

Environmental changes and violent conflict

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Abstract

This letter reviews the scientific literature on whether and how environmental changes affect the risk of violent conflict. The available evidence from qualitative case studies indicates that environmental stress can contribute to violent conflict in some specific cases. Results from quantitative large-N studies, however, strongly suggest that we should be careful in drawing general conclusions. Those large-N studies that we regard as the most sophisticated ones obtain results that are not robust to alternative model specifications and, thus, have been debated. This suggests that environmental changes may, under specific circumstances, increase the risk of violent conflict, but not necessarily in a systematic way and unconditionally. Hence there is, to date, no scientific consensus on the impact of environmental changes on violent conflict. This letter also highlights the most important challenges for further research on the subject. One of the key issues is that the effects of environmental changes on violent conflict are likely to be contingent on a set of economic and political conditions that determine adaptation capacity. In the authors' view, the most important indirect effects are likely to lead from environmental changes via economic performance and migration to violent conflict.

Keywords: environmental changes, violent conflict, adaptation, migration

1. Introduction

The assessment reports of the Intergovernmental Panel on Climate Change (2001, 2007) and the Stern review (2006) conclude that human activity contributes in important ways to environmental changes. Such changes include temperature increases, changes in precipitation levels and patterns, rising sea levels and intensification of natural hazards, such as storms, floods, droughts and landslides. These climate-related environmental changes are likely to worsen already existing environmental problems and thus have serious implications for humans and nature. For instance, they could cause mass migrations out of severely affected areas and violent conflict between and within countries.

Ever since Thomas Malthus published his 'Essay on the Principle of Population' (1798), many policy makers and scholars have claimed that environmental degradation can

cause violent conflict at the sub-national level and between states (e.g. Ban 2007, Homer-Dixon 1994). Systematic scientific assessment of this claim is rather recent, however: a considerable body of scientific and policy-oriented literature on environmental conflicts has emerged only in the past two decades.

In this letter, we take stock of the scientific literature on the subject. In principle, it would be very helpful to know what kinds of environmental changes have what kinds of influences on what kinds of conflict. Our letter essay shows, however, that the existing literature is still far from offering differentiated answers to these questions. Current theorizing and empirical research in fact focuses on the broader question of whether environmental changes increase the risk of violent conflict, and the answer remains strongly debated. Based on what we regard as the most sophisticated studies on the subject, we conclude that there is no systematic and

direct causal relationship between environmental degradation and violent conflict; rather, the effect of environmental changes on violent conflict appears to be contingent on a set of intervening economic and political factors that determine adaptation capacity (e.g. Koubi *et al* 2012, Salehyan 2008a, Buhaug *et al* 2008, Kahl 2006, Martin 2005).

We review the existing literature on the environmental–conflict nexus along the following lines. First, we outline and compare the arguments of the ‘neo-Malthusian’ and ‘cornucopian’ perspectives. This section emphasizes possible causal mechanisms linking environmental changes and conflict. Second, we review empirical studies on the subject. In doing so, we concentrate on large-N research because we believe that, in order to be regarded as scientifically robust and generalizable, arguments about the environment–conflict nexus ultimately have to pass such testing. Third, we highlight data shortcomings and common analytical problems in existing research and offer our assessments of these. By implication, this section accounts for why empirical findings have been contradictory so far. We conclude by pointing to the main avenues for further research.

2. Neo-Malthusian versus cornucopian arguments

One group of scholars, frequently referred to as ‘neo-Malthusians’, claims that environmental changes pose a severe and direct threat to security because of their potential to increase resource scarcity³. Homer-Dixon for instance argues that decreasing access to renewable resources increases frustration, which in turn creates grievances against the state, weakens the state and civil society and increases the opportunity for instigating an insurrection. He identifies three types of environmental scarcity: (1) supply induced scarcity, i.e. reduced availability of renewable resources due to consumption and degradation that develop faster than regeneration processes; (2) demand induced scarcity, which is a consequence of population growth and/or increased consumption per capita; and (3) structural scarcity caused by an unequal distribution of access to natural resources (Homer-Dixon 1994, 1999).

These three components interact and reinforce each other, resulting in two social processes labelled as ‘resource capture’ and ‘ecological marginalization’. The former occurs when resource depletion and population growth induce unequal access to resources. In such cases, powerful state elites—attempting to secure resources that may become scarce in the future—manipulate a country’s policies in their own favour. This weakens institutional responses to social grievances and increases the risk of violent conflict. The latter process occurs when unequal resource access and population growth affect resource degradation and depletion. Under those circumstances, groups facing resource scarcity may migrate

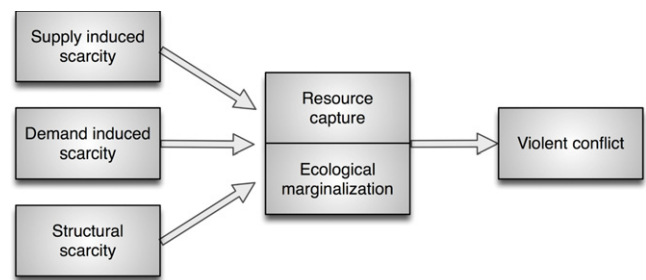


Figure 1. Environmental scarcity and violent conflict.

into areas that are already ecologically stressed. This increases the risk of violence between natives and newcomers⁴. Figure 1 summarizes these mechanisms. While subsequent research has led to some refinements of these mechanisms (e.g. Buhaug *et al* 2008), figure 1 still represents the baseline model for neo-Malthusian environment–conflict arguments.

