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Implications of Climate Change for Armed Conflict[1]

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Contents

Executive Summary

This paper offers an assessment of theories and evidence for a relationship between climate change and armed conflict. We identify three processes through which climate change could cause social instability and conflict: intensification of natural disasters, increasing resource scarcity, and sea-level rise. The risks associated with these processes primarily concern destruction of infrastructure, increased health risk, and loss of livelihood. Five complementary mechanisms have been proposed:

- Economic instability
- Political instability
- Social fragmentation
- Migration
- Inappropriate response

The projected impacts of climate change will not result in elevated conflict risk in all societies. The extent to which any of these mechanisms play out and increase the likelihood of organized violence depends crucially on country-specific and contextual factors. The resulting causal model depicts a two-stage process: first, whether climate change has adverse socio-political and economic effects on a given society, and second, whether any resulting negative consequences increases the baseline risk of armed conflict.

The issue of climate change and armed conflict is characterized by two paradoxes that pass by largely unnoticed in the current debate. First, the many processes associated with global warming, which have truly started to appear only over the last fifteen years, have occurred during a time when we have witnessed a dramatic reduction in the frequency and severity of armed conflict.

Second, the empirical foundation for a general relationship between resource scarcity and armed conflict is indicative at best, and numerous questions regarding the proposed causal association remain to be answered. Several single-case analyses suggest that resource scarcity contribute to outbreak of organized violence, though always in interaction with exogenous conflict-promoting factors. The statistical literature, in contrast, has failed to converge on any significant and robust association between resource scarcity and civil war. Although we cannot rule out the possibility of no general linkage, substantial limitations in

data and research designs leave a lot to be desired. Accordingly, the potential for improvement is high, particularly within the quantitative research tradition.

Nine areas of improvement should receive high priority in future research on the topic: increase focus on plausible catalysts of conflict; increase focus on natural disasters; investigate the agency of involved individuals; collect time-varying measures of resource availability; develop disaggregated research designs; acknowledge and account for regional implications; widen the definition of conflict to include non-state conflicts; explore the influence of climate change for the course and outcome of ongoing conflicts; and combine research traditions to test complex relationships in a systematic and generalizable manner.

Given the notable lack of robust findings, the general literature on environmental conflict has few immediate policy implications to offer. However, the theorized indirect nature of the environment-conflict nexus offers some insights into where future development and peacebuilding efforts should be targeted. Six recommendations are identified:

1. **Invest in vigorous, systematic research.** Global climate change policy is crucially dependent upon the early warning of events in areas that have not necessarily had such problems in the past. For this, we need better generalizable knowledge. Precise point predictions are not realistic, but general models can provide guidance as to the probability of future problems and thus help to select priority areas for remedial action.

2. **Promote more systematic environmental accounting.** The debate so far has rightly focused on the negative impact of climate change. A more systematic assessment is needed of positive vs. negative effects, including effects for security, with a view to targeting countermeasures and mitigation most effectively.

3. **Assess the security effects of countermeasures to climate change.** Drastic mitigation and adaptation measures may themselves have significant security effects; these need to be assessed in order to find the best countermeasures overall.

4. **Use development policies for peacebuilding.** The probable causal chains from climate change to insecurity run through economic and social mechanisms. Until systematic research succeeds in uncovering specified and robust associations between climate change and armed conflict, investing in sustainable development in vulnerable societies may be the best instrument for promoting peace and security.

5. **Prioritize the most vulnerable societies.** Today's conflict-prone societies face a double security challenge through additional climate-imposed strains on human health and livelihood. This is likely to exacerbate the differences between those who are able to adapt to a changing environment and those who are caught in the 'conflict trap'.

6. **Include security issues in the next round of IPCC assessments.** In contrast to the natural science of climate change, the social implications lack solid research foundation and are dealt with by the IPCC only in scattered comments. If the security implications of climate change are to be taken seriously in the policy debate, the IPCC should take the lead in investigating them systematically.

1. Introduction

A number of high-profile individuals and policy reports have spurred alarmist claims that environmental change in general and climate change in particular will have enormous impacts on humanity. In a highly influential article *The Coming Anarchy*, Robert D. Kaplan (1994) envisioned the core foreign-policy challenge for the twenty-first century as the 'political and strategic impact of surging populations, spreading disease, deforestation and soil erosion, water depletion, air pollution, and possibly, rising sea levels – developments that will prompt mass migration and, in turn, incite group conflicts'. More recently, a report from Christian Aid (2007: 2) claims that an estimated 1 billion people will be forced to leave their homes between now and 2050, which might 'de-stabilise whole regions where increasingly desperate populations compete for dwindling food and water'. Along the same lines, Thomas Homer-Dixon (2007) – perhaps the most widely-publicized scholar in the area of environmental conflict – argues that 'climate change will help produce [..] insurgencies, genocide, guerrilla attacks, gang warfare, and global terrorism.' More dramatic still, a report to the Pentagon on implications of climate change for US national security sketches scenarios of epic proportions, including the risk of reverting to a Hobbesian state of nature whereby humanity would be engaged in 'constant battles for diminishing resources' (Schwartz & Randall, 2003: 16). Later, eleven retired US generals and admirals added more military authority to the issue, arguing that 'Climate change can act as a threat multiplier for instability in some of the most volatile regions of the world' and that this 'presents significant national security challenges for the United States' (CNA, 2007: 1). The UK Treasury-commissioned *Stern Review* (2006) and the Fourth Assessment Report (AR4) of the UN's Intergovernmental Panel on Climate Change (IPCC, 2007), are generally more cautious in their references to conflict, but warn against potentially dire societal consequences of climate change.

