Drought and Political Violence in sub-Saharan Africa

Christian Webersik[1]

JSPS-UNU Postdoctoral Fellow, United Nations University – Institute of Advanced Studies

Prepared for presentation at the 49th annual International Studies Association convention, San Francisco, CA, 26–29 March 2008

Background

The study of environmental change and civil war onset in Africa has become a major focus of attention in the scholarly literature. This paper argues that a negative change in rainfall in sub-Saharan countries is associated with higher risk of armed internal conflict. Societies, in particular in the developing world which are dependent on renewable resources are more vulnerable to environmental stress, such as erratic rainfall. In most sub-Saharan economies the manufacturing and industrial sectors are in preliminary stages. Instead, agriculture constitutes a large percentage of overall national economic income. In some countries, such as the Central African Republic, Ethiopia and the Democratic Republic of Congo, the share of agriculture in the gross domestic product was 54%, 48% and 46% respectively[2]. Moreover, most agricultural production is based on rain-fed agriculture rather than irrigation agriculture. In Africa, less than 7 per cent of the overall agricultural production derives from irrigated lands.[3] As a result, changes in rainfall patterns that can lead to drought translate into increased vulnerability and hence poverty. Compared to other parts of the world, Africa has the highest economic loss risk due to droughts. (See map 1) In turn, poverty can increase political instability and eventually culminate into violent conflict with possible spill-over effects to other countries, posing a threat to international security.

As a general proposition, I argue that water scarcity induced by sudden rainfall shortages can lead to wealth deprivation that increases the likelihood of an armed rebellion. I hypothesise that regions with a higher dependency on agricultural production are more likely to experience civil conflict in a given drought year. It is in this context that a sudden economic shock caused by

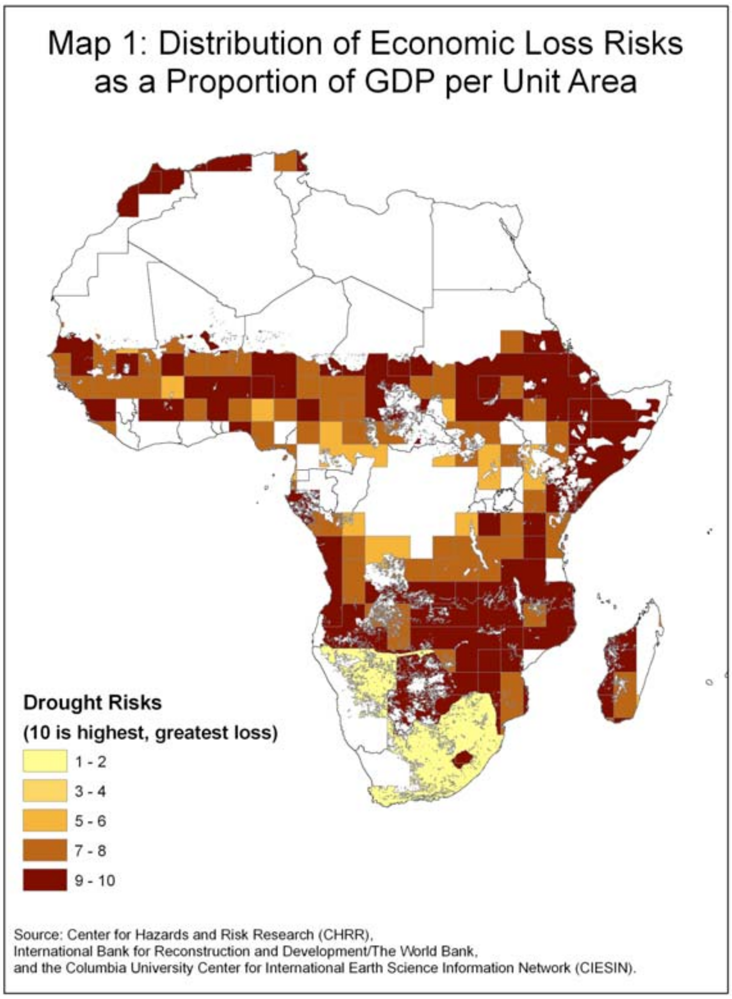
---

[1] *Christian Webersik* is a JSPS-UNU Postdoctoral Fellow at the United Nations University's Institute of Advanced Studies (UNU-IAS). He may be contacted at: webersik@ias.unu.edu. I would like to thank Jon Philipsborn, Program Coordinator, Conservation International, for his invaluable contribution to this paper, especially the Sudan section.

[2] World Bank, World Development Indicators (Washington, D.C.: The World Bank, 2007).

[3] UNECA, Economic Report on Africa (Addis Ababa: UNECA, 2005).

failing rains free labor leading to an abundant supply of potential rebel soldiers with low opportunity costs. Consequently, in an environment with reduced economic returns caused by drought the incentives to engage in a war economy increase. This argument is in line with the civil war literature that attempts to explain armed conflict by focusing on economic opportunity costs whether or not an individual is joining a rebellion.[4]



If rainfall is shaping economic conditions in sub-Saharan African countries, then changes in rainfall patterns induced by either anthropogenic interference can be associated with the outbreak of civil violence, a connection, however, that has been not tested rigorously. There are few studies that have provided evidence that climate change will lead to decreased rainfall causing more widespread poverty while lowering rebel recruitment costs.[5] Hendrix and Glaser (2007)

[4] J. D. Fearon and D. D. Laitin, "Ethnicity, insurgency and civil war," American Political Science Review 97.1 (2003).
[5] Ragnhild Nordås and Nils Petter Gleditsch, "Climate change and conflict," Political Geography 26.6 (2007).