Cornucopians are ‘resource optimists’. They do not share the pessimistic neo-Malthusian view. They acknowledge that environmental changes may periodically put human well-being at risk. But they also claim that humans are and will be able to adapt to resource scarcities either through market mechanisms, technological innovations, social institutions for resource allocation or any combination thereof (Lomborg 2001, Simon 1989, 1996). Simon (1996), for example, argues that mankind will be able to respond to new circumstances imposed by environmental changes through improvements in technology and efficiency—although he admits that population growth may lead to resource shortages or increased economic burdens in the short run. In the same vein, cornucopians criticize neo-Malthusian arguments as overly deterministic and ignorant of economic and socio-political factors (e.g. Gleditsch 1998, Matthew and Gaulin 2000, de Soysa 2002a, 2002b, Barnett and Adger 2007, Salehyan 2008a, Koubi *et al* 2012).⁵

Resource optimists suggest various causal mechanisms in which scarcity of resources is just one of several key factors in the overall relationship between environmental changes and violent conflict. In those explanatory models, cooperation between resource users is a distinct possibility for mitigating and/or adapting to resource scarcity. In other words, even if environmental changes exacerbate resource scarcity, violent conflict is not a foregone conclusion. Moreover, even if violent conflict occurs, resource scarcity is unlikely to be the main cause although it may be present in the respective case.

3. Empirical evidence

Much of the existing empirical work on the environment–conflict nexus relies on qualitative case studies of specific

³ Some scholars have argued that local abundance of natural resources can contribute to violent conflict as well (Collier and Hoeffler 2004, 1998, Ross 2004, Fearon and Laitin 2003, Le Billon 2001). This work, which remains very much contested (Brunnschweiler and Bulte 2008, de Soysa 2002a, 2002b, Cramer 2002), is less relevant in our context because it deals with extraction of high value resources, for instance oil, gold or diamonds, rather than environmental changes.

⁴ Many neo-Malthusian arguments are in fact motivated by observations of low-intensity communal disputes over scarce natural resources.

⁵ Most cornucopians do not believe that resource scarcity leads to major violent conflict, but they do concede that smaller-scale violent conflict over scarce resources is possible, though not unavoidable. Hence the main disagreement between neo-Malthusians and cornucopians appears to concern primarily the deterministic character of the neo-Malthusian argument and the expected frequency of larger-scale violent conflict.

countries or regions. Many of these studies have been undertaken by the Toronto Group's Environmental Change and Acute Conflict Project (ECACP), and the Environmental Conflicts Project (ENCOP) at ETH Zurich. They provide evidence that environmental scarcity has been a contributing factor in recent conflicts. Examples include violence in South Africa, the insurgency in Assam, the Zapatista rebellion in Chiapas (Homer-Dixon 1991, 1994, 1999, Percival and Homer-Dixon 1998, Homer-Dixon and Blitt 1998), as well as conflicts in Sudan, the Middle East and Nigeria (Baechler 1998, Spillman 1995, Baechler *et al* 1996).⁶

This research has produced important insights into the pathways that may link environmental conditions and conflict. However, social and political implications of environmental changes are likely to vary considerably between different types of environmental changes (e.g. water scarcity, floods, soil degradation, deforestation, etc) as well as areas and societies of the world. Most of the case studies literature on the environment–conflict relationship uses a ‘grounded theory’ approach; theoretical arguments are developed inductively, based on in-depth analysis of individual cases. Alternatively, case studies are also used to illustrate, rather than to test, theoretical arguments. Qualitative case studies are, therefore, very useful for theory development and illustration, and for providing an in-depth understanding of particular events. But they need to be complemented by quantitative research in order to arrive at robust and generalizable findings with respect to the key issue of concern: whether environmental changes do (rather than can) increase the risk of violent conflict. Hence the remainder of this section concentrates on the recent wave of empirical large-N research. It is structured according to conflict types, i.e. inter- versus intrastate conflict, and also considers the environmental conditions (water scarcity, land degradation, deforestation, climatic changes, etc) under study.

With regard to interstate conflict, most of the existing quantitative work focuses on the effects of water scarcity on the probability of conflict while controlling for other determinants⁷. Hauge and Ellingsen (2001) and Gleick (1993) provide some evidence that water scarcity can lead to armed conflict. In addition, systematic empirical analyses suggest that transboundary waters are associated with low-level conflicts, but not with full-scale ‘water wars’ (e.g. Gleditsch and Hegre 2000, Tose *et al* 2000, Gleditsch *et al* 2006, Hensel *et al* 2006, Brochmann and Hensel 2009, Dinar 2009, Dinar *et al* 2011). In contrast to these studies, Kalbhenn (2012), Dinar *et al* (2007), Wolf (2002), and Yoffe *et al* (2003) report that states tend to cooperate rather than fight over their shared water resources, and most international water conflicts are not full-scale wars, but rather diplomatic tensions⁸.

⁶ Moran (2011) discusses the effects climate change is likely to have on 42 countries and regions until 2030, including the USA, the EU, China, India, Brazil and Southern Africa.

⁷ Tir and Diehl (1998) examine the impact of population growth and density (the standard proxy for the neo-Malthusian resource pressure) on militarized interstate disputes (MIDs) onset from 1930 to 1989. They find a positive relationship between population growth and the risk of MIDs, but the results offer no evidence that population density affects conflict involvement, initiation or escalation.

⁸ Similarly, Gartzke (2012) shows that climatic changes—in particular the rise in global temperature—did not lead to an increase in interstate conflict.