The issue of climate change and armed conflict is characterized by two paradoxes that have passed by largely unnoticed by the above-mentioned contributors. First, the many processes associated with global warming, which have truly started to appear only over the last fifteen years, have occurred during a time when we have witnessed a dramatic reduction in the frequency and severity of armed conflict. While we should not conclude about current and future links based on this simplistic comparison, the opposing trends nonetheless deserve some consideration.

Second, the empirical foundation for a general relationship between resource scarcity and armed conflict is indicative at best, and numerous questions regarding the proposed causal association remain to be answered. Several single-case analyses suggest that resource scarcity contribute to outbreak of organized violence, though always in interaction with exogenous conflict-promoting factors. The statistical literature, in contrast, has failed to converge on any significant and robust association between resource scarcity and civil war. While we cannot rule out the possibility of no general linkage, substantial limitations in data and research designs leave a lot to be desired. Accordingly, the potential for improvement is high, particularly within the quantitative research tradition.

2. Concepts and Trends

2.1 Environmental change

Global warming is expected to bring about a number of significant changes to the environment. Among the many projected impacts highlighted in the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC), we identify and discuss three potential natural consequences that could have substantial security implications: increasing scarcity and variability of renewable resources, sea-level rise, and intensification of natural disasters. We put most emphasis here on the dynamics of scarcity – in particular negative changes in per capita resource access – as these will impose more challenges on a society than static scarcity. Moreover, we expect sudden or unexpected climate-induced events, such as flash floods, tropical storms, and droughts, to constitute a larger threat to human security than gradual reductions in resource availability (e.g. desertification and rising sea level). In the former cases, where uncertainty is high, adaptation tends to take the form of establishing costly shock-resilient buffers (e.g. robust infrastructure, financial pools), while the latter changes allow for more efficient, targeted solutions (e.g. introduction of alternative crops). Overall, we expect unpredicted events to be more hazardous to the prospects of sustained peace than less rapid changes in resource availability, which in turn are likely to be more harmful than a stable but scarce resource base. Most crucially, the vulnerability and adaptive capacity of affected societies determine whether armed conflict is a potential end result of worsening climatic conditions. Below, we summarize prevailing evidence on how climate change is expected to affect each of the three environmental phenomena.

Resource scarcity

Climate change may have adverse security implications through its effect on availability of resources necessary for sustained livelihood. In line with common practice, we define scarcity as low per-capita access to a resource. When we talk about *resource scarcity*, we refer to a low per capita availability of a renewable resource, such as freshwater. Growing scarcity will be the consequence of either one (or both) of the two following processes: (i) a dwindling resource base, and/or (ii) increased demand for the resource through increased population pressure and/or increased consumption.[2] While increasing scarcity is generally regarded as more harmful than scarcity per se, increasing resource *variability*, which is associated with higher levels of unpredictability, will often constitute the greatest challenge to human livelihood.

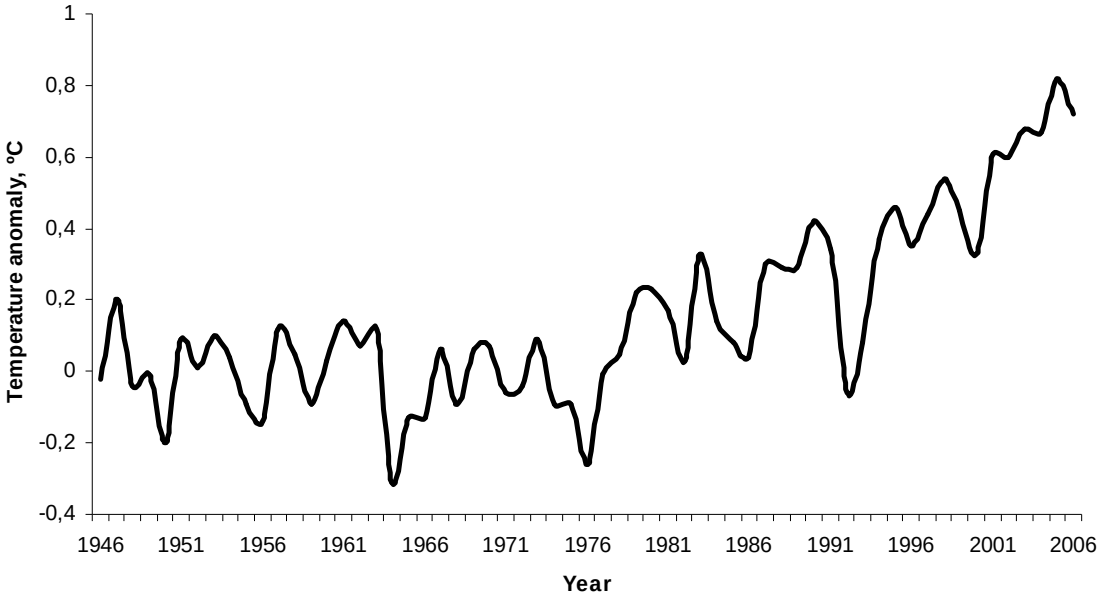
According to the AR4 and similar studies, the environmental impacts of climate change will vary enormously between regions. Some areas, including Northern Europe, are likely to benefit from an increase in average temperature as it is expected to result in increased crop yields, increased forest growth, decreased energy demand for heating, and reduced mortality from cold exposure. Most parts of the world, however, including the most densely populated regions, face a grimmer future. Increasing temperatures, changing precipitation patterns, and an overall reduction in annual rainfall suggest that some of the most crucial subsistence resources will become increasingly scarce. For example, the AR4 predicts a 10–30% reduction in average river runoff and water availability in dry regions at mid-latitudes and in the dry tropics by 2050. This is likely to exacerbate over-consumption of groundwater in many areas, with the possible consequence that aquifers become contaminated or depleted, thus further reducing the supply of freshwater. A warmer climate can also result in the melting of glaciers in Himalaya, the Andes, and several other major sources of water in the dry season for large sections of the developing world. More extreme precipitation could also increase topsoil erosion, in turn leading to less fertile soil for productive purposes. Faster evaporation is also argued to turn more land into desert.

