Ministry of Animal Wealth in 1996, which has focused on cattle and sheep to the exclusion of camels (Young *et al* 2009, 47); and the 1990s policy of renting unattended village fences to wealthy individuals who could fine pastoralists for intrusion, which undermined the traditional "forgiveness" mechanism of dispute resolution (Fadul 2006, 41).

60. Suliman 2005, 19.

61. Flint and De Waal 2005, 48.

62. Rolandsen 2007, 151, 159.

63. This article focuses on the motivations for individuals to join the counterinsurgency rather than the motivations for individuals to join the insurgency, because in Darfur it was the counterinsurgency that made the war so bloody. Had the counterinsurgency not been so effectively mobilized, it is likely that the 2003 rebellion would have ultimately amounted to one in a sea of low-grade conflicts in the region. In other words, this article attributes the civil war (high-intensity conflict) onset in 2003 to Janjawiid recruitment success, rather than to African rebel recruitment.

64. Collins 2008, 285, 289.

65. Flint and De Waal 2008, 38.

66. Ibid, 126.

67. Young *et al.* 2009, 67.

68. Ibid, 57.

69. Collins 2008, 284-285.

70. The pastoralists, for their part, probably started moving south earlier because of stagnating supplies of what the FAO defines as "permanent pasture" land. We cannot be sure because, as

discussed above, the data on permanent pasture are too unreliable to use in this article. For instance, both the GoS and the FAO report the exact same quantity of permanent pasture (117.18 million hectares) in Sudan between 1999 and 2005, which seems implausible given what we know about changes in rainfall and arable land supply during the same period.

71. Flint and De Waal 2008, 38.

72. For example, a Masalit leader told Human Rights Watch: "In August 2003, the government said all Arabs who came with a horse or a camel would get a salary … and a gun. The Arabs weren't organized before; it was only groups of thirty or forty attacking civilians for their cows" (Flint *et al.* 2004, 46).

73. Flint and De Waal 2008, 121.

74. *Washington Post*, June 16, 2007, A15.

75. For a similar view on joint causation of the conflict, see Homer-Dixon 2007.

76. Global annual rainfall data are from the Tyndall Center for Climate Change Research, at http://www.cru.uea.ac.uk/~timm/cty/obs/TYN_CY_1_1.html (accessed May 9, 2009).

77. For instance, an article reviewing 54 prior studies of desertification suggested 27 potential causes, and over-determination appears frequent (Geist and Lambin 2004).

Bibliography

Adger, Neil *et al.* 2007. Summary for Policymakers. In *Climate Change 2007: Impacts,*

Adaptation and Vulnerability. Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report, edited by Neil Adger *et al.*, 1-22. Geneva: IPCC Secretariat.

Bescançon, Marie. 2005. Relative Resources: Inequality in Ethnic Wars, Revolutions and Genocides. *Journal of Peace Research* 42, No. 4, 393-415.

Bromwich, Brendan. 2008. Environmental Degradation and Conflict in Darfur: Implications for Peace and Recovery. *Humanitarian Exchange Magazine* 39, 22-29.

Brown, Ian. 2010. Assessing Eco-Scarcity as a Cause of the Outbreak of Conflict in Darfur: A Remote Sensing Approach. *International Journal of Remote Sensing* 31, No. 10), 2513-2520.

Buhaug, Halvard *et al.* 2008. *Implications of Climate Change for Armed Conflict*. Washington: World Bank Group, Social Development Department.

Campbell, Kurt *et al.* 2007. *The Age of Consequences: The Foreign Policy and National Security Implications of Global Climate Change.* Washington: Center for a New American Security.

Collier, Paul and Anke Hoeffler. 2004. Greed and Grievance in Civil War. *Oxford Economic Papers* 56, No. 4, 563-595.

Collins, Robert. 2008. *A History of Modern Sudan*. Cambridge, UK: Cambridge University Press.

Cramer, Christopher. 2003. Does Inequality Cause Conflict? *Journal of International Development* 15, No. 4, 397-412.

Davies, James. 1962. Toward a Theory of Revolution. *American Sociological Review* 27, No. 1), 5-19.

De Soysa, Indra. 2002. Ecoviolence: Shrinking Pie or Honey Pot? *Global Environmental Politics* 2, No. 4), 1-34.

Deudney, Daniel. 1991. Environmental Security: Muddled Thinking. *Bulletin of the Atomic Scientists* 47, No. 3), 22-28.

De Waal, Alex. 2004. Counterinsurgency on the Cheap. *Review of African Political Economy* 31, No. 102). 716-725.

------------------. 2007. Sudan: The Turbulent State. In *War in Darfur and the Search for Peace*, edited by Alex De Waal, 1-38. Cambridge, Mass.: Harvard University Press.

Esty, Daniel *et al.* 1999. State Failure Task Force Report: Phase II Findings. *Environmental Change and Security Project Report* 5, 49-72.

Fadul, Abduljabbar Abdalla. 2006. Natural Resources Management for Sustainable Peace in

Darfur. In *Conference Proceedings: Environmental Degradation as a Cause of Conflict in Darfur*, edited by Sean O'Fahey, 33-44. Addis Ababa: University for Peace Africa Program.

Fearon, James and David Laitin. 2003. Ethnicity, Insurgency, and Civil War. *American Political Science Review* 97, No. 1, 75-90.

Flint, Julie and Alex De Waal. 2005. *Darfur: A Short History of a Long War*. London: Zed Books.

------------------------------------. 2008. *Darfur: A New History of a Long War*. London: Zed Books.

Flint, Julie, Jemera Rone and Leslie Lefkow. 2004. Darfur Destroyed: Ethnic Cleansing by Government and Militia Forces in Western Sudan. *Human Rights Watch* 16, No. 6A), 1-75.

Geist, Helmut and Eric Lambin. 2004. Dynamic Causal Patterns of Desertification. *Bioscience* 54, No. 9), 817-829.

Gleditsch, Nils. 1998. Armed Conflict and the Environment: A Critique of the Literature.*Journal of Peace Research* 35, No. 3), 381-400.

Gurr, Ted. 1968a. A Causal Model of Civil Strife: A Comparative Analysis Using New Indices. *American Political Science Review* 62, No. 4), 1104-1124.

------------. 1968b. Psychological Factors in Civil Violence. *World Politics* 20, No. 3), 245-278.

-----------. 1970. *Why Men Rebel*. Princeton, NJ: Princeton University Press.

Hauge, Wenche and Tanja Ellingsen. 1998. Beyond Environmental Scarcity: Causal Pathways to Conflict. *Journal of Peace Research* 35, No. 3), 299-317.

Hendrix, Cullen and Sarah Glaser. 2007. Trends and Triggers: Climate, Climate Change and Civil Conflict in Sub-Saharan Africa. *Political Geography* 26, No. 6), 695-715.

Homer-Dixon, Thomas. 1999. *Environment, Scarcity and Violence*. Princeton, NJ: Princeton University Press.

----------------------------. 2007. “Cause and Effect.” Available on-line: http://blogs.ssrc.org/darfur/2007/08/02/cause-and-effect (accessed August 19, 2009).

Kahl, Colin. 2006. *States, Scarcity, and Civil Strife in the Developing World*. Princeton: Princeton University Press.

Le Billon, Philippe. 2001. The Political Ecology of War: Natural Resources and Armed Conflicts. *Political Geography* 20, No. 5, 561-584.

Levy, Marc *et al.* 2005. Freshwater Availability Anomalies and the Outbreak of Internal War: Results from a Global Spatial Time Series Analysis. Paper presented at the Human Security and Climate Change Workshop, June, Asker, Norway.

Miguel, Edward, Shanker Satyanath, and Ernest Sergenti. 2004. Economic Shocks and Civil Conflict: An Instrumental Variables Approach. *Journal of Political Economy* 112, No. 4, 725-753.

Morrison, Donald and Hugh Stevenson. 1972. Integration and Instability: Patterns of African Political Development. *American Political Science Review* 66, No. 3), 902-927.

Prunier, Gerard. 2005. *Darfur: The Ambiguous Genocide*. Ithaca, NY: Cornell University Press.

Raleigh, Clionadh and Henrik Urdal. 2007. Climate Change, Environmental Degradation and Armed Conflict. *Political Geography* 26, No. 6, 674-694.

Rolandsen, Øystein. 2007. Sudan: The Janjawiid and Government Militias. In *African Guerillas:*

Raging Against the Machine, edited by Morten Bøås and Kevin Dunn, 151-170. Boulder, Colo.: Lynne Rienner.

Salehyan, Idean. 2008. From Climate Change to Conflict? No Consensus Yet. *Journal of Peace Research* 45, No. 3, 315-326.

Sarkees, Meredith. 2000. The Correlates of War Data on War: An Update to 1997. *Conflict Management and Peace Science* 18, No. 1), 123-144.

Spilerman, Seymour. 1970. The Causes of Racial Disturbances: A Comparison of Alternative Explanations. *American Sociological Review* 35, No. 4), 627-649.

Suliman, Mohamed. 2005. Ecology, Politics and Violent Conflict. *Respect: Sudanese Journal for Human Rights, Culture and Issues of Cultural Diversity* 1, 1-25.

Theisen, Ole Magnus. 2008. Blood and Soil? Resource Scarcity and Internal Armed Conflict Revisited. *Journal of Peace Research* 45, No. 6), 801-818.

Tubiana, Jerome. 2007. Darfur: A Conflict for Land? In *War in Darfur and the Search for Peace*, edited by Alex De Waal, 68-91. Cambridge, Mass.: Harvard University Press.

United Nations. 1991. *World Map of the Status of Human-Induced Soil Degradation*. Nairobi: United Nations Environment Program

Urdal, Henrik. 2005. People v. Malthus: Population Pressure, Environmental Degradation, and Armed Conflict Revisited. *Journal of Peace Research* 42, No. 4), 417-434.

Wickham-Crowley, Timothy. 1992. *Guerillas and Revolution in Latin America: A Comparative Study of Insurgents and Regimes Since 1956*. Princeton, NJ: Princeton University Press.

Wood, Elisabeth. 2003. *Insurgent Collective Action and Civil War in El Salvador*. Cambridge, UK: Cambridge University Press.

Young, Helen et al. 2009. Livelihoods, Power and Choice: The Vulnerability of the Northern Rizaygat, Darfur, Sudan. Medford, Mass.: Feinstein International Center, Tufts University.

Appendix: Summary Statistics and DV-IV Scattergram

Summary Statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Percent Land Degraded	5040	36.23452	30.89065	0	100
Delta-Land (percent)	4410	1.990645	8.537548	-51.49351	100
Land per capita (hectares)	4990	.3541218	.3861697	.0002526	3.647891
Delta-Population (percent)	4792	6.377184	6.714631	-57.43896	117.0544
Land GINI (coefficient)	3395	.6335118	.1646593	.2274741	.9797344
Delta-Imports (percent)	4349	24.32307	209.2319	-99.37708	10447.37
POLITY 2 (score)	5399	-.5067605	7.536763	-10	10
Average POLITY (score)	4395	-.5934016	7.437818	-10	10
GDP per capita (thousands of dollars)	5262	4.003274	4.805031	.133	66.735
Delta-GDP per capita (percent)	4636	5.927578	14.04066	-67.70492	118.8797
Ethnic Fractionalization (index)	5365	.4761155	.2699846	.001999	1
Religious Fractionalization (index)	5436	.3763336	.2195643	0	.7828
Sub-Saharan Africa (dummy)	5436	.2831126	.4505521	0	1
Male Secondary Education (index)	4547	42.42303	30.39131	1	147
Percent Mountainous Terrain	5436	17.50109	21.08829	0	94.3
Political Instability (dummy)	5429	.1445938	.3517233	0	1
Cold War (dummy)	5436	.7178072	.4501081	0	1
Peace Years	5402	24.97316	16.35579	0	53
Percent Urban Population	5174	44.37705	24.19238	2.08	100
Delta-Urban Population (difference in percentages)	4411	1.530329	2.300428	-6.96	73.18
Delta-Rainfall (percent)	4378	2.4625	26.53951	-86.88431	663.3065

DV-IV Scattergram