With regard to intrastate conflict, Hauge and Ellingsen (1998) examine the effects of land degradation, freshwater scarcity, population density⁹ and deforestation on intrastate conflict in 1980–1992. They find that all these factors have direct and positive effects on the incidence of conflict. Theisen (2008) shows, however, that the results of Hauge and Ellingsen (1998) cannot be replicated even with the original data. In his own analysis, Theisen (2008) finds that only a very high level of land degradation increases the risk of civil war. He concludes that ‘scarcity of natural resources has limited explanatory power in terms of civil violence’ (Theisen 2008).¹⁰

Raleigh and Urdal (2007) and Hendrix and Glaser (2007) study how factors presumably related to climate change, such as land degradation and freshwater availability, affect the likelihood of civil conflict in Africa. They find that only water scarcity significantly increases the likelihood of conflict. Hendrix and Glaser (2007) also examine the impact of short-term climatic changes (inter-annual variability in rainfall) on civil conflict onset in sub-Saharan Africa. They report that positive changes in rainfall significantly decrease the conflict risk in the following year.

Hsiang *et al* (2011) study the impact of planetary-scale climatic changes on civil conflict and show that the ‘probability of new civil conflicts arising throughout the tropics doubles during El Niño years relative to La Niña years.’ Similarly, Burke *et al* (2009) find that temperature increases in Africa between 1981 and 2002 have a significantly positive effect on civil war onset. They report that a 1 °C temperature increase boosts the risk of civil war by 4.5% points during the same year. Buhaug (2010), on the other hand, shows that this result is not robust to alternative model specifications. He also finds that climate variability, measured as inter-annual growth and deviation from annual mean precipitation and temperature, does not predict civil conflict. In the same vein, Theisen *et al* (2012), using various drought measures while controlling for socio-political characteristics such as politically marginalized population, do not find any effect of drought on civil conflict in Africa. They conclude that the critical determinant of civil conflict is the extent of political and economic marginalization of ethnic groups rather than environmental issues (see also Raleigh 2010). Also, Brückner and Ciccone (2010) do not find any significant effect of rainfall growth on civil war onset.

Brancati (2007) and Nel and Righarts (2008) examine the impact of natural disasters, such as earthquakes, volcanic eruption, tsunami, etc, on intrastate conflict. They find that natural disasters significantly increase the risk of civil conflict, especially in countries with a lower gross domestic product, sluggish economic growth, mixed political regimes and preexisting conflicts. Nel and Righarts (2008) concede, however, that different dynamics apply to minor as compared

⁹ Note that several authors (e.g. Raleigh and Urdal 2007, Urdal 2005, de Soysa 2002a, 2002b) report a significant positive influence of population density on domestic armed conflict. But others (Collier and Hoeffler 2004, Hegre and Sambanis 2006) do not find any effect. Overall, the existing findings offer only weak empirical support for the neo-Malthusian population pressure–conflict argument.

¹⁰ Similarly, the US State Failure Task Force Project did not find a significant, direct relationship between indicators of environmental scarcity and various types of state failure—including civil war (Esty *et al* 1998).

to major conflicts. This somewhat limits the generalizability of their results. In this context, Bergholt and Lujala (2012) investigate the economic consequences of natural disasters and how these may be linked to civil conflict. They do not find support for the argument that the negative effect of disasters on economic growth increases the likelihood of armed civil conflicts.

Binningsbo *et al* (2007) use the ecological footprint index (Rees 1992)—a popular measure of environmental sustainability—as a measure of environmental scarcity/degradation. They find that increasing a country's ecological footprint reduces the risk of violent conflict. This result cuts against neo-Malthusian claims, suggesting that higher per capita consumption of natural resources is associated with lower probability of violent conflict. They conclude that this finding is consistent with a liberal perspective on armed conflict: as people become wealthier, they have more to lose from violence and, consequently, will try harder to avoid it.

In summary, in its attempts to identify whether environmental changes contribute to violent conflict, existing research has, thus far, arrived at contradictory findings. These contradictory results stem primarily from differences across studies in: (a) the type of conflict under study; (b) differences in the type of environmental changes whose effect is examined; and (c) differences in country samples and time-periods. With a view to the saying that 'absence of evidence does not necessarily mean evidence of absence', we should not jump to the conclusion that the neo-Malthusian claim is empirically false, and that, by implication, the cornucopians are right. The main reason, as discussed in section 4, is that several important analytical problems remain to be solved.

4. Problems in existing empirical research

Qualitative case studies have shown that environmental changes played a role in several, mostly small-scale and local violent conflicts in various parts of the world. Still, larger-scale comparisons—including comparisons with cases in which environmental changes have not led to violent conflict—are clearly needed in order to arrive at general conclusions with respect to the neo-Malthusian versus cornucopian debate. As demonstrated in section 3, however, large-N quantitative research has produced interesting, yet rather contradictory findings. In fact, the findings discussed above are not robust to alternative model specifications. Hence there is no consensus on the impact of environmental changes on conflict. We believe that several analytical problems are likely to be the reason for that. In this section we highlight what we regard as the most important research challenges and then focus in detail on the issue of indirect effects and endogeneity in the subsequent section.

First, there is a lack of issue coding in existing conflict data—these data capture the outcome to be explained. That is, existing studies do not explicitly identify whether the issue over which a violent conflict broke out is related to environmental changes. They merely infer causal effects of environmental changes on conflict by identifying partial coefficients on environmental variables in regression models

(e.g. Bernauer and Kalbhenn 2010). The most promising solution to this lacuna lies in the coding of time-series cross-sectional event data that identify conflict events also in terms of their likely trigger¹¹. Existing data that could be useful in this respect focus exclusively on international river-basin conflicts and cooperation (transboundary freshwater dispute database (TFDD); Kalbhenn and Bernauer 2012; issue correlates of war project). In addition, a recent data coding project offers quantitative information on domestic water conflict/cooperation in the Mediterranean and Sahel areas (Bernauer *et al* 2011).¹² Extensions to environmental conflicts more broadly would be very useful.