The AR4 further predicts that at lower latitudes even small local temperature increases of 1–2°C will decrease agricultural output and increase the risk of hunger. Already by 2020,

[2] Homer-Dixon (1999) uses the concept environmental scarcity, which in addition to the two components we include also incorporates distributional issues. For purposes of analytical clarity, we exclude the distributional aspect from our definition and discussion of scarcity here, but return to the issue of inequality in the discussion of how resource scarcity can translate into armed conflict (Section 3.3).

access to food in many African countries is predicted to be severely compromised. Generally, climate change will have a differential impact on agricultural output depending on the form of agriculture (Kurukulasuriya et al. 2006). The yield of rain fed harvest especially in dry land areas is likely to taper off with warmer climate. Returns from irrigated crops might increase, at least with moderate warming, or at least be substantially more robust against further temperature rise with its likely consequences such as less reliable precipitation patterns. With global average temperature rise above 1.5–2.5°C, an estimated 20–30% of plant and animal species are likely to be at increased risk of extinction. According to Gallup et al. (1999) a tropical climate is already a great impediment to agricultural productivity through the unsuitability of tropical soil to large-scale mechanized farming and the high disease burden.

Figure 1. Temperature deviation from global mean, 1951–80



Source: NASA Goddard Institute for Space Studies (GISS), Columbia University.

Rising sea level

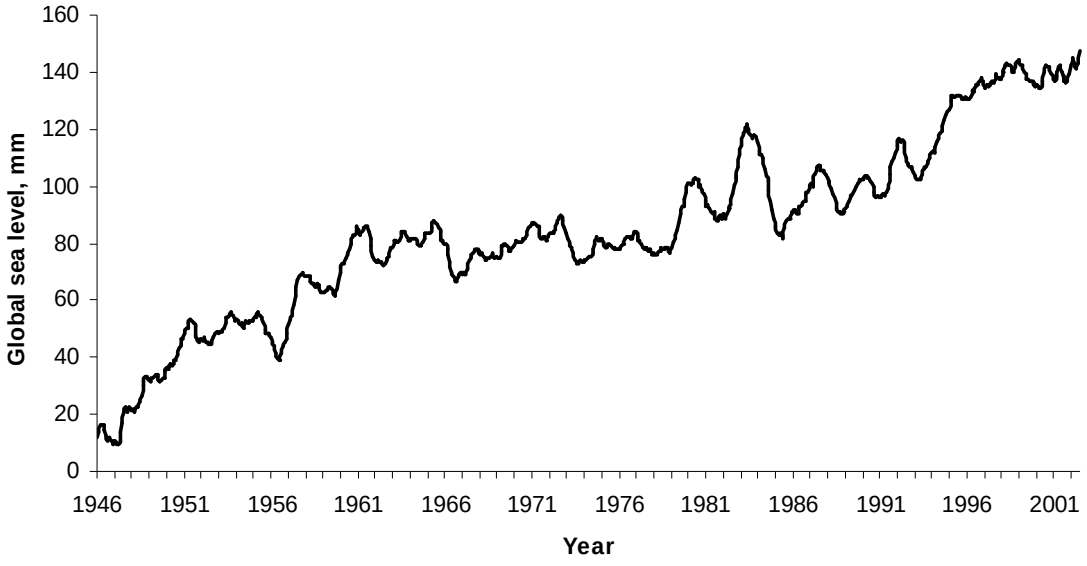
A second consequence of global warming, rising sea level is projected to have negative implications for peace and security primarily through its potential for massive population displacement. Unlike other anticipated climate-induced environmental changes, however, sea-level rise will occur relatively uniformly across the globe.