have undertaken cross-country studies using inter-annual rainfall figures that confirm these effects.[6] Other authors arrived at similar conclusions using monthly rainfall data.[7] A recent article published in the *Atlantic Monthly* argues in favour of an "ecological origin of the Darfur crisis" making climate change responsible for the death of thousands of people. This paper aims at making the connection between failing rains and armed conflict using a large-N study. Along these lines, a recent study published by the UN Environment Programme claims that "there is a very strong link between land degradation, desertification and conflict in Darfur."[8] Another study examines the impact of climate change on warfare in Eastern China over the last millennium. The authors find that cooling periods can be associated with a higher frequency of armed conflict.[9] Other authors find a low effect of environmental and demographic variables on conflict onset but state that local water scarcity increases conflict risks.[10]

It is evident that climate change will impact on human well-being posing a risk to human insecurity.[11] This is particularly true for societies that are already vulnerable due to a high disease burden, poverty and natural resource dependence. Climate change will increase pressures on theses societies with potentially violent outcomes. In order to illustrate the relationship between humans and their environment I will briefly discuss the case of Somalia and Sudan to see whether environmental explanations of conflict can be salvaged. However, it would be beyond the scope of this paper to examine the effects of future global climate change on political instability in Africa.

Linking rainfall to conflict: Main findings

Although precipitation does not directly impact on political stability, it is a robust predictor of economic performance. Research demonstrates that economic growth is associated with the onset of civil war.[12] Once conflict broke out, negative economic growth can be explained by other factors. Armed clashes are often accompanied with the destruction of property, destruction of

---

[6] Cullen S. Hendrix and Sarah M. Glaser, "Trends and triggers: Climate, climate change and civil conflict in Sub-Saharan Africa," Political Geography 26.6 (2007).

[7] Patrick Meier, Doug Bond and Joe Bond, "Environmental influences on pastoral conflict in the Horn of Africa," Political Geography 26.6 (2007).

[8] United Nations Environment Programme, Sudan Post-Conflict Environmental Assessment (Nairobi: UNEP, 2007), 8.

[9] David D. Zhang, Jane Zhang, Harry F. Lee and Yuan-qing He, "Climate Change and War Frequency in Eastern China over the Last Millennium," Human Ecology 35 (2007).

[10] Clionadh Raleigh and Henrik Urdal, "Climate change, environmental degradation and armed conflict," Political Geography 26.6 (2007).

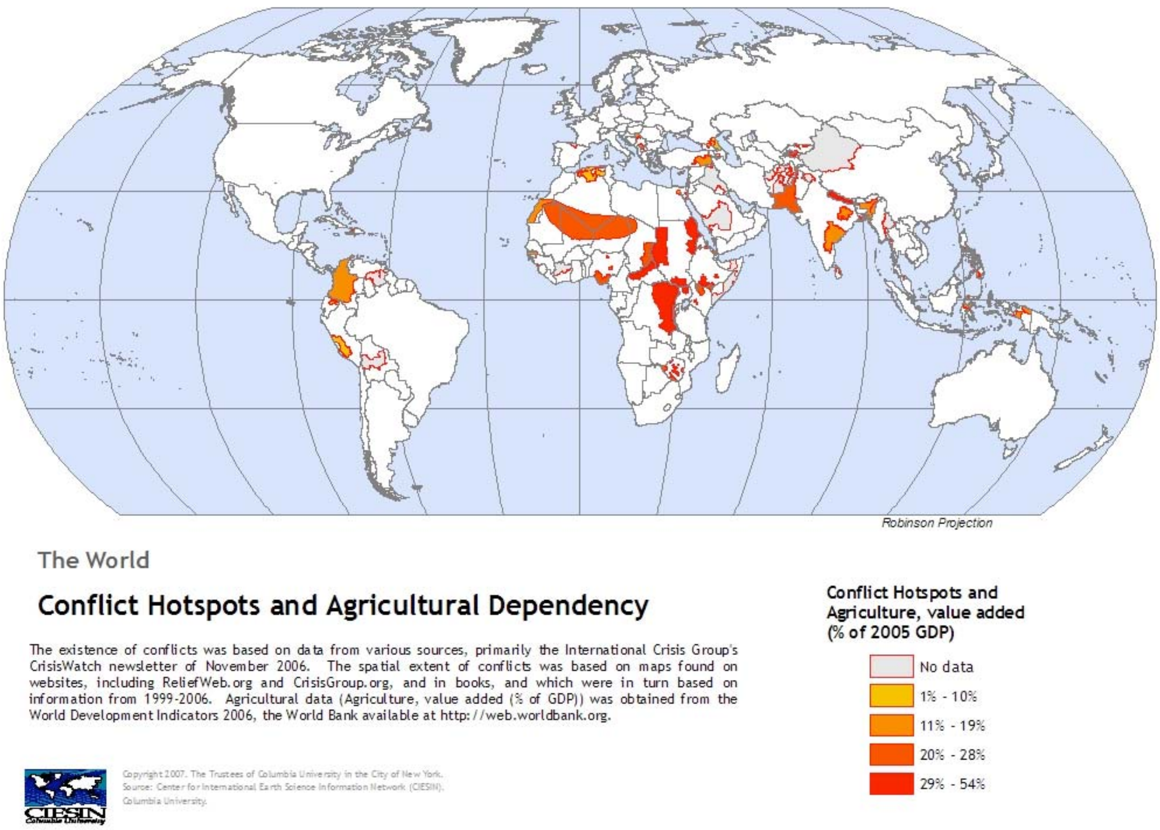
[11] Jon Barnett and W. Neil Adger, "Climate change, human security and violent conflict," Political Geography 26.6 (2007).

[12] Paul Collier and Anke Hoeffler, "On the Incidence of Civil War in Africa," Journal of Conflict Resolution 46.1 (2002), Ibrahim Elbadawi and Nicholas Sambanis, "How Much War Will We See? Explaining the Prevalence of Civil War," Journal of Conflict Resolution 46.3 (2002), J. D. Fearon and D. D. Laitin, "Ethnicity, insurgency and civil war," American Political Science Review 97.1 (2003).

industries, or the disrupting farming systems. It is therefore difficult to observe the direction of the relationship of economic growth and civil war. In order to avoid this known problem of reversed causality, Miguel *et alia* used rainfall as an instrumental variable for economic growth.[13] In this paper I replicate Miguel's model using a time series, covering the years 1981 to 1999.

I hypothesise that countries with greater dependency on agriculture are more vulnerable to climatic variability and thus more likely to experience political instability. I therefore select countries on the basis of their dependency on agriculture. The selection criterion for the sub-sample is the percentage of agriculture adding to the gross national income (GDP). Only those countries are selected if their share of agriculture is more than one 30 percent. It worth noting that the majority of countries that experienced armed conflict in 2006 is largely agrarian, especially in sub-Saharan Africa. (See map 2)

Map 2: Conflict Hotspots and Agricultural Dependency, 2006



[13] Edward Miguel, Shanker Satyanath and Ernest Sergenti, "Economic Shocks and Civil Conflict: An Instrumental Variables Approach," Journal of Political Economy 112.4 (2004).

The results of table 4 and 5 show that the risk of conflict in countries with more than 30 per cent of agriculture as per cent of GDP is higher by 21 percentage points (see table 3) whereas the risk of experiencing conflict in the full sample is higher by 12 percentage points (see table 2). This dataset includes all conflicts that are above a threshold of 25 battle-related deaths. Using a higher threshold of 1,000 battle related deaths, the pattern is similar: the risk for the agricultural dependent countries is higher by 12 percentage points (see table 5), whereas the risk for the full sample is higher by 7 percentage points (see table 4). As a result, in the case of a sharp drop in rainfall, the risk to experience violence in a country that is agricultural-based increases by 9 and 5 percentage points, respectively.

It is interesting to note that the inclusion of other rainfall variables, such as the deviation from the mean or the number of drought years did not yield significant results. This may point to the strength of functioning coping strategies and adaptation capacities in the affected regions. It is only the sudden sharp drop in rainfall that yields statistically significant results.

Data and Estimation Framework

In order to measure the dependent variable, armed conflict, I use a data set developed by the Peace Research Institute in Oslo and the University of Uppsala (referred to as UCDP/PRIO conflict data set). The UCDP/PRIO conflict data base reports all conflicts that are above a certain threshold, namely more than 25 reported battle-related deaths per year. The data is divided into four types of conflicts, extrasystemic armed conflict, interstate armed conflict, internal armed conflict and internationalized internal armed conflict. In the following analysis, I will use internal armed conflicts and internationalized armed conflict. Regarding the category internationalized armed conflict, it is crucial to select only those cases which occurred on the territory of the affected country, a caveat that was ignored by Miguel *et alia.* At the time of writing, a new and more comprehensive data set is being developed by the same group, called the ACLED data set. It reports conflict events by date and location, making it possible to use disaggregated sub-national data sets. I, however, decline to use this data set for this analysis because only eight countries have been coded to date. Therefore, keeping with Miguel's country/year dyad makes comparability between different models and samples possible.

The rainfall data is largely taken from two main sources in order to cover the period from 1981 to 1999. Rainfall data derives from the Global Precipitation Climatology Project (GPCP) and from the Global Precipitation Climatology Center (GPCC). Both rainfall products consist of a mix of precipitation indicators, combining gauge with satellite data. Both data sets have similar values, the correlation between the GPCP and GPCC from 1981 to 1999 is significant at the 0.01 per cent level. It is interesting to note that measures of water availability, especially water runoff, did not yield significant results. This may be due to the difference in the composition of the runoff measures.

Some of the control variables are the same as in Miguel's model to ensure comparability. They include ethnolinguistic fractionalization based on the Soviet ethnographic index, religious fractionalization based on the CIA Factbook, level of democracy drawn from the Polity IV data set, the proportion of a country's mountainous terrain (drawn from Fearon and Laitin 2003). In addition to Miguel, I include a measurement of poverty using Infant Mortality Rates. The agricultural, economic and demographic data are drawn from the World Development Indicators database.

Discussion of the empirical results

At first, I replicated Miguel's first-stage regression using data covering the years 1961-1999 for both samples, the full and the sub-sample. In both samples, rainfall growth is strongly positively related to economic growth at the 0.01 per cent confident level. (See table 1) As expected, the impact of rainfall growth on economic growth is much stronger in the sub-sample. In a next step and in line with Miguel, I use rainfall growth to instrument for economic growth. Country fixed effects and country specific time trends are included in some specifications to account for additional variation.

Table 1: Rainfall and Economic Growth (first-stage regression)

	Dependent Variable Economic Growth Rate, *t*			
Explanatory Variable	Model 1 (full sample)	Model 2 (full sample)	Model 3 (sub-sample, at least 30% agriculture, value added (% of GDP)	Model 4 (sub-sample, at least 30% agriculture, value added (% of GDP)
Growth in rainfall, *t*	.055***	.049***	.090***	.078**
Country fixed effects	no	yes	no	yes
Country-specific time trends	no	yes	no	yes
R^2	0.02	0.13	.04	.13
Observations	743	743	352	352

* Significantly different from zero at 90 percent confidence.
** Significantly different from zero at 95 percent confidence.
*** Significantly different from zero at 99 percent confidence.

As already demonstrated by Miguel *et alia*, lagged rainfall growth is positively related to conflict onset. This result is consistent with the 25 and the 1,000 battle-related death threshold but the effect is larger when using the 25 battle-related death threshold. (See table 2 and 3) The results of the models in table 3 and 5 support the hypothesis that countries with a higher dependency of agricultural have an elevated risk of experiencing an armed conflict when experiencing sudden negative changes of rainfall. In most models, only changes in lagged rainfall growth variable show significant results. This can be explained with the time lag between the actual precipitation and its subsequent impact on agricultural yields. The only non-lagged variable that is significantly different is the Normalized Difference Vegetation Index (NDVI, see model 7 in table 2-5). This is because the index already contains a time lag, as rainfall does not have an immediate impact on changes in the NDVI.

However, other rainfall variables, such as deviation from the mean or the number of dry years did not yield significant results. The critical question remains why rainfall variables, such as deviation from mean, or the number of years that are below a certain threshold do not show significant results. The answer could lie in the capacity of countries to adapt to the adverse consequences of subsequent dry years. Another explanation could be the influx of foreign aid in a given drought period that offsets the negative economic impact.

There may be other factors that heighten the risk for armed conflict in countries that have a strong agricultural sector. One explanation relates to the structure of the economy and its dependency on agriculture. Countries that lack economic integration and have largely agrarian economies – regardless of oil and diamond deposits – have an elevated conflict risk. As one study points out: “Natural-resource dependent economies may have weak manufacturing sectors […] and correspondingly low levels of internal trade. Insofar as internal trade is associated with greater levels of social cohesion and interregional interdependence, the weakness of the manufacturing sector and the fragmentation of an economy into independent enclaves of production may raise conflict risks.”[14] Post-conflict countries such as Sierra Leone, Liberia or Somalia, for example, have not gone through a process of industrialization, and this has generated clusters of agricultural communities with weak commercial ties. This argument is consistent with the weak-state-thesis that low-income countries that are largely agrarian have a lower capacity to contain upheaval.[15]

Somalia and Sudan: More droughts, more conflicts?

Statistical analysis is incomplete without supplementing it with case-study analysis. In the following, I briefly refer to Somalia and Sudan, and whether the general pattern observed in the

---

[14] Macartan Humphreys, "Natural Resources, Conflict, and Conflict Resolution: Uncovering the Mechanisms," Journal of Conflict Resolution 49.4 (2005): 513.

[15] J. D. Fearon and D. D. Laitin, "Ethnicity, insurgency and civil war," American Political Science Review 97.1 (2003).

statistical analysis can be confirmed or rejected. Both countries have a history of conflict and are largely agrarian, although in the case of Sudan, revenues from oil are increasing. This makes an attempt to explain conflict more complex. In Sudan, natural resource wealth – mainly from oil – offer large resource rents to elites by providing the financing needed to start or to sustain conflict. These rents provide strong incentives for 'peace spoilers'.[16] As mentioned earlier, the dependence on natural resource production weakens the state structures that redistribute wealth, and are less reliable and competent to provide public goods. Weak states, in turn, are at higher risk of civil war because they rely on natural resources for revenue rather than on taxation, have weaker state structures and are thus less able to contain violence. In addition, they tend to be less democratic as they need not be accountable to the public because natural resources provide large rents that preclude the need for taxation.[17] Clearly, the causes that trigger, sustain, and prolong conflict to recur are multi-dimensional and cannot reduced to a single variable.

Somalia

For almost two decades, Somalia has experienced human suffering and warfare. All efforts to form a functioning government have failed. The most recent one, the establishment of the Transitional Federal Government did not succeed in uniting the country and providing peace and security. The hope of a prosperous and politically stable Somalia has once again been destroyed by armed clashes between Ethiopian-supported government troops and militias of the Islamic Courts Union in Mogadishu and other part of southern Somalia. Because Somalia is largely an arid country, highly susceptible to natural disasters, especially to droughts and floods, and because its people have been victims of severe famine in recent decades, it seems evident that annual changes in rainfall have an economic impact with consequences for the country's political stability.

Somalia is part of the East African savannah, which is part of the Sahel stretching from Senegal in the West, to Djibouti in the Far East. Its climate is semi-arid and hot reaching 45 degrees Celsius. This environment shaped the historical patterns of livelihoods and the predominantly pastoral life of the Somalis. It is a life where animals and humans live in mutual, interdependent relationship. One cannot live without the other. The semi-arid belt covers the whole of Somalia although particular riverine areas, such as the Lower Shabelle region or the Juba valley have fertile irrigated land. The precarious and competitive conditions of the savannah shaped Somali

[16] Stephen Stedman, "Spoiler Problems in Peace Processes," International Security 22.2 (1997).
[17] Macartan Humphreys, Jeffrey Sachs and Joseph E. Stiglitz, Escaping the resource curse (New York: Columbia University Press, 2007).

culture and traditions; precarious because of the unpredictability of rainfall and competitive because of scarce resources, such as water and grazing areas.[18]

Somalia is a country that is prone to droughts and erratic rainfall. Most farmers of the riverine and inter-riverine areas depend on rain-fed cropping. In Lower Shabelle – depending on the water flow if the Shabelle River – irrigated and flood irrigated farming constitutes an additional but limited source of agricultural activity. In an environment where rainfall is low and unpredictable, local farmers and pastoralists are pushed to the limits of subsistence when external stress such as droughts or floods inflict on them. Additional anthropogenic factors, such as deforestation, depletion of the water table through borehole drilling, and over-grazing can lead to a situation whereby environments become critical. Although I do not support the hypothesis that environmental criticality is a cause of violent conflict *per se* it is inevitably intertwined with the political causes of conflict in southern Somalia.

Environmental criticality refers to the depletion of minerals and renewable resources. Criticality is reached when non-renewable resources become scarce at the marginal costs of depletion. Whereas renewable resources become critical when resources are used at a rate exceeding the rate of renewal. As minerals play a marginal economic role in southern Somalia, the focus of environmental criticality is on renewable resources.[19] Kasperson *et alia* define criticality as "situations in which the extent and/or rate of environmental degradation preclude the continuation of current human-use systems or levels of human well-being, given feasible adaptations and societal capabilities to respond".[20]

According to the above-mentioned definition, Somalia is a critical region. Rainfall is low, unevenly distributed and irregular in southern Somalia. The rain pattern is bimodal normally having two rainy seasons per year. These rainy seasons are defined by the annual movements of the Inter-Tropical Convergence Zone, the longer lasting of the two, the *gu* from April to June and the shorter or *deyr* from October to December. In between the rainy seasons there is the *haga'a* (July-September) and the long *jilaal* (December-March) dry season. The mean annual rainfall stays below 500 mm per annum with localized rainfall patterns. Rainfall can vary in terms of

---

[18] John Drysdale, Stoics Without Pillows: A Way Forward for the Somalilands (London: HAAN Associates Publishing, 2000) 2.
[19] Some sources indicate that minerals reserves exist in and north-east and north-west of Somalia but there is little evidence about the South. It has been stated that that fossil coal is present in coastal belt of north Puntland and Somaliland, along the Red Sea, in feasible quality and quantity. Lorenzo Bertolli, Emerging Opportunities to Develop the Processing and Manufacturing Industry within the Private Sector in the Puntland State of Somalia (Nairobi: United Nations Development Programme, Somalia, 2000).
[20] Jeanne X. Kasperson, Roger E. Kasperson and B. L. Turner II, eds., Regions at risk: Comparisons of Threatened Environments (Tokyo: United Nations University Press, 1995) 25.

duration and quantity in areas only a few kilometers apart in a given month, season or year. These uncertainties apply to both farmers and pastoralists alike. Crop failures occur on periodic intervals. As a rule of thumb, one in every five harvests will be a partial failure whereas one in ten is a complete write-off.[21] Apart from the 1926-29 and the 1973-74 droughts that affected the whole country, droughts occur in specific regions and normally last only for one season. About 18 droughts, however not confined to territory, occurred in the past hundred years in Somalia.[22] Rainfalls play such an important role for most Somalis that they are remembered by those affected with special names. Also, droughts are differentiated according to their severity. *Abaar* ('drought') *neebsooy* ('take a rest') refers to the failure of the *gu* or *deyr* rainy season so that farmers can stay at home and 'take a rest' from cultivating activities, while the more severe *abaar nuuhiyi* ('nothing is left') refers to the failure of crops, empty stores, no pasture and no livestock. Besides, farmers not only fear the failure of rainfall but are also plagued by floods. Though floods are important for irrigation they can become destructive when exceeding certain levels.

Living in one of the hottest area of the globe, known as the torrid zone, caused Somali pastoralists to develop exceptional skills to cope with his environment. Drysdale argues that pastoralism was the most likely livelihood to evolve in a semi-arid region, such as the African savannah.[23] Water was crucial for human survival in a hot climate. In the pastoral setting, mobility was important to increase social resilience to cope with the unpredictability of rainfall.[24] Animals provide meat and milk for daily food intake. Camels can go without water for several days, sometimes weeks, which enabled humans to walk long distances. The animals provided meat and milk and the means to transport water for human consumption. The development of this symbiotic relationship between pastoralists and their animals, which evolved over the past 8,000 years, led to an exceptional high level of social resilience to cope with the critical environmental conditions of the savannah.

Likewise, migration among farmers was an equally important coping strategy as storing grain. Helander argues that mobility among the Rahanweyn households in Bay region was essential to

[21] P Conze and T Labahn, "From a Socialistic System to a Mixed Economy: The Changing Framework for Somali Agriculture," Somalia: Agriculture in the Winds of Change, eds. P Conze and T Labahn (Saarbrücken: EPI Verlag, 1986).
[22] Ben Wisner, "Jilaal, Gu, Hagaa, and Der: Living with the Somali Land, and Living Well," The Somali Challenge : From Catastrophe to Renewal?, ed. Ahmed I. Samatar (Boulder, London: Lynne Rienner, 1994).
[23] John Drysdale, Stoics Without Pillows: A Way Forward for the Somalilands (London: HAAN Associates Publishing, 2000).
[24] Peter D. Little, Somalia: Economy without State (Oxford, Bloomington & Indianapolis, Hargeisa: James Currey, Indiana University Press, Btec Books, 2003) 65.

react to external shocks.[25] For instance during the 1998-99 drought, people migrated from Bay region to Lower Shabelle, where clan connections were strong.[26] Labour constraints led to the development of labour-sharing arrangements that required mobility to be effective. Further, people inherited property in which they might only hold partial rights; they could therefore use migration to redistribute property according to their needs. If their mobility was restricted either through war or legislation, it would increase their social vulnerability forcing them out of the farming sector into urban centres and wage labour. The fragility of the relationship between the Somalis and their environment together with population growth led to the assumption that the Somali conflict may be related to changes in rainfall patterns.

Apart from climatic changes, there are several other factors that influence warfare in Somalia. Just to list a few, the role of political leadership, the fragmentation of the Somali clan system, external interests, especially by Ethiopia and Eritrea, the unjust distribution of economic resources, such as charcoal, and the colonial legacy are all factors that shape political violence in Somalia.

In Somalia, economic interests have become significant in the perpetuation of the civil war and some authors underline this point.[27] Keen emphasises that war may well be the continuation of economics by other means.[28] Small but influential groups thus come to have an economic interest in prolonged conflict as they benefit from lawlessness. This viewpoint affirms that it can be misleading to associate war with complete collapse or breakdown of an economy – although it may certainly skew the development of an economy.

Moreover, droughts do not necessarily affect a country's population evenly. De Waal argued that the famine in southern Somalia was highly selective: The people most affected by the famine were the inter-riverine farming communities and internally displaced persons.[29]

---

[25] Bernhard Helander, "The Hubeer in the Land of Plenty: Land, Labor, and Vulnerability Among a Southern Somali Clan," The Struggle for Land in Southern Somalia: The War Behind the War, eds. Catherine Lowe Besteman and Lee V. Cassanelli (London, Boulder: HAAN Associates Publishing, Westview Press, 1996) 48.

[26] United Nations Development Programme, Human Development Report, Somalia 2001 (Nairobi: United Nations Development Programme Somalia Country Office, 2001), 74.

[27] Mats R. Berdal, David Malone and International Peace Academy, Greed & Grievance: Economic Agendas in Civil Wars (Boulder, London, Ottawa: Lynne Rienner Publishers ,International Development Research Centre, 2000).

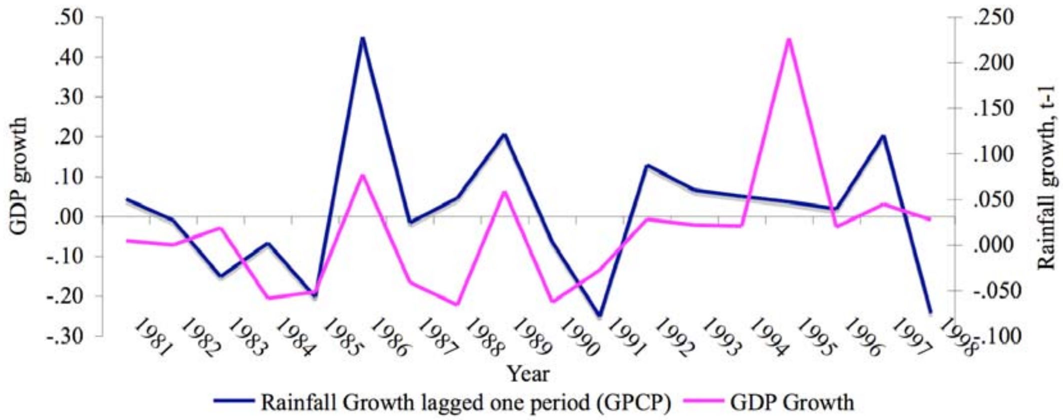
[28] David Keen, "Incentives and Disincentives for Violence," Greed & grievance: economic agendas in civil wars, eds. Mats R. Berdal, David Malone and International Peace Academy (Boulder, London, Ottawa: Lynne Rienner Publishers, International Development Research Centre, 2000) 27.

[29] Alexander De Waal, Famine Crimes: Politics and the Disaster Relief Industry in Africa, African issues (Oxford, Bloomington: Currey, Indiana University Press, 1997) 159.

Sudan

Sudan as the largest country in Africa has a long-standing history of armed conflict. When the Comprehensive Peace Agreement (CPA) was signed in 2005 there was hope for a prosperous and politically stable Sudan. Instead, massive killings in the Darfur region triggered a humanitarian catastrophe. Sudan, a highly agrarian country has long been dependent on rainfall that follows the ups and downs in the country's economic growth pattern. (See figure 1) 1994 was an exceptional good year for the country, a bumper crop and a year without reports of major armed conflicts. In 1993 and 1994, the conflict in Sudan did not reach the 1,000 battle-related death threshold. This enabled Sudan's economy to prosper in years of relative stability. Observers of the recent conflict in Darfur phrased it in the terms of ethnicity, African black farmers fighting against Muslim herders. But little attention has been paid to the economic circumstances of this region that largely depends on erratic rainfall.

Figure 1: GDP Growth and Rainfall Growth Sudan 1981-1998



As most African nations rely heavily on their agriculture sectors, Sudan is no different. In the Sudan, agriculture represents roughly 80% of the work force and has so for decades. Consequently, the nation's economy relies heavily on this sector. In 1996, agriculture accounted for 48% of the countries GDP. In 2005, this number had been reduced to 39% as the contribution of crude oil exports has steadily increased since Sudan began exporting this natural resource in 1999. Though the contribution to GDP has decreased by roughly 10%, the percentage of the population employed by agriculture has remained at 80%. Sudan also boasts the second largest animal population in Africa, which annually contributes a lot to the nation's GDP. Civil war has marred Sudan since 1983. Despite this, the country's wealth of natural resources (oil) has allowed for recent GDP growth of close to 7%.

Sudan gained its independence from Britain in 1956, but little time since has been free from conflict. Weak institutional structure during colonial times did not improve upon independence. Divides within the country grew and continued civil war (1962-1972, and 1983 – present) did not allow time for resources to be invested into addressing the countries needs. Differences between the North and South were partly created during colonial rule, but are also largely due to regional environmental variation and pre-existing cultural and religious groups in each region. The North has generally been populated with Arabic Muslims and has always been more developed. This is in direct contrast with the very underdeveloped southern Sudan, which has been largely inhabited by Africans who are either animist or Christian.

Even with recent economic success from crude oil exports, Sudan's population has not shifted from being overwhelmingly agrarian, and remains largely dependant on rain-fed farms. Sudan faces several environmental issues. All but one has to do with water. Inadequate supplies of potable water, soil erosion, desertification, and periodic draught all plague Africa's largest country, and fifth largest population. Where as an estimated 42% of the total area is considered cultivatable land, only 7% of that portion is actually cultivated. Average rainfall in Sudan varies greatly by region, with annual rainfall of less than 25 mm in the North, to close to 1500 mm in the South. Vast swamp regions in Sudan also affect the water stability in the country as they greatly increase the amount of evaporation that occurs annually (roughly 3 times as much water evaporates due to the swamps as is annually available for use).[30] Annual rainfall has been declining for some time, and most publications attribute this to weak economic performances.

Most nations struggle to deal with just one major problem. Sudan has been dealing with many. Coupled with years of violent conflict, lack of national infrastructure, and corrupt governance, rainfalls have continued to decline. The latter has only exacerbated the problems associated with the prior. And those problems initially listed have left Sudan unable to deal with the fact that they are an agrarian nation, reliant on precipitation.

Conclusion

Certainly, both countries, Somalia and Sudan are agrarian-based that makes them susceptible to sudden drops in rainfall and subsequent droughts. As demonstrated above, countries with a higher dependency on the primary sector are more likely to experience civil war when rains fail. Especially large drops in rainfall from one year to the next increase the risk of civil war. By using rainfall growth to instrument for theoretical factors that are fairly robust predictors to civil

[30] A. Kassa, "Drought risk monitoring for the Sudan," SOAS, 1999.

war – in particular economic growth – but are potentially endogeneous to civil war onset, it is possible to establish a causal relationship between negative rainfall growth and war onset.[31]

However, predicting an increase of warfare in Africa based on declining rainfall as suggested by the IPCC climate change scenarios is problematic. First, the variation of the predictive models is very large making it difficult to use the models to forecast where conflicts will be likely to take place. Second, important socio-economic control variables, such as GDP per capita or population density, are also subject to change, and we do not know the direction of this change. Third, the causes of conflict are complex and multi-facetted.

It remains an open question whether human-induced climate change manifested in droughts will lead to more conflict. Research by scholars at the International Research Institute for Climate and Society has demonstrated that the drying of the Sahel in the 20th century, where many of the conflict zones are located (see map 2), can be attributed to anthropogenic activities. Although it is beyond the scope of this paper, it is interesting to follow the question to what extend anthropogenic climate change will influence the risk of civil conflict.

Maybe as a reflection of this uncertainty, the Forth Assessment Report published by the Intergovernmental Panel on Climate Change (IPCC) makes little reference to conflict or political instability. Given the fact that some countries in particular in the developing world will continue to depend on agriculture, global climate change may affect people in more serious way than we anticipated.

---

[31] Edward Miguel, Shanker Satyanath and Ernest Sergenti, "Economic Shocks and Civil Conflict: An Instrumental Variables Approach," Journal of Political Economy 112.4 (2004).

Tables

Table 2: Rainfall and Civil Conflict							
	Dependent Variable Civil Conflict $\geq$ 25 Deaths						
Explanatory Variable	Model 1 using GPCP data (Miguel)	Model 2 using GPCP data (IRI)	Model 3 using GPCC data	Model 4 using UNH runoff	Model 5 using NCEP data (Miguel)	Model 6 using FAO data (Miguel)	Model 7 using NDVI data (Miguel)
Growth in rainfall, t	-.024	-.034	.017	-.001	.011	.002	-.345***
Growth in rainfall, t-1	-.122**	-.146***	-.103**	-.001	-.055	-.031*	-.143
Country fixed effects	yes	yes	yes	yes	yes	yes	yes
Country-specific time trends	yes	yes	yes	yes	yes	yes	yes
R^2	.71	.71	.71	.71	.71	.72	.71
Root mean square	.25	.25	.25	.25	.25	.24	.26
Observations	743	743	743	743	743	607	607

* Significantly different from zero at 90 percent confidence.
** Significantly different from zero at 95 percent confidence.
*** Significantly different from zero at 99 percent confidence.

Table 3: Rainfall and Civil Conflict Countries with at least 30% Agriculture, value added (% of GDP)							
	Dependent Variable Civil Conflict $\geq$ 25 Deaths						
Explanatory Variable	Model 1 using GPCP data (Miguel)	Model 2 using GPCP data (IRI)	Model 3 using GPCC data	Model 4 using UNH runoff data	Model 5 using NCEP data (Miguel)	Model 6 using FAO data (Miguel)	Model 7 using NDVI data (Miguel)
Growth in rainfall, t	-.032	-.021	.050	-.003***	.032	.040	-.503*
Growth in rainfall, t-1	-.205**	-.210**	-.159*	-.003***	-.066	-.162*	-.250
Country fixed effects	yes	yes	yes	yes	yes	yes	yes
Country-specific time trends	yes	yes	yes	yes	yes	yes	yes
R^2	.68	.68	.68	.68	.68	.70	.68
Root mean square	.29	.29	.29	.29	.29	.29	.29
Observations	352	352	352	352	352	287	295

* Significantly different from zero at 90 percent confidence.
** Significantly different from zero at 95 percent confidence.
*** Significantly different from zero at 99 percent confidence.

Table 4: Rainfall and Civil Conflict							
	Dependent Variable Civil Conflict ≥ 1000 Deaths						
Explanatory Variable	Model 1 using GPCP data (Miguel)	Model 2 using GPCP data (IRI)	Model 3 using GPCC data	Model 4 using UNH runoff data	Model 5 using NCEP data (Miguel)	Model 6 using FAO data (Miguel)	Model 7 using NDVI data (Miguel)
Growth in rainfall, t	-.062**	-.066**	-.063**	-.00003	-.064**	-.006	-.310***
Growth in rainfall, t-1	-.069**	-.082**	-.047	-.00003	-.065*	-.009	-.180**
Country fixed effects	yes	yes	yes	yes	yes	yes	yes
Country-specific time trends	yes	yes	yes	yes	yes	yes	yes
R^2	.70	.70	.70	.70	.70	.80	.68
Root mean square	.22	.22	.22	.22	.22	.17	.23
Observations	743	743	743	743	743	607	607
* Significantly different from zero at 90 percent confidence. ** Significantly different from zero at 95 percent confidence. *** Significantly different from zero at 99 percent confidence.							

Table 5: Rainfall and Civil Conflict Countries with at least 30% Agriculture, value added (% of GDP)							
	Dependent Variable Civil Conflict ≥ 1000 Deaths						
Explanatory Variable	Model 1 using GPCP data (Miguel)	Model 2 using GPCP data (IRI)	Model 3 using GPCC data	Model 4 using UNH runoff data	Model 5 using NCEP data (Miguel)	Model 6 using FAO data (Miguel)	Model 7 using NDVI data (Miguel)
Growth in rainfall, t	-.115*	-.105*	-.109*	0	-.104***	-.056	-.642***
Growth in rainfall, t-1	-.124**	-.118*	-.086*	0	-.121***	-.122	-.104
Country fixed effects	yes	yes	yes	yes	yes	yes	yes
Country-specific time trends	yes	yes	yes	yes	yes	yes	yes
R^2	.67	.67	.67	.67	.67	.75	.66
Root mean square	.25	.25	.25	.25	.25	.22	.25
Observations	352	352	352	352	352	287	295
* Significantly different from zero at 90 percent confidence. ** Significantly different from zero at 95 percent confidence. *** Significantly different from zero at 99 percent confidence.							

References

Barnett, J., and W. N. Adger. "Climate change, human security and violent conflict." Political Geography 26.6 (2007): 639-55.

Berdal, M. R., D. Malone, and I. P. Academy. Greed & Grievance: Economic Agendas in Civil Wars. Boulder, London, Ottawa: Lynne Rienner Publishers ,International Development Research Centre, 2000.

Bertolli, L. Emerging Opportunities to Develop the Processing and Manufacturing Industry within the Private Sector in the Puntland State of Somalia. Nairobi: United Nations Development Programme, Somalia, 2000.

Collier, P., and A. Hoeffler. "On the Incidence of Civil War in Africa." Journal of Conflict Resolution 46.1 (2002): 13-28.

Conze, P., and T. Labahn. "From a Socialistic System to a Mixed Economy: The Changing Framework for Somali Agriculture." Somalia: Agriculture in the Winds of Change. Eds. P. Conze and T. Labahn. Saarbrücken: EPI Verlag, 1986. 13-54.

De Waal, A. Famine Crimes: Politics and the Disaster Relief Industry in Africa. African issues. Oxford, Bloomington: Currey, Indiana University Press, 1997.

Drysdale, J. Stoics Without Pillows: A Way Forward for the Somalilands. London: HAAN Associates Publishing, 2000.

Elbadawi, I., and N. Sambanis. "How Much War Will We See? Explaining the Prevalence of Civil War." Journal of Conflict Resolution 46.3 (2002): 307-34.

Fearon, J. D., and D. D. Laitin. "Ethnicity, insurgency and civil war." American Political Science Review 97.1 (2003): 75-90.

Helander, B. "The Hubeer in the Land of Plenty: Land, Labor, and Vulnerability Among a Southern Somali Clan." The Struggle for Land in Southern Somalia: The War Behind the War. Eds. C. L. Besteman and L. V. Cassanelli. London, Boulder: HAAN Associates Publishing, Westview Press, 1996. xi, 222.

Hendrix, C. S., and S. M. Glaser. "Trends and triggers: Climate, climate change and civil conflict in Sub-Saharan Africa." Political Geography 26.6 (2007): 695-715.

Humphreys, M. "Natural Resources, Conflict, and Conflict Resolution: Uncovering the Mechanisms." Journal of Conflict Resolution 49.4 (2005): 508-37.

Humphreys, M., J. Sachs, and J. E. Stiglitz. Escaping the resource curse. New York: Columbia University Press, 2007.

Kasperson, J. X., R. E. Kasperson, and B. L. Turner II, eds. Regions at risk: Comparisons of Threatened Environments. Tokyo: United Nations University Press, 1995.

Kassa, A. "Drought risk monitoring for the Sudan." SOAS, 1999.

Keen, D. "Incentives and Disincentives for Violence." Greed & grievance: economic agendas in civil wars. Eds. M. R. Berdal, D. Malone and I. P. Academy. Boulder, London, Ottawa: Lynne Rienner Publishers, International Development Research Centre, 2000. vii, 251.

Little, P. D. Somalia: Economy without State. Oxford, Bloomington & Indianapolis, Hargeisa: James Currey, Indiana University Press, Btec Books, 2003.

Meier, P., D. Bond, and J. Bond. "Environmental influences on pastoral conflict in the Horn of Africa." Political Geography 26.6 (2007): 716-35.

Miguel, E., S. Satyanath, and E. Sergenti. "Economic Shocks and Civil Conflict: An Instrumental Variables Approach." Journal of Political Economy 112.4 (2004): 725-52.

Nordås, R., and N. P. Gleditsch. "Climate change and conflict." Political Geography 26.6 (2007): 627-38.

Raleigh, C., and H. Urdal. "Climate change, environmental degradation and armed conflict." Political Geography 26.6 (2007): 674-94.

Stedman, S. "Spoiler Problems in Peace Processes." International Security 22.2 (1997): 5-53.

UNECA. Economic Report on Africa. Addis Ababa: UNECA, 2005.

United Nations Development Programme. Human Development Report, Somalia 2001. Nairobi: United Nations Development Programme Somalia Country Office, 2001.

United Nations Environment Programme. Sudan Post-Conflict Environmental Assessment. Nairobi: UNEP, 2007.

Wisner, B. "Jilaal, Gu, Hagaa, and Der: Living with the Somali Land, and Living Well." The Somali Challenge : From Catastrophe to Renewal? Ed. A. I. Samatar. Boulder, London: Lynne Rienner, 1994. 29-59.

World Bank. World Development Indicators. Washington, D.C.: The World Bank, 2007.

Zhang, D. D., J. Zhang, H. F. Lee, and Y.-q. He. "Climate Change and War Frequency in Eastern China over the Last Millennium." Human Ecology 35 (2007): 403-14.