Second, conflict data that are commonly used for large-N studies of the environment–conflict nexus, notably the UCDP/PRIO Armed Conflict Dataset and the Correlates of War (COW) data, only capture rather high-intensity conflict events. The UCDP/PRIO data, for instance, define conflicts as violent events that involve government actors on at least one side of the conflict, and the data record only those conflicts with 25 or more battle deaths per year. Although there is much merit in focusing on high-intensity violent conflict, this approach still leaves aside other types of conflict events, such as demonstrations, riots and various forms of communal violence not involving state actors. The Armed Conflict Location and Event Data (ACLED) provide information on communal conflicts, albeit only for Africa and the time period 1997–2010. A new dataset, the Social Conflict in Africa Database (SCAD), provides highly useful information on low levels of violence in African countries (e.g. demonstrations and riots) in recent years¹³. We believe that the absence of sufficient data on low-intensity non-state conflict is likely to be one important reason why existing quantitative research does not offer much insight into what kinds of environmental changes have what kinds of influences on what kinds of conflict or cooperation. Specifically, violent conflicts, as measured by existing datasets, are extremely rare events. Hence there is a problem of over-determination, which makes it very hard to identify whether particular environmental stress factors are associated with particular types of conflicts. Moreover, the lack of issue coding in existing conflict datasets means that we have far too little information on the distribution of conflicts across particular kinds of environmental stress factors.

Third, better data for differentiating local environmental conditions are needed. Researchers often patch together various data from different localities in a country to construct a national environmental-pressure average, which in turn

¹¹ While issue coding is very useful in principle, it can be difficult in some cases to identify and isolate what the 'issue' in question really is. For example, it might be difficult in some cases to identify what the 'real' drivers of individual episodes of violence are, and to separate structural from proximate causes. While a violent conflict over access to water appears like an easy case for issue coding, environmental determinants may be less obvious in other violent events. To mitigate this and related problems, issue coding can be accompanied by qualitative case studies that can provide an in-depth understanding of particular events.

¹² See also Bernauer *et al* (2011) for a discussion of difficulties associated with issue coding.

¹³ Hendrix and Salehyan (2012) use the SCAD data to investigate the effect of deviations from normal rainfall patterns on civil conflict as well as civil unrest during the last twenty years. They find that wetter and drier than normal conditions are associated with both civil conflict and civil unrest.

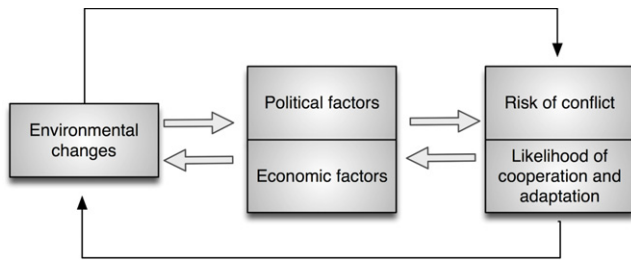


Figure 2. Indirect effects of environmental changes on conflict and cooperation.

is correlated with conflict data. Because environmental conditions may vary strongly across different locations within countries, such averaging is likely to lead to biased and potentially wrong results (Jensen and Gleditsch 2009; see also Theisen *et al* 2012). For example, assume there is strong environmental degradation in two locations within a country, and a violent conflict occurs in each of those locations. If there is no environmental degradation anywhere else in the country, the national average environmental condition would be benign and we would not observe a correlation between environmental degradation and conflict. Fixing this data problem will require intense cooperation between environmental scientists and conflict researchers.

Yet another problem in existing empirical research is that it does not adequately deal with endogeneity among conflict and environmental changes. That is, the majority of studies empirically measures environmental changes in terms of water scarcity, soil erosion, land degradation or deforestation. The problem with those indicators is that they are likely to be endogenous to conflict as well as other types of human activity, i.e. economic and political factors. This means that the causal arrow may not (only) run from environmental changes to conflict, but may also point in the opposite direction (Koubi *et al* 2012, Buhaug *et al* 2008, Salehyan 2008a, Miguel *et al* 2004, Gleditsch 1998).

Moreover, several authors (e.g. Koubi *et al* 2012, Buhaug *et al* 2008, Salehyan 2008a) emphasize that existing studies focus primarily on a direct link between environmental changes and conflict. Conditional effects that could result from economic and political factors have been discussed in the qualitative case studies literature. But they have, so far and perhaps surprisingly, been neglected in quantitative studies on the environment–conflict nexus. This research gap is problematic because, for instance, ignoring the role of governments in managing and redistributing scarce resources could easily lead to wrong *ex post* conclusions, predictions or policy prescriptions. Section 5 concentrates on this issue.

5. Research priorities

We contend that indirect effects between environmental changes and violent conflict cannot be ignored (figure 2), and that empirical analyses of indirect effects are required to further substantiate these indirect causal pathways.

Notably, future studies should consider that economic and political factors are likely to mediate effects that environmental

changes may have on the risk of conflict. Such research on indirect effects will in fact address the cornucopian claim. The latter emphasizes the adaptive capacity of societies facing conditions of environmental and resource scarcity.

Gizelis and Wooden (2010) and Koubi *et al* (2012) argue that economic conditions and political institutions affect the distribution of and access to environmental resources. Political systems and economic conditions can respond to the pressure of natural and structural scarcity in this context. Conflict may, therefore, not always occur in nations that suffer from droughts, temperature increases or water scarcity, and ‘in fact, the modal tendency may be for it not to occur’ (Gizelis and Wooden 2010: 446). Gizelis and Wooden (2010) emphasize and empirically find evidence that these factors have the ability to effectively alleviate grievances and help societies adapt to environmental changes. In other words, some countries are better endowed with economic resources and technological capabilities than others and are therefore better able to cope with environmental stress through effective adaptation policies. Similarly, some countries may have responsive and effective governments as well as superior political institutions—characteristics that are usually associated with mature democracies. Such states will find it easier to deal with environmental changes. Democracies in particular are thus likely to perform better in avoiding conflict over scarce resources. In effect, several studies have identified a significantly positive relationship between democracy and environmental performance (e.g. Bernauer and Koubi 2009, Li and Reuveny 2006).

In our view, the most important indirect effects are likely to lead from environmental changes via economic performance and migration to violent conflict. Several studies empirically support the stylized fact that poor economic performance—either temporary or persistent—breeds violent conflict (e.g. Blattman and Miguel 2010, Hegre and Sambanis 2006, Miguel *et al* 2004, Collier and Hoeffler 2002, 2004, Fearon and Laitin 2003, Elbadawi and Sambanis 2002, Hess and Orphanidis 1995, Russett 1987). If environmental changes, such as temperature increases or decreases, strong deviations in precipitation patterns, or increased water scarcity reduce economic welfare, then conflict could become more likely. Recent empirical work has made first steps in addressing these indirect effects between environmental changes, economic performance and the risk of conflict. Zhang *et al* (2007) find evidence that climatic changes affect conflict through their effects on agricultural productivity over the period 1400–1900. Miguel *et al* (2004) study 41 African countries from 1981 to 1999 and find that negative rainfall growth rates reduce national economic growth, and thereby indirectly increase the likelihood of civil war onset¹⁴. Hidalgo *et al* (2010), using a panel dataset with over 50 000 municipality-year observations, show that land invasions by the rural poor in Brazil occur immediately after adverse economic shocks, which are instrumented by rainfall in the statistical analysis.

¹⁴ Ciccone (2011) re-evaluates the Miguel *et al* (2004) findings using rainfall levels instead of rainfall growth rates. He reports that lower rainfall levels are associated with a lower probability of civil conflict.

In addition to affecting economic performance, environmental changes and degradation could contribute to human migration by pushing people out of adversely affected or uninhabitable areas. Existing studies indicate that internal and international migration is a frequently observed coping response to drought, desertification, water scarcity, sea level rise and other environmental pressures (Laczko and Aghazarm 2009, Henry *et al* 2004, Knerr 2004, Tamondong-Helin and Helin 1991). Furthermore, existing work suggests that environmentally induced migration can lead to conflict in receiving areas because of competition for scarce resources and economic opportunities, ethnic tensions when migrants are from different ethnic groups, and exacerbation of socioeconomic ‘fault lines’ (Raleigh *et al* 2008). Similarly, Gleditsch *et al* (2008: 487; see also Salehyan 2008b, Salehyan and Gleditsch 2006, Sandler 2004: 201) point to spill-over effects, in the sense that mass refugee migration creates new tensions in neighbouring or other receiving states by imposing an economic burden and causing political instability. Eventually, such spillovers can become militarized when states close their borders or take other measures to prevent conflict transmissions. For example, Reuveny (2007) examines the impact of environmental problems on migration and conflict in a study of 38 migration cases in Asia, Africa, and Latin America over the past few decades. His results show that environmental migration does not necessarily induce violent behaviour; but when it does so, environmentally motivated migration seems to intensify intrastate and interstate disputes alike. Suhrke (1993), on the other hand, contends that whether or not environmentally induced migration leads to conflict in receiving areas depends on the capacity of the state to accommodate the needs and alleviate the grievances of migrants and locals alike. It is important to note, however, that it is very challenging to isolate the different causes of migration, and to identify whether specific population movements occurred as a direct result of environmental changes. Furthermore, the lack of systematic data on the impact of environmental degradation on migration and on the effects of environmentally induced migration on conflict is a strong impediment to research on this issue (Laczko and Aghazarm 2009). Consequently, the link between environmentally induced migration and conflict remains speculative.

We submit that environmentally induced economic hardship and migration is likely to lead to violent conflict primarily in or between those states where political institutions and conflict resolution mechanisms are either missing, have failed, or are weak (Skaperdas 2003, 1992, Garfinkel 1994, Suhrke 1993, Haavelmo 1954). Koubi *et al* (2012), using global data for the period 1950–2004, find some evidence that non-democratic countries are more likely to experience civil wars when climatic conditions—measured as deviation of the current level of precipitation and temperature from their past long run average levels—lead to economic downturns. Similarly, Gizelis and Wooden (2010) find some support for the argument that water scarcity is less likely to be associated with intrastate conflict in democracies.

With a view to the latter findings, and also in view of policy debates on appropriate adaptation policies, future

research should focus much more on the role of political and economic factors in mediating the effect of environmental changes on violent conflict. In addition, at the methodological level, future research should deal with the endogeneity of conflict to economic crisis and political institutions. The scarce empirical evidence we have to date suggests that reduced levels of domestic economic activity tend to create incentives for increased external and internal violent conflict, which in turn depresses domestic economic activity (Blomberg *et al* 2006, Blomberg and Hess 2002). Such effects point to a potential ‘poverty–conflict nexus.’ They have to be taken into account in empirical analyses that focus on the entire ‘environment–poverty–conflict nexus.’

6. Conclusion

As noted in section 1, policy makers and scholars alike would like to know what kinds of environmental changes have what kinds of influences on what kinds of conflict or cooperation. Our letter of existing research demonstrates, however, that there is no consensus in the scientific literature on what the answers to these questions should be.

We have shown that current theorizing and empirical research focuses primarily on the broader question of whether environmental changes increase the risk of violent conflict, as predicted by the neo-Malthusian perspective. The available empirical evidence, notably the evidence from qualitative case studies, shows that environmental stress can contribute to violent conflict in some specific cases. The evidence from quantitative large-N studies strongly suggests, however, that we should be very careful in drawing general conclusions from location- and time-specific case-study results. Particularly those large-N studies that we regard as the most sophisticated ones find that the effects of environmental changes on violent conflict, examined for a large population of countries and locations over long time-periods, are not robust to alternative model specifications. Overall, the existing evidence suggests that environmental changes may, under specific circumstances, increase the risk of violent conflict—but do not systematically do so. Our letter also highlights what we consider the most important problems that further research should deal with.

Data gaps, particularly with respect to information on conflicts, environmental problems and environmentally induced migration, loom large. The main gaps pertain to issue coding of conflict events and data for lower-intensity non-state conflicts. Similar problems exist with respect to spatially resolved data on environmental conditions. Such shortcomings constitute a key reason why scientific research cannot, at present, identify whether particular types of environmental changes are systematically associated with particular types of conflict or cooperation.

Another key challenge is to empirically identify indirect and conditional effects of environmental changes on violent conflict. Systematic consideration of intervening variables, such as economic and political conditions, which are very much emphasized by the cornucopian perspective and are to some extent also considered in the qualitative case studies literature, are crucial in this context. Recent large-N

research has begun to address this issue more systematically (e.g. Koubi et al 2012, Gizelis and Wooden 2010, Buhaug et al 2008, Salehyan 2008a, Miguel et al 2004). We believe that significant progress towards resolving these analytical problems is possible on the basis of existing datasets and that these analytical solutions can then fruitfully be applied to new environmental as well as conflict data as they become available.

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References

- Baechler G 1998 Why environmental transformation causes violence: a synthesis *Environ. Change Secur. Proj. Rep.* **4** 24–44
- Baechler G, Böge V, Klötzli S, Libiszewski S and Spillmann K R 1996 *Environmental Degradation as a Cause of War: Ecological Conflicts in the Third World and Peaceful Ways of Resolving Them* (Zurich: Rügger)
- Ban K M 2007 A climate culprit in Darfur *The Washington Post* (www.washingtonpost.com/wp-dyn/content/article/2007/06/15/AR2007061501857.html)
- Barnett J and Adger W N 2007 Climate change, human security and violent conflict *Polit. Geogr.* **26** 639–55
- Bergholt D and Lujala P 2012 Economic effects of natural disasters and armed civil conflict *J. Peace Res.* at press
- Bernauer T, Böhmelt T, Buhaug H, Gleditsch N P, Tribaldos T, Weibust E B and Wischnath G 2011 Intra-state Water-Related Conflict and Cooperation: A New Event Dataset, unpublished
- Bernauer T and Kalbhenn A 2010 The politics of international freshwater resources *International Studies Encyclopedia* (New York: Wiley)
- Bernauer T and Koubi V 2009 Effects of political institutions on air quality *Ecol. Econ.* **68** 1355–65
- Binningsbo H M, de Soysa I and Gleditsch N P 2007 Green giant or straw man? Environmental pressure and civil conflict, 1961–99 *Popul. Environ.* **28** 337–53
- Blattman C and Miguel E 2010 Civil War *J. Econ. Lit.* **48** 3–57
- Blomberg B and Hess G D 2002 The temporal links between conflict and economic activity *J. Conflict Resolution* **46** 74–90
- Blomberg B, Hess G D and Thacker S 2006 On the conflict–poverty nexus *Econ. Polit.* **18** 237–67
- Brancati D 2007 Political aftershocks: the impact of earthquakes on intrastate conflict *J. Confl. Resolut.* **51** 715–43
- Brochmann M and Hensel P R 2009 Peaceful management of international river claims *Int. Negot.* **14** 393–418
- Brückner M and Ciccone A 2010 International commodity prices, growth, and civil war in sub-Saharan Africa *Econ. J.* **120** 519–34
- Brunnschweiler C N and Bulte E 2008 Linking natural resources to slow growth and more conflict *Science* **320** 616–7
- Buhaug H 2010 Climate not to blame for African civil wars *Proc. Natl Acad. Sci.* **107** 16477–82
- Buhaug H, Gleditsch N P and Theisen O M 2008 Implications of climate change for armed conflict *World Bank Workshop on Social Dimensions of Climate Change* (Washington, DC: World Bank)
- Burke M B, Miguel E, Satyanath S, Dykema J and Lobell D B 2009 Warming increases the risk of civil war in Africa *Proc. Natl Acad. Sci.* **106** 20670–4
- Ciccone A 2011 Economic shocks and civil conflict: a comment *Am. Econ. Rev.: Appl. Econ.* **3** 215–27
- Collier P and Hoeffler A 1998 On economic consequences of civil war *Oxford Econ. Papers* **50** 563–73
- Collier P and Hoeffler A 2002 On the incidence of civil war in Africa *J. Confl. Resolut.* **46** 13–28
- Collier P and Hoeffler A 2004 Greed and grievance in civil war *Oxford Econ. Papers* **56** 563–95
- Cramer C 2002 *Homo economicus* goes to war: methodological individualism, rational choice and the political economy of war *World Develop.* **30** 1845–64
- de Soysa I 2002a Paradise is a bazaar? Greed, creed and governance in civil war, 1989–99 *J. Peace Res.* **39** 395–416
- de Soysa I 2002b Ecoviolence: shrinking pie or honey pot? *Glob. Environ. Polit.* **2** 1–34
- Dinar A, Dinar S, McCaffrey S and McKinney D 2007 *Bridges over Water. Understanding Transboundary Water Conflict, Negotiation and Cooperation* (Hackensack, NJ: World Scientific)
- Dinar S 2009 Scarcity and cooperation along international rivers *Glob. Environ. Polit.* **9** 109–35
- Dinar S, Dinar A and Kurukulasuriya P 2011 Scarcity and cooperation along international rivers: an empirical assessment of bilateral treaties *Int. Stud. Q.* **55** 809–33
- Elbadawi I and Sambanis N 2002 How much war will we see? Explaining the prevalence of civil war *J. Confl. Resolut.* **46** 307–34
- Esty D, Goldstone J, Gurr T, Harff B, Levy M, Dabelko G, Surko P and Unger A N 1998 *State Failure Task Force Report: Phase II Findings* (McLean, VA: Science Applications International)
- Fearon J and Laitin D 2003 Ethnicity, insurgency and civil war *Am. Polit. Sci. Rev.* **97** 75–90
- Garfinkel M R 1994 Domestic politics and international conflict *Am. Econ. Rev.* **84** 1294–309
- Gartzke E 2012 Climate change and interstate conflict *J. Peace Res.* at press
- Gizelis T-I and Wooden A E 2010 Water resources, institutions, and intrastate conflict *Polit. Geogr.* **29** 444–53
- Gleditsch K S, Salehyan I and Schultz K 2008 Fighting at home, fighting abroad—how civil wars lead to international disputes *J. Confl. Resolut.* **52** 479–506
- Gleditsch N P 1998 Armed conflict and the environment: a critique of the literature *J. Peace Res.* **35** 363–80
- Gleditsch N P, Furlong K, Hegre H, Lacina B and Owen T 2006 Conflicts over shared rivers: resource scarcity or fuzzy boundaries? *Polit. Geogr.* **25** 361–82
- Gleditsch N P and Hegre H 2000 Shared rivers and intrastate conflict *Polit. Geogr.* **19** 971–96
- Gleick P H 1993 Water and conflict: fresh water resources and international security *Int. Security* **18** 79–112
- Hauge W and Ellingsen T 2001 Causal pathways to peace *Environmental Conflict* ed P Diehl and N P Gleditsch (Boulder, CO: Westview Press)
- Haavelmo T 1954 *A Theory of Economic Evolution* (Amsterdam: North-Holland)
- Hauge W and Ellingsen T 1998 Beyond environmental scarcity: causal pathways to conflict *J. Peace Res.* **35** 299–317
- Hegre H and Sambanis N 2006 Sensitivity analysis of the empirical literature on civil war onset *J. Confl. Resolut.* **50** 508–35
- Hendrix C and Glaser S 2007 Trends and triggers: climate, climate change and civil conflict in sub-Saharan Africa *Polit. Geogr.* **26** 695–715

- Hendrix C and Salehyan I 2012 Climate change, rainfall, and social conflict in Africa *J. Peace Res.* at press
- Henry S, Schoumaker B and Beauchemin C 2004 The impact of rainfall on the first out-migration: a multilevel event-history analysis in Burkino Faso *Popul. Environ.* **25** 423–60
- Hensel P, McLaughlin Mitchell S and Sowers T E 2006 Conflict management of riparian disputes *Polit. Geogr.* **25** 383–411
- Hess G D and Orphanidis A 1995 War politics: an economic, rational voter framework *Am. Econ. Rev.* **85** 828–46
- Hidalgo D, Naidu S, Nichter S and Richardson N 2010 Occupational choices: economic determinants of land invasions *Rev. Econ. Stat.* **92** 505–23
- Homer-Dixon T 1991 On the threshold: environmental changes as causes of acute conflict *Int. Security* **16** 76–116
- Homer-Dixon T 1994 Environmental scarcities and violent conflict: evidence from cases *Int. Security* **19** 5–40
- Homer-Dixon T 1999 *Environment, Scarcity, Violence* (Princeton, NJ: Princeton University Press)
- Homer-Dixon T and Blitt J 1998 *Ecoviolence: Links Among Environment, Population and Security* (Lanham, MD: Rowman and Littlefield)
- Hsiang S, Meng K and Cane M 2011 Civil conflicts are associated with the global climate *Nature* **476** 438–41
- Intergovernmental Panel on Climate Change 2001 *Third Assessment Report (AR3): Climate Change 2001: Synthesis Report* (Geneva: World Meteorological Organization)
- Intergovernmental Panel on Climate Change (IPCC) 2007 *Fourth Assessment Report (AR4): Climate Change 2007: Synthesis Report* (Geneva: World Meteorological Organization)
- Jensen P S and Gleditsch K S 2009 Rain, growth, and civil war: the importance of location *Defence Peace Econ.* **20** 359–72
- Kahl C H 2006 *States, Scarcity, Civil Strife in the Developing World* (Princeton, NJ: Princeton University Press)
- Kalbhenn A 2012 A river runs through it: democracy, international interlinkages and cooperation over shared resources *J. Peace Res.* at press
- Knerr B 2004 Desertification and human migration *Biological Resources and Migration* ed D Werner (Berlin: Springer) pp 317–38
- Koubi V, Bernauer T, Kalbhenn A and Spilker G 2012 Climate change, economic growth, and conflict *J. Peace Res.* at press
- Laczko F and Aghazarm C (ed) 2009 *Migration, Environment and Climate Change: Assessing the Evidence* (Geneva: International Organization for Migration)
- Le Billon P 2001 The political ecology of war: natural resources and armed conflicts *Polit. Geogr.* **20** 561–84
- Li Q and Reuveny R 2006 Democracy and environmental degradation *Int. Stud. Q.* **50** 935–56
- Lomborg B 2001 *The Sceptical Environmentalist: Measuring the Real State of the World* (Cambridge, MA: Cambridge University Press)
- Martin A 2005 Environmental conflict between refugee and host communities *J. Peace Res.* **42** 329–46
- Matthew R A and Gaulin T 2000 Environment and security in an international context: critiquing a pilot study from NATO's committee on the challenges of modern society *Environmental Change and Security Project Report 6*
- Miguel E, Satyanath S and Sergenti E 2004 Economic shocks and civil conflict: an instrumental variables approach *J. Polit. Econ.* **112** 725–53
- Moran D 2011 *Climate Change and National Security: A Country-Level Analysis* (Washington, DC: Georgetown University Press)
- Nel P and Righarts M 2008 Natural disasters and the risk of violent conflict *Int. Stud. Q.* **52** 159–85
- Percival V and Homer-Dixon T 1998 Environmental scarcity and violent conflict: the case of South Africa *J. Peace Res.* **35** 279–98
- Raleigh C 2010 Political marginalization, climate change, and conflict in African Sahel states *Int. Stud. Rev.* **12** 69–86
- Raleigh C, Jordan L and Salehyan I 2008 Assessing the impact of climate change on migration and conflict *Paper Prepared for the Social Dimensions of Climate Change* (Washington, DC: World Bank)
- Raleigh C and Urdal H 2007 Climate change, environmental degradation and armed conflict *Polit. Geogr.* **26** 674–94
- Rees W E 1992 Ecological footprints and appropriated carrying capacity: what urban economics leaves out *Environ. Urbanisation* **4** 121–30
- Reuveny R 2007 Climate change-induced migration and violent conflict *Polit. Geogr.* **26** 656–73
- Ross M 2004 What do we know about natural resources and civil war? *J. Peace Res.* **41** 337–56
- Russett B 1987 Economic change as a cause of international conflict *Peace, Defense and Economic Analysis* ed C Schmidt and F Blackaby (New York: St Martin Press)
- Salehyan I 2008a From climate change to conflict? No consensus yet *J. Peace Res.* **45** 315–26
- Salehyan I 2008b The externalities of civil strife: refugees as a source of international conflict *Am. J. Polit. Sci.* **52** 787–806
- Salehyan I and Gleditsch K S 2006 Refugees and the spread of civil conflict *Int. Org.* **60** 335–66
- Sandler T 2004 *Global Collective Action* (Cambridge: Cambridge University Press)
- Simon J 1989 Lebensraum: paradoxically, population growth may eventually end wars *J. Confl. Resolut.* **33** 164–80
- Simon J 1996 *The Ultimate Resource II* (Princeton, NJ: Princeton University Press)
- Skaperdas S 1992 Cooperation, conflict, and power in the absence of property rights *Am. Econ. Rev.* **82** 720–39
- Skaperdas S 2003 Restraining the genuine homo economicus: why the economy cannot be divorced from its governance *Econ. Polit.* **15** 135–62
- Spillman K R 1995 From environmental change to environmental conflict *Environmental Crisis: Regional Conflicts and Ways to Cooperate* ed K Spillmann and G Bächler (Zurich: Centre for Security Studies)
- Stern N 2006 *The Economics of Climate Change: The Stern Review* (Cambridge, MA: Cambridge University Press)
- Suhrke A 1993 Pressure points: environmental degradation, migration and conflict (unpublished)
- Tamondong-Helin S and Helin W 1991 *Migration and the Environment: Interrelationship in Sub-Saharan Africa. Field Staff Report No. 22. Environmental Change in the West African Sahel* (San Francisco, CA: Natural Heritage Institute and National Academy Press)
- Theisen O M 2008 Blood and soil? Resource scarcity and internal armed conflict revisited *J. Peace Res.* **45** 801–18
- Theisen O M, Holtermann H and Buhaug H 2012 Drought, political exclusion, and civil war *Int. Security* at press
- Tir J and Diehl P 1998 Demographic pressure and interstate conflict: linking population growth and density to militarized disputes and wars, 1930–89 *J. Peace Res.* **35** 319–39
- Toset H P, Gleditsch N P and Hegre H 2000 Shared rivers and interstate conflict *Polit. Geogr.* **19** 971–66
- Urdal H 2005 People versus malthus: population pressure, environmental degradation, and armed conflict revisited *J. Peace Res.* **42** 417–34
- Wolf A (ed) 2002 *Conflict Prevention and Resolution in Water Systems* (Cheltenham: Edward Elgar)
- Yoffe S, Wolf A and Giordano M 2003 Conflict and cooperation over international freshwater resources: indicators of basins at risk *J. Am. Water Resour. Assoc.* **39** 1109–26
- Zhang D, Brecke P, Lee H F, He Y-Q and Zhang J 2007 Global climate change, war, and population decline in recent human history *Proc. Natl Acad. Sci.* **104** 19214–9