Working Group 2 of the AR4 predicts a global mean sea-level rise of between 0.28 and 0.43 meters within this century, depending on the applied scenario (p. 323). Within 2080, coastal population (those residing below 100 m elevation and less than 100 km from the

coast) could rise from 1.2 billion (1990 estimate) to between 1.8 and 5.2 billion. Recent projections show that even the most extreme emission scenario presented in the AR4 (A1F1) underestimates the true rate of sea ice melting in the Arctic (NSIDC, 2007). Assuming that the melting of the Greenland ice sheet follows the same pattern, sea-level rise will also continue at a higher rate than previously anticipated.[3] In fact, until now the demonstrated global rise in sea level is almost exclusively a result of warmer oceans (water expands as it heats), not melting of polar ice. Metaphorically speaking, we may only be seeing the tip of the iceberg.

Rising sea level is most immediately threatening to populations on small island states, as found in the Indian Ocean, the Caribbean, and the Pacific. However, billions of people in low-lying urban areas will also become more exposed to soil erosion, seasonal flooding, extreme weather, and other coastal hazards in coming decades.

Figure 2. Global sea level rise since 1946



Source: Permanent Service for Mean Sea Level (PSMSL) database, Proudman Oceanographic Laboratory.

[3] Greenland alone has the potential to increase global mean sea level by approximately seven meters if it were to experience near-total deglaciation, although this might require a consistent increase in annual average temperature of 3.2–6.2°C lasting for centuries (NSIDC, 2007).

Natural disasters

The third proposed consequence of climate change that has the potential to affect human security relates to natural disasters. Aside from its effect on supply of subsistence resources, global warming is predicted to increase the frequency and intensity of tropical storms, flash floods, landslides, and wild fires, and substantially alter precipitation patterns in many parts of the world. The 2005 hurricane Katrina demonstrates that climate-related disasters can, and occasionally do, have direct security implications even in developed societies, even if a substantial share of reports and rumors about the resulting mayhem in New Orleans turned out to be false (Dwyer & Drew, 2005).

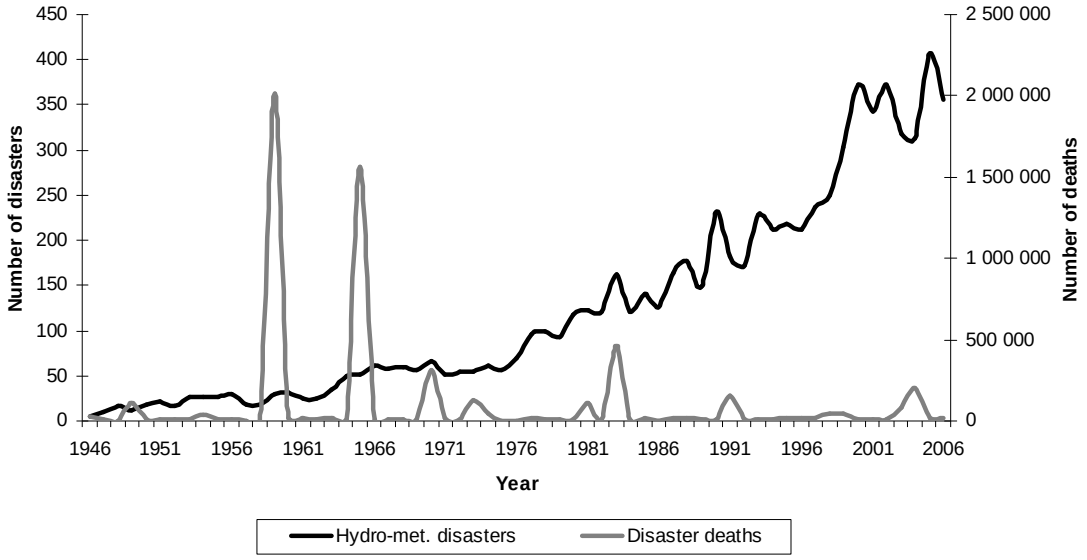
The 20th century saw a dramatic increase in the number of disasters.[4] Some of this trend is due to contemporaneous increases in reporting and systematic data gathering. In 2006, 427 disasters were recorded, killing more than 23,000 people (CRED, 2007). Forty-four percent of these events occurred in Asia. Natural disasters can be categorized as either geological or hydro-meteorological. Almost all of the temporal increase in disaster frequency is accounted for by the hydro-meteorological (or climatic) category. Floods constitute the most prevalent disaster type. More than one-third of the world's landmass and 82% of the world's population live in flood-prone areas (World Bank, 2005). In 2006, floods accounted for 55% of all registered disasters. Drought is the second most frequent type, threatening about 70% of the world's population. Changing precipitation patterns and more extreme weather imply that hydro-meteorological disasters are expected to become more frequent in the future.

The severity of disasters, measured as the number of casualties, shows a much more volatile pattern with two extreme peaks and no evident time trend (Figure 3). By virtue of their widespread character, climate-related disasters on average generate far higher numbers of victims (casualties plus affected) than do geological events, but the latter group is slightly

[4] CRED (2007: 15) defines a natural disaster as 'a situation or event, which overwhelms local capacity, necessitating a request to national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction, and human suffering'. A disaster is entered into their database if at least 10 people are reported killed, 100 people reported affected, a state of emergency has been declared, or a call for international assistance has been issued.

more deadly.[5] However, the severity of a natural disaster – indeed the very definition of disaster – is endogenous to the coping capacity of a society, even if the physical disturbance in itself is not. A sustained increase in extreme weather events need not be accompanied by a corresponding trend in casualty figures if exposed societies become better prepared and able to respond to such challenges. Likewise, similar environmental events in different locations may have very dissimilar outcomes, so much depends on where we will see weather patterns change most dramatically. Southern Europe, which is one of the regions projected to experience worsened conditions, is better equipped to cope with heat waves and extended periods of drought than are societies in the Sahel.

Figure 3. Frequency and severity of hydro-meteorological disasters since 1946



Source: EM-DAT, Centre for Research on the Epidemiology of Disasters (CRED).

2.2 Environmental Security

The concept of environmental security was formulated in order to lift environmental issues to the level of 'high politics', i.e. security studies (Gleditsch, 2007). It implies a wider definition of security than the traditional military definition in terms of territorial integrity and the absence of war. Much of the current rhetoric about climate change as a security issue refers to

[5] The average geological disaster between 1946 and 2006 caused 885 lives. The corresponding figure for hydro-meteorological disasters is 735, according to statistics from CRED's emergency events database (EM-DAT), www.em-dat.net.

security in the wide sense of threats to human activity that could have implications equally serious to those of war. Widespread hunger because of food scarcity, mass forced migration, or large-scale disasters, clearly could be interpreted as a threat if we apply a wide understanding of security. The Norwegian Nobel Committee refers to security in this wider sense in its announcement of the Peace Prize for 2007 to IPCC and Al Gore.

Most claims linking climate change to issues of instability and conflict argue that it may act as a 'threat multiplier' (e.g. CNA, 2007) by adding stress to those countries and peoples who already suffer from problems of underdevelopment, repression, or conflict. Paul Collier (2007) has identified a set of 54 countries in what he calls 'the bottom billion'; countries that have low development, low economic growth, frequent civil conflict, incompetent governments, and are land-locked with bad neighbors. It seems likely that the bottom billion countries, among which countries in Africa south of the Sahara are disproportionately overrepresented, will be more than average affected by climate change – although this remains to be rigorously tested.[6]

In the following, when we refer to environmental security, we stick to a more traditional notion of security. In other words, we focus in particular on the way in which climate change may affect the risk and course of armed conflict.

2.3 Armed conflict

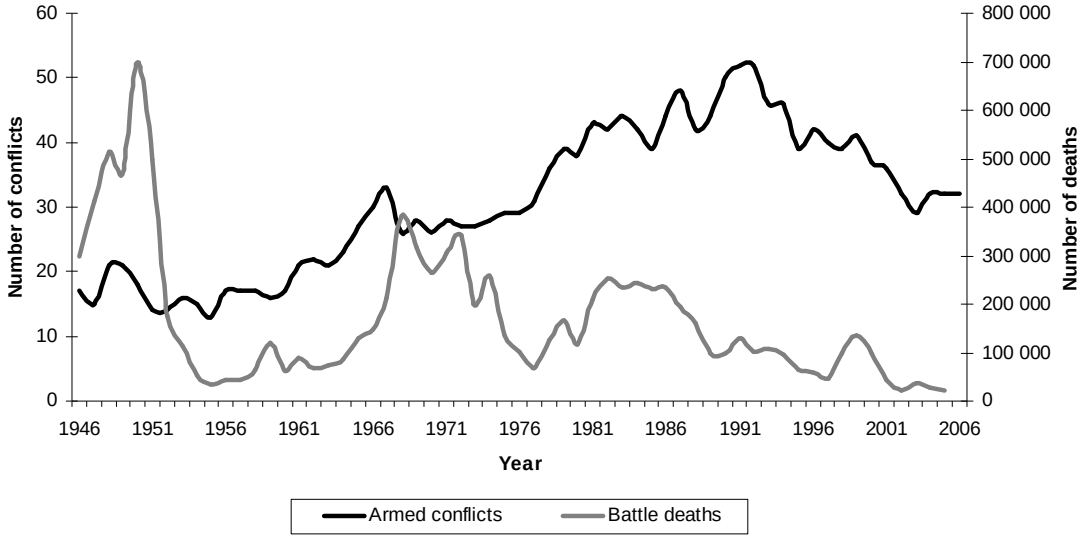
Throughout this paper, we apply an inclusive understanding of conflict, incorporating not only state-based (interstate and intrastate) conflicts, but also non-state conflicts (one-sided and communal). We do not enforce a strict severity threshold, although we are primarily concerned with deadly violence between organized groups. However, urban gang warfare and organized criminal activity that lack any form of political motivation are excluded. Wherever relevant, we specify and limit discussion to particular forms of conflict.

Armed conflict, in a narrow sense, exhibits an interesting but oft-unnoticed time pattern. Figure 4, which is based on the UCDP/PRIO Armed Conflict Dataset (henceforth ACD), shows that the number of conflicts in the world increased steadily from the mid-1950s until it peaked in the early 1990s. Since then, armed conflicts have become significantly less

[6] Noteworthy, Collier himself completely ignores the issue of climate change.

frequent.[7] The severity of armed conflict, measured as annual battle-related deaths, has generally declined since World War II. If we consider the contemporaneous growth in the world's population, the downward trend is even stronger.[8]

Figure 4. Frequency and severity of armed conflict since 1946



Source: UCDP/PRIO Armed Conflict Dataset and PRIO Battle Deaths Dataset.

A closer inspection of the conflict data reveals a more complex situation, with both disturbing and reassuring trends (Table 1). On the negative side, the downward trend in the frequency of armed conflict appears to have stagnated, with 32 active conflicts registered in four of the five last years. Hidden beneath this aggregate figure, we find substantial year-to-year variation. In 2006, four previously active conflicts dropped out while another four reappeared after one or more year(s) of inactivity. No less than nine of the 32 conflicts in

[7] The ACD project defines armed conflict as 'a contested incompatibility that concerns government or territory or both where the use of armed force between two parties [of which at least one is the government of a state] results in at least 25 [annual] battle-related deaths' (Gleditsch et al., 2002: 618–619). Data available from www.prio.no/cscw/armedconflict/ and www.pcr.uu.se.

[8] The PRIO Battle Deaths Dataset, v. 2.0 (Lacina & Gleditsch, 2005), see www.prio.no/cscw/armedconflict/. The battle deaths data include all reported killings in battles (incl. civilians in crossfire) between the recorded actors. These figures do not include indirect casualties due to e.g. hunger and epidemics in the wake of conflict; nor do they include casualties from one-sided violence (genocide, ethnic cleansing, terrorism) and criminal behavior.

2005 were inactive during the preceding year (and, similarly, nine conflicts active in 2004 were no longer active in 2005).[9]

Apart from the general decline in conflict since the end of the Cold War and the decline in the lethality of conflict since World War II, there are two noteworthy positive trends. First, we are now in the longest period since World War II without interstate war. The two most recent conflicts between independent countries were the India-Pakistan Kashmir dispute and the US-led invasion of Iraq, both ending in 2003.[10] Second, there were no *new* conflicts of any kind during the previous two years; this is the first time in the post-WWII period in which two consecutive years have passed with no new conflicts having broken out. More than half of the active conflicts in 2006 originated during the Cold War. Of course, one cannot infer empirically that the trend will continue. However, to the extent that the downward trend in conflict is linked to the growth of liberal factors like democracy and economic interdependence, an optimistic view is warranted.[11]

Table 1. Trends in armed conflict since 2000

	2000	2001	2002	2003	2004	2005	2006
Interstate	2	1	1	2	0	0	0
Intrastate	31	30	28	25	28	26	27
Internationalized intrastate	4	5	3	2	4	6	5
Total	37	36	32	29	32	32	32
Recurring conflicts	4	1	2	5	8	9	4
New conflicts	1	3	1	2	2	0	0

During the Cold War, armed conflict was a prevalent feature in many parts of the world but today almost all conflicts are fought in Asia or Africa. Moreover, most conflicts are

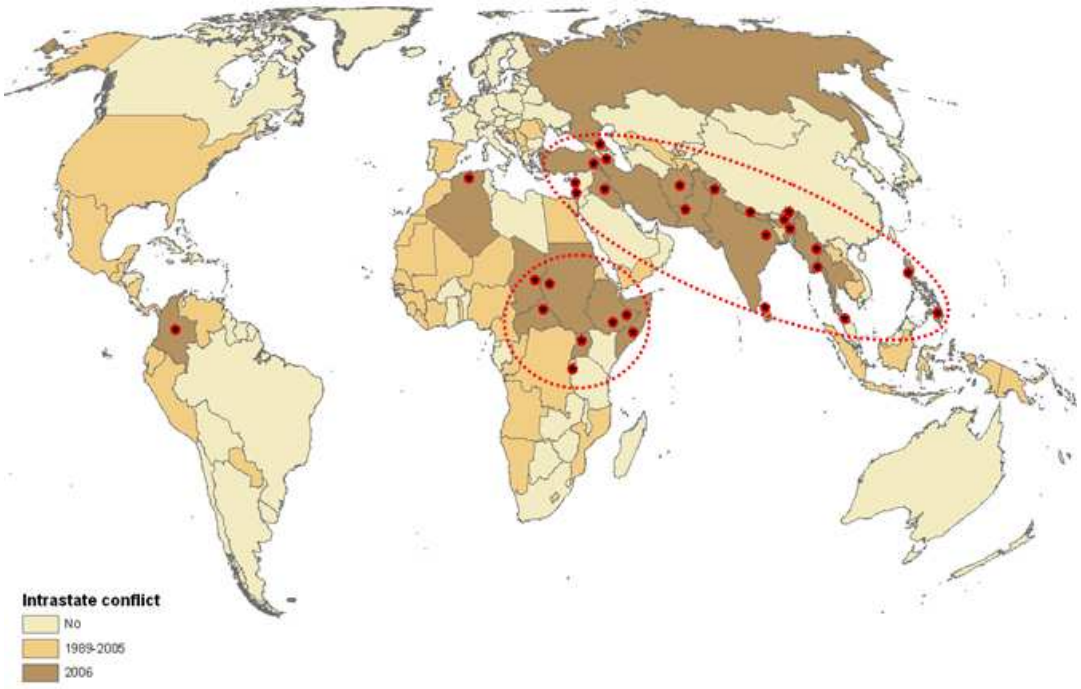
[9] The ACD applies an annual minimum severity threshold of 25 deaths. Conflicts are only registered (and labeled 'active') in years when the fighting results in at least as many casualties. Accordingly, the pool of armed conflicts that have not been settled peacefully will always be higher than the number of active conflicts. This may result in small temporal fluctuations without there being a substantial underlying trend in global conflict activity. Recurring conflicts are those cases where conflict re-ignites or escalates after one or more years of inactivity. We see little trend with regard to these re-activated conflicts.

[10] The current conflict in Iraq is considered an internationalized intrastate conflict between the Iraqi government, supported by foreign troops, and numerous non-governmental groups.

[11] For the liberal case, see in particular Russett & Oneal (2001). For a broad debate on 'the waning of war', see Väyrynen (2006).

geographically grouped. Two clusters are evident: one takes the form of a 'shatter belt' stretching from the Caucasus to the Philippines, the other centers around the Great Lakes region and the Horn of Africa. Only Colombia and Algeria no longer lie inside a regional nexus of conflict (Map 1).

Map 1. Intrastate armed conflicts in 2006

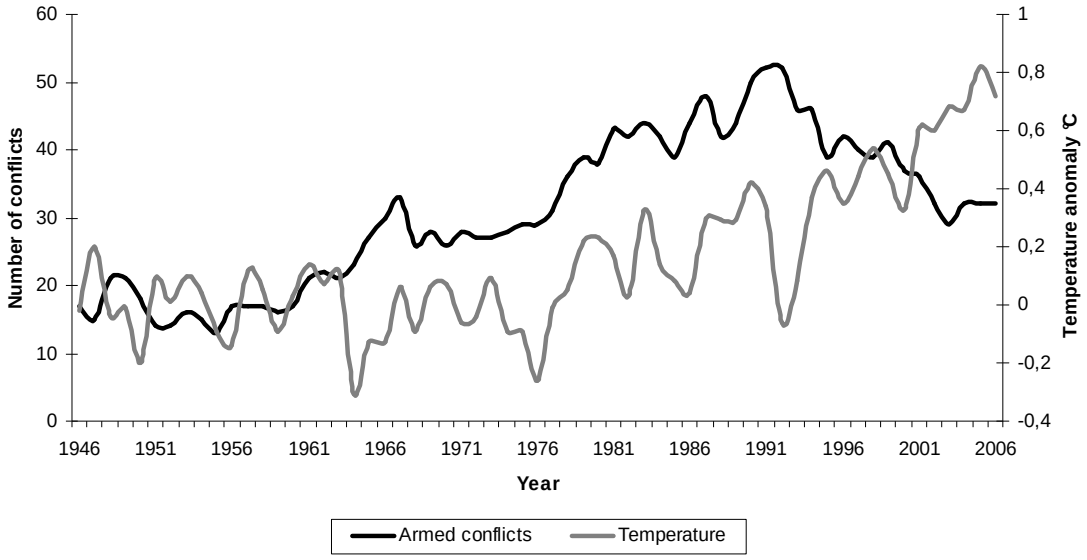


The map shows countries in armed conflict in 2006 (brown) and countries with intrastate armed conflict on their soil between 1989 and 2005 (ochre). Red symbols denote approximate sub-national location of conflict zones.

Armed conflicts are increasingly concentrated in the poorest and most vulnerable portion of the world's countries. Future environmental changes will place further strains on these countries, possibly reducing the prospects for conflict resolution and sustained economic growth. Nonetheless, the collapse of the Cold War's bipolar logic and the international community's improved efforts at peacebuilding have had remarkable effects on the distribution of war. A comparison of the temporal patterns in armed conflict and global warming (Figure 5) reveals radically opposing trends in the most recent period. In statistical terms, the post-Cold War correlation between conflict and temperature deviation is estimated at $r = -0.82$. The negative relationship is highly statistically significant. While such a bivariate

assessment should be interpreted with caution, it nonetheless serves to call for similar caution when claiming a connection between climate variability and armed conflict.

Figure 5. Comparing the trends in global warming and frequency of armed conflict



3. Linking Climate Change to Armed Conflict

3.1 Possible coping strategies

The extent to which global warming constitutes a threat to human security is determined by the affected society's level of vulnerability. The IPCC (2007: 6) defines vulnerability as 'the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes.' The vulnerability concept thus captures both the risk and degree of exposure *and* the ability to handle the challenges imposed by the environment. While vulnerability to environmental conditions is crucially dependent on the type of hazard and the nature of the context, certain determinants of vulnerability apply to a wide set of scenarios. Important generic factors are mostly developmental, including poverty, health, education, inequality, and governance (Brooks et al., 2005).

Groups and societies facing dramatic reduction in the quality of life because of a changing climate have several coping strategies from which to choose. First, they may seek to adapt to the new challenges. Adaptation is here understood as 'adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates

harm or exploits beneficial opportunities' (IPCC, 2007: 6). Adaptation can occur on any scale, from the individual to the international level. The most extreme forms of adaptation involve pursuing alternate modes of livelihood or finding substitutes for the necessary but increasingly scarce commodity. Less drastic means of adaptation include conservation programs and efforts to reduce consumption, investment in technology to enhance production/consumption efficiency, and trade.

Societies unable to adjust to the new challenges are left with two main options: fight or flee. The former strategy implies securing an increasing share of the diminishing resources – by force if necessary. This includes Homer-Dixon's (1999: 73) so-called 'resource capture' mechanism, whereby elites take control over the increasingly precious resource on the expense of the poor, although it applies to resource competition more broadly. Prophesized, though empirically unsubstantiated, large-scale wars over oil or water (e.g. Klare, 2001) also belong to this category. Alternatively, increasing climate variability and worsening environmental conditions may lead people to move to more attractive locations.[12]

Whether an increasingly exposed society seeks adaptation, contention, or exit will depend on the nature of the changing environment, the vulnerability of the population, and contextual factors. Gradual changes, such as desertification and sea level rise, are generally likely to be met with gradual response where various forms of adaptation constitute the primary response. This is exemplified by the Maldives, which despite facing the long-term prospect of complete inundation has initiated a comprehensive adaptation scheme that includes coastal protection, land reclamation, rainwater harvesting, and enhanced waste management (NAPA, 2006). The absence of any reference to an exit strategy in the NAPA report – even as a last resort – is striking. Intensifying climate variability and natural hazards, in contrast, exhibit much shorter temporal traits, ranging from mere minutes (landslides) to months (drought). Such environmental challenges will require almost immediate action. If the exposed population is unprepared or lack necessary ability to adapt successfully, rapid migration and resource contention become plausible strategies for remedy.

The inability to adapt plays a central role in the environmental security literature. Homer-Dixon (1999) argues that a low level of development means less to spend on research,

[12] Mitigation, or initiatives to remove the causes of anthropogenic climate change (e.g. carbon capture and storage (CCS) facilities and development of alternative energy technologies), is inherently global in scope. Besides, the momentum of current global warming implies that such strategies are viable only within a long-term perspective.

resource conservation, and the development of resilient systems to tackle unexpected events. Although he acknowledges that scarcity could promote adaptation through innovation, Homer-Dixon argues that market failure, social friction, narrow self-serving coalitions, lack of capital, cognitive limits to ingenuity, and growing costs of research are more likely outcomes of climate change in the developing world. It is this ingenuity gap – or the inability to address resource scarcity by innovation – that eventually makes these countries more prone to instability and conflict. Lower economic productivity affects both state repressive capacity and public grievances by reducing the state's revenues, weakening its distribution capacity, and, consequently, lowering state legitimacy.

In the following, we review theory and evidence for a general connection between anticipated negative consequences of global warming, notably scarcities of renewable resources, and armed conflict.

3.2 Climate change and conflict – a synthesized causal model

> The risks of climate change to social systems is as much about the characteristics of those systems as it is about changes in environmental systems. (Barnett & Adger, 2007: 641)

Contrasting common wisdom and the attention given in the media, very few scholars actually claim that there is a direct link between scarcity of renewable resources and armed conflict. This is reflected by the noteworthy lack of pure 'scarcity conflicts' in the case study material. Rather, most assessments of the environment and conflict sketch a causal story where scarcity of renewables constitute yet another stone to the burden, implying that violence is a probable outcome only in societies already suffering from a multitude of other ill-beings. As stated by Homer-Dixon (1999: 16), 'environmental scarcity is *never* [emphasis added] a sole or sufficient cause of large migrations, poverty, or violence; it always joins with other economic, political, and social factors to produce its effects.' Along this line, a study by eleven retired US generals and admirals concludes that climate change is likely to act as a 'threat multiplier' in volatile regions, e.g. by decreasing food production and freshwater availability (CNA, 2007: 44). Although the exact mechanisms through which this is thought to work is not outlined any further, several intermediate factors are hinted at: 'Such changes will add significantly to existing tensions and can facilitate weakened governance, economic collapses, massive human migrations, and potential conflicts' (2007: 20). A recent report by

International Alert (2007) comes to similar conclusions. In their wording, understanding the influence of climate change on conflict requires tracing the '*consequences of consequences*' [emphasis original] (2007: 7). Four key links are identified: political instability, economic weakness, food insecurity, and mass migration.

Applying a more individualistic approