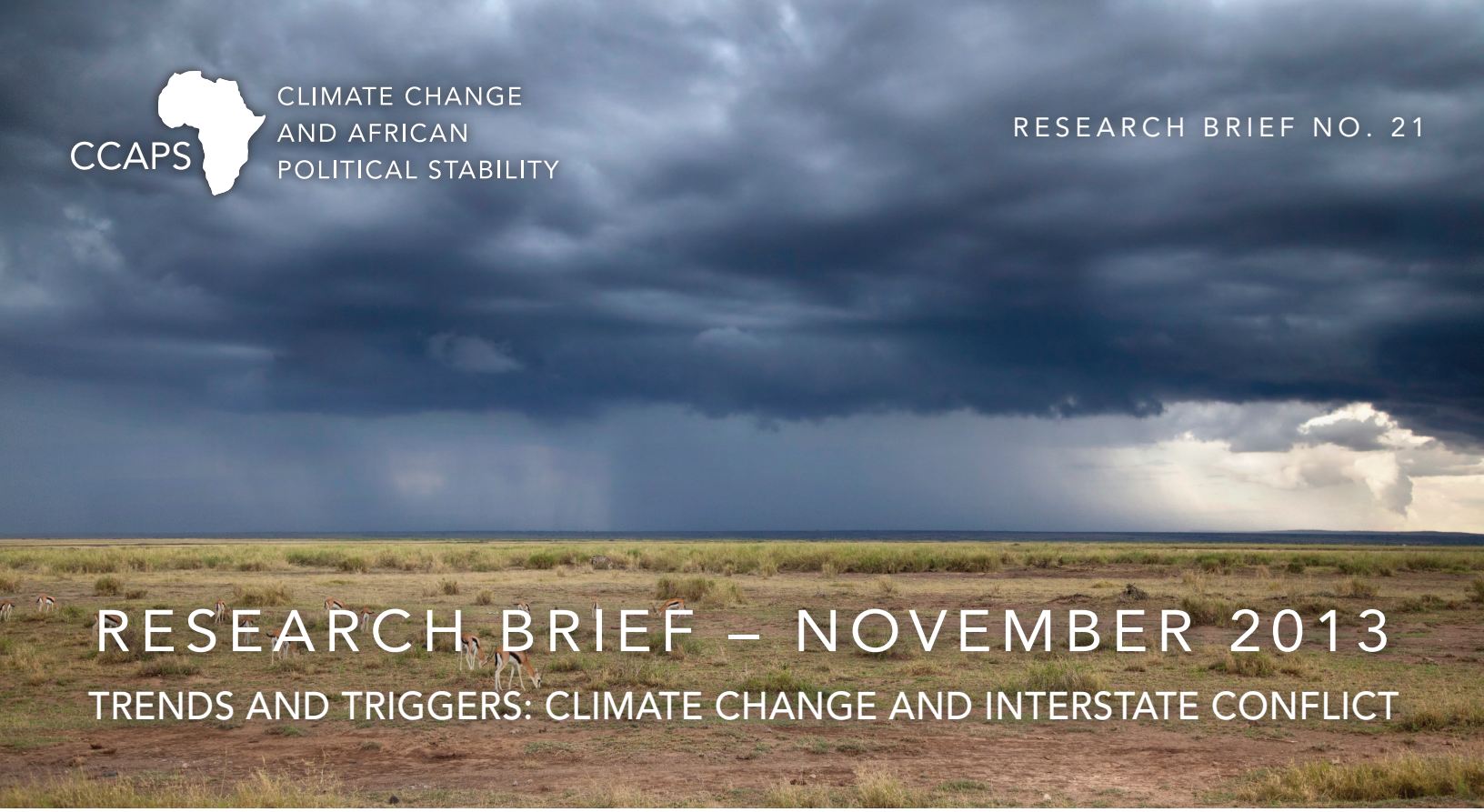

CCAPS CLIMATE CHANGE AND AFRICAN POLITICAL STABILITY

RESEARCH BRIEF NO. 21

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TRENDS AND TRIGGERS: CLIMATE CHANGE AND INTERSTATE CONFLICT

EXECUTIVE SUMMARY

Fresh water is crucial to sustaining human life. At a time when most climate change scenarios forecast changes in relative abundance of this critical resource, concern is warranted. This brief addresses the concern that changing precipitation patterns will be a cause of future interstate conflict, an issue that is largely neglected in climate change studies.[1] Pushing beyond simple theories about resource-based conflict, it utilizes important concepts of *trends* (long-term means) that may affect the baseline probability of conflict, and *triggers* (short-term deviations) that may affect the probability of conflict in the short run. The findings illustrate that higher long-run variability in precipitation and, to a lesser extent, lower mean levels of precipitation are associated with the outbreak of militarized interstate disputes, or clashes short of full-blown war. In contrast, joint water scarcity – defined as both countries experiencing below mean rainfall in the same year – has a conflict-dampening effect.

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Water is a critical natural resource. It is necessary for sustaining human, animal, and plant life, provides a variety of ecosystem services, and is an increasingly important source of electrical power. Despite its centrality to human existence, nearly one billion people lack reliable access to clean drinking water. A 2009 report by the Water Resources Group projects that by 2030 annual global freshwater needs will reach 6.9 trillion cubic meters, which is 64 percent more than the existing accessible, reliable, and sustainable supply.[2]

This forecast, while alarming, likely understates the magnitude of the challenge, as it does not account for the impacts of global climate change on hydrological systems. While the Intergovernmental Panel on Climate Change (IPCC) forecasts an increase in total precipitation at the global level, regional patterns will vary significantly. Rainfall will likely decline by more than 20 percent across North Africa and the Middle East, central Mexico and Central America and the Caribbean, Southern Africa, the eastern Amazon basin, and western Australia, leading to decreases in water availability of 10 to 30 percent.[3] The IPCC also forecasts a 90 percent likelihood that variability in rainfall will increase, leading not only to more numerous dry spells, but also to more extreme precipitation events and flooding.

Water's critical role in the survival of human life, combined with imminent changes in its relative abundance, generates concern that this significant resource will be both a cause of future conflict and a source of bargaining power for states that control access to surface and groundwater supplies. Policy discussions of climate change impacts on water security have tended to focus on declining stocks of freshwater resources – absolute scarcity – as the primary driver of conflict. This discourse is rooted in a neo-Malthusian characterization of the relationship between carrying capacity and violence: declining

or degraded stocks of natural resources, for which no substitutes are available, spark distributional conflicts.[4]

Water's critical role in human survival, combined with imminent changes in its relative abundance, generates concern that this resource will be both a cause of conflict and a source of bargaining power.

The prospect of conflict over water resources is most clear in shared river basins, in which surface freshwater is shared between two or more states. In these cases, river water constitutes a common pool resource whose consumption is rival: one country's increasing consumption necessarily leaves the other country, or countries, with less. Policy discussions have focused on potential links between climate change and conflict that may occur through changes in declining mean levels of freshwater abundance from other sources.

The U.S. National Intelligence Council concludes that, while water-related interstate conflict is unlikely over the next decade, serious water shortages will, over the medium term, destabilize already tense bilateral relationships.[5] As suggested in this forecast, climate change has the potential to exacerbate existing water resource competition through increased water scarcity.

Climate change will likely affect levels of precipitation, with some countries growing more arid and others wetter. However, climate change will also result in increasing climatic variability: more frequent dry spells and flooding, more erratic rainfall patterns, and larger year-to-year variability in precipitation levels. That is, climate change is likely to affect both the means and variability of precipitation in a given area. Conjectures about whether these changes will have security implications, however, should be rooted in an understanding of the role (if any) that precipitation levels, variability, and short-term scarcity have played in past interstate conflict behavior.

This brief addresses the concern that changing precipitation patterns will be a cause of future interstate conflict, an issue that is largely neglected in climate change studies. Pushing beyond simple theories about resource-based conflict, this research distinguishes between *trends*, longer-term mean states that may affect the baseline probability of conflict, and *triggers*, acute scarcity or abundance, that may affect the probability of conflict in the short run. It moves past simple explanations for resource-based conflict and instead explores how climatic factors may affect bargaining between states more generally, as opposed to just those interactions taking place over shared resources. This study assesses whether precipitation scarcity has differential effects at differing time scales: while over the long term more scarce rainfall may be associated with a greater probability of conflict due to increasing resource strain, over the short term acute scarcity should have a pacifying effect due to states attention being diverted to addressing the economic and social effects of below-average rainfall. The same model yields the expectation that conflict will be more likely in pairs of countries characterized by higher variation in rainfall.

The findings are consistent with the theoretical expectations. First, precipitation variability is more strongly associated with the outbreak of conflict, operationalized as militarized interstate disputes – threats, displays of or uses of military force short of war – than mean levels of rainfall. Second, states which are both experiencing acute water scarcity are less, not more, likely to enter into disputes. These findings suggest the policy emphasis on increasing water scarcity should be accompanied by a focus on variability. In particular, variability plays a role apart from an increase in extreme, acute climatic events such as floods and droughts – short-term triggers that may affect the probability of conflict in a given year.

TRENDS AND TRIGGERS

Climate refers to long-run, stable patterns of variation in precipitation, temperature, and other meteorological variables that persist in a given region. With respect to precipitation, a particular climate will be characterized by a relatively stable

a) mean level of annual precipitation and b) variability in annual precipitation levels around that mean. These are climatic *trend* variables. In addition to these longer-term climatic means, acute water scarcity – resulting from lower than normal rainfall in a given year – may *trigger* conflict.

Figure 1 presents the relationship between *mean precipitation*, *current precipitation*, and *precipitation variability* for Sri Lanka, Nigeria, and Somalia. The solid lines represent annual rainfall at a given time for each of the three countries, while the dashed lines represent country mean values. The bar chart to the right shows the coefficient of variation[6] – the ratio of the standard deviation to the mean – for the three countries. Sri Lanka has the highest mean value for precipitation and the largest absolute deviations. Somalia has comparatively small year-to-year deviations in rainfall from the panel mean, but because of the low panel mean, these smaller absolute deviations represent larger proportional changes from the mean state. These three variables constitute the relevant dimensions of precipitation that are forecast to change under most climate change scenarios.

WATER SCARCITY, WATER VARIABILITY, AND CONFLICT

While water security is an important issue for all states, the significance of shared water resources varies according to the degree of dependence states have on them. Pairs of countries with higher levels of domestic renewable freshwater in the form of rainfall attach less salience to shared water resources. In contrast, pairs of countries with low mean levels of precipitation are more dependent on groundwater and/or freshwater from external sources. Shared water resources should thus be more important to comparatively rainfall-scarce countries than those whose freshwater needs are adequately met by domestic, renewable surface sources. This suggests that pairs of countries with lower overall levels of mean rainfall will be more likely to enter into conflict over water resources. If the mechanism linking scarcity to conflict operates through incentives to appropriate scarce resources, there must be a shared resource to appropriate. The corollary to this expectation, then, is that mean rainfall scarcity should have larger impacts on pairs of countries that share a river basin and/or are contiguous.

However, conflict cannot create new resources, and conflict itself entails significant costs for belligerent parties. Violent conflict generally only occurs when negotiations have failed to produce an outcome that both parties prefer; conflict can thus be understood as a bargaining failure. The effect of rainfall on the bargaining context thus becomes important in hypothesizing why conflicts occur, illustrating that while neo-Malthusian concerns focusing on scarcity of resources may establish motive, they should not be considered in isolation.

This research moves past simple explanations for resource-based conflict and instead explores how climatic factors may affect bargaining between states more generally.

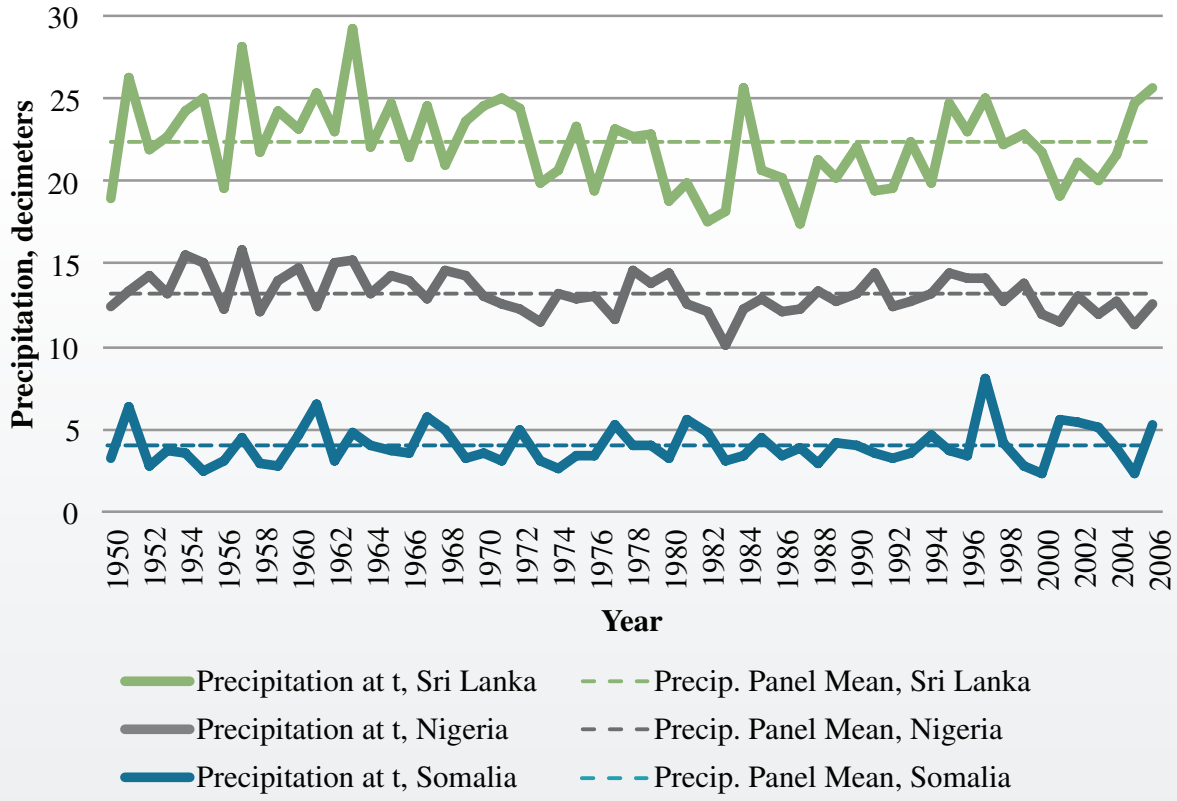
Variability in precipitation may contribute to tensions between states by making their withdrawal needs from shared water resources less predictable, as year-to-year changes in rainfall are proportionately larger. When states are uncertain about their needs from shared resources, both explicit and implicit agreements governing the use of shared resources are more difficult to achieve and maintain. Bargaining may be more likely to break down between riparian states characterized by high year-to-year variability in, and therefore uncertainty about, rainfall. Thus, conflict seems more likely in dyads – pairs of countries – characterized by higher year-to-year variability in rainfall.

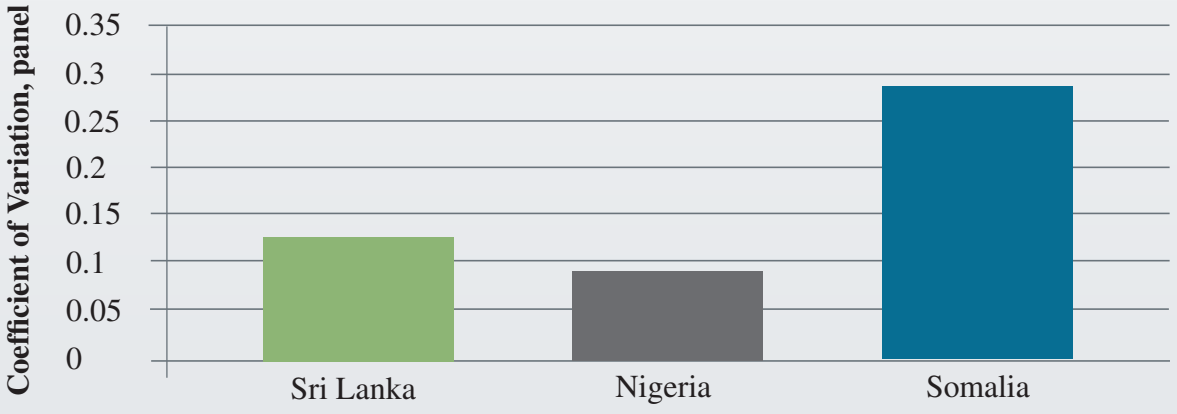
But what about acute scarcity? For neo-Malthusians, during periods of acute water scarcity due to lower-than-normal rainfall, states have no alternative but to increase their demands on shared water resources. Accordingly, the probability of conflict outbreak should be highest when co-riparian states simultaneously increase their demands on shared resources due to abnormally low rainfall in both states.

When variability in precipitation makes states uncertain about their needs from shared resources, agreements governing the use of shared resources are more difficult to achieve and maintain.

Instead of focusing on acute water scarcity as a motive for conflict, acute water scarcity can be viewed alternately as a factor affecting the perceived costs of fighting. These costs can be real, in terms of "blood and treasure," but also take the form of opportunity costs: the economic and social losses stemming from diversion of productive resources into fighting. Acute water scarcity and higher temperatures lead to overall economic contraction, with particularly severe impacts on the agricultural and subsistence sectors.[7] Demand for state resources, in the form of drought response activities such as emergency feeding programs and the provision of crop insurance, increases while state revenues, especially in poorer

Figure 1. Precipitation Means, Variability, and Current Levels





countries, decrease.[8] Opportunity costs to fighting thus increase with acute water scarcity. As opportunity costs are increasing for both countries, the range of outcomes that both states prefer to fighting increases, and conflict should be less likely. A secondary implication of the opportunity cost argument is that the effects of acute water scarcity should not be conditional on the countries *sharing a water source*. Because the opportunity cost model relates to domestic conditions affecting states' ability to bear costs, rather than distributional conflicts over common-pool resources, the effects should not be more pronounced in contiguous countries that share a river basin. The effect should be unconditional.

DATA ANALYSIS

This research examines interstate conflict behavior in a global sample of dyads from 1950 to 2002.[9] The results provide strong evidence that acute water scarcity actually has a suppressing effect on conflict initiation. The analysis concerns militarized interstate disputes (MIDs), or instances of conflict behavior that fall short of full-blown war. Examples of MID behavior include firing warning shots at foreign naval vessels, sending troops into disputed territory, or mobilizing combat units in response to perceived aggressive acts.

When both dyad members are experiencing *acute rainfall scarcity* – rainfall below their long-run mean levels – such conflict between the two is 30 percent less likely. Moreover, this relationship is not contingent on the two countries actually sharing a water resource.

Evidence for the effects of *mean levels of precipitation* is mixed, with some models used in this analysis finding that lower levels of average precipitation within the dyad are associated with an increased probability of conflict, while others reported no effect.

This study's models found consistent and strong evidence for a link between *precipitation variability* and conflict: as precipitation variability in a dyad increases, conflict becomes more likely. A one standard deviation increase in dyadic precipitation variability from the mean value is associated with a 48.3 percent increase in the probability of MID occurrence and a 30.6 percent increase in the probability of fatal MID – a conflict resulting in actual loss of life. Again, there is no evidence to indicate that countries must share a water resource for this relationship between precipitation means and variability to be relevant.

Considered together, these findings suggest three broad conclusions. First, there is evidence for significant impacts of precipitation – both longer-term means and variability and shorter-term fluctuations – on interstate conflict. Much recent scholarship has been dedicated to investigating the impacts of climatic conditions on "new" foci in security studies: civil war, non-state and one-sided conflict, and social conflict.[10] Comparatively few studies, however, have tackled the potential for climatic impacts on interstate conflict. The leading journal Science recently published a meta-analysis of 30 studies of intergroup violence, but it included only one that analyzed trans-boundary (i.e., interstate) conflict.[11] In a recently published literature review on the links between climate change and armed conflict, senior researchers at the Peace Research Institute Oslo (PRIO) – one of the main hubs of research on the climate-conflict nexus, explicitly omitted a discussion of potential links between interstate conflict and climatic conditions.[12] This study's findings provide strong evidence for climatic impacts on interstate conflict, over both short and longer temporal scales, challenging the current deficiency of research exploring this topic.

At shorter time scales, acute rainfall scarcity is pacifying. Over the longer-term, however, rainfall scarcity and variability are linked to increased propensity for conflict.

Second, these effects do not seem to rely on the countries in question sharing water resources. In the case of joint acute scarcity, this finding can be interpreted in light of the bargaining model: irrespective of whether the countries share a water source, below-normal rainfall places

strains on each country's economy and implies a larger role for the state in responding to crisis. The opportunity cost to fighting is thus higher during these periods, and conflict relatively less likely.

The findings regarding precipitation mean levels and variability, however, do not have as straightforward an interpretation. These findings could be evidence of a general effect of dyadic water stress – countries dealing with water scarcity and high levels of water variability, *ceteris paribus*, face greater domestic ecological pressures than those which are not similarly stressed. These stresses cause states to behave more aggressively in the international sphere.

This study contributes to the understanding of climate change as a potential source of friction between countries by focusing attention not just on absolute water scarcity, but also on water resource variability.

This ambiguity relates to a broader debate in environmental security literature over whether the policy community is interested only in environmental conflict, i.e., conflicts caused by environmental scarcity of a resource, or in the broader concept of environmental impacts on conflict. Most policy discussions of environmental conflict presuppose that environmental conditions primarily affect *motives* for engaging in conflict. However, climatic conditions might affect the specific timing or intensity of conflict irrespective of whether environmental conditions were ultimately the "cause."

Finally, temporal scale matters. The findings demonstrate that at shorter time scales, acute rainfall scarcity is pacifying. Over the longer-term, however, rainfall scarcity and variability are linked to increased propensity for conflict.

With the release of its 2013 report, the IPCC will, for the first time, identify an increase in violent conflict as one of the forecasted effects of climate change, with the effects flowing mostly through changes in freshwater availability. However, the report will likely neglect to address the impacts of climatic variables on interstate conflict due to the dearth of studies specifically addressing this issue. In the absence of rigorous analysis to inform planning, policy makers are likely to fill the void with dramatic, but unsubstantiated, conjectures. In 2003, Peter Schwartz and Doug Randall published *An Abrupt Climate Change Scenario and Its Implications for United States National Security*, an extreme climate change scenario commissioned by the U.S. Department of Defense. In it, they challenged U.S. strategic planners to "Envision Pakistan, India, and China – all armed with nuclear weapons – skirmishing at their borders over refugees, access to shared rivers, and arable land…With over 200 river basins touching multiple nations, we can expect conflict over access to water for drinking, irrigation, and transportation."[13]

The security implications of climate change have become the subject of much conjecture, often without significant grounding in empirical research. This is due both to the inherent difficulties of forecasting human innovation and adaptation to shifting climatic realities and to a relative scarcity of research in key areas.

While much work has focused on absolute resource scarcity as a source of conflict, comparatively little has explored one of the potentially more powerful effects of climate change: increasingly frequent "shocks" and increased variability in ecosystems. This study contributes to the understanding of climate change as a potential source of friction between countries by focusing attention not just on absolute water scarcity, but also on water resource variability. This analysis will hopefully push the discussion toward more closely aligning the modeling of human impacts with the understanding of the physical impacts of climate change.

ENDNOTES

1 This brief is based on Colleen Devlin and Cullen S. Hendrix, "Trends and Triggers Redux: Climate Change, Water Scarcity, and Interstate Conflict" (Paper presented at the annual meeting of the International Studies Association, San Francisco, CA, April 3-6, 2013).

2 Water Resources Group, *Charting Our Water Future: Economic Frameworks to Inform Decision-Making* (Washington: McKinsey & Co, 2009).

3 IPCC, *Climate Change 2007: Impacts, Adaptation and Vulnerability* (Cambridge: Cambridge University Press, Intergovernmental Panel on Climate Change, 2007); IPCC, Working Group I Contribution to the IPCC Fifth Assessment Report, *Climate Change 2013: The Physical Science Basis*, Final Draft Underlying Scientific-Technical Assessment (Geneva: IPCC Secretariat, 2013).

4 Thomas Malthus (1798) theorized that while population grew geometrically, i.e., in more or less constant percentage terms (3 percent per year), the food supply grew only arithmetically, i.e., by a fixed quantity per year. The logical implication was that human populations, like many animal populations with high population growth rates, would be locked into an immiserating "boom and bust" cycle of rapid growth, conflict, and population collapse due to food scarcity. Though Malthus' conjecture has not been born out in the intervening two centuries, his thoughts on the relationship between scarcity and violence still underpin much thinking on the relationship between environmental conditions and conflict. See Thomas Malthus, *An Essay on the Principle of Population* (New York: Oxford University Press, 1798 (2000 reprint)).

5 National Intelligence Council, *Global Water Security, ICA 2012-08* (Washington: Office of the Director of National Intelligence, 2012).

6 Coefficient of variation for dyad d = $sd/x_d/X_d$, where s is the sample standard deviation of water scarcity for dyad *d* and *x* is the dyad mean. The coefficient of variation is a useful statistic for representing dispersion of values around the mean – absent information about the mean value, standard deviations are not directly comparable across units.

7 David S. Battisti and Rosamond L. Naylor, "Historical Warnings of Future Food Insecurity with Unprecedented Seasonal Heat," *Science* 323 (2009): 240-244.

8 Sommarat Chantarat, Christopher B. Barrett, Andrew G. Mude, and Calum Turvey, "Using Weather Index Insurance to Improve Drought Response for Famine Prevention," *American Journal of Agricultural Economics* 89 (2007):1262-1268; Ilan Noy and Aekkanush Nualsri, "Fiscal Storms: Public Spending and Revenues in the Aftermath of Natural Disasters," *Environment and Development Economics* 16,1 (2011): 113-128.

9 The empirical tests were conducted by a reanalysis of two influential, recent studies on the shared water resources and conflict: Jaroslav Tir and Douglas M. Stinnett, "Weathering Climate Change: Can Institutions Mitigate International Water Conflict?" *Journal of Peace Research* 49 (2012): 211-225, and Marit Brochmann and Nils Petter Gleditsch, "Shared Rivers and Conflict – A Reconsideration," *Political Geography* 31 (2012): 519-527.

10 See Todd Smith, "Food Price Spikes and Social Unrest in Africa," CCAPS Research Brief No. 11 (Austin: Robert S. Strauss Center for International Security and Law, 2013); Cullen S. Hendrix, "Climate Change, Global Food Markets, and Urban Unrest," CCAPS Research Brief No. 7 (Austin: Robert S. Strauss Center for International Security and Law, 2013); and Cullen S. Hendrix and Idean Salehyan, "Climate Shocks and Political Violence," CCAPS Research Brief No. 3 (Austin: Robert S. Strauss Center for International Security and Law, 2012).

11 Solomon M. Hsiang, Marshall Burke, and Edward Miguel, "Quantifying the Influence of Climate on Human Conflict," *Science* 341 (2013): 1235367.

12 Ole Magnus Theisen, Nils Petter Gleditsch, and Halvard Buhaug, "Is Climate Change a Driver of Armed Conflict?" *Climatic Change* 117 (2013): 613-625.

13 Peter Schwartz and Doug Randall, *An Abrupt Climate Change Scenario and Its Implications for United States National Security* (Pasadena: Jet Propulsion Laboratory, 2003), 18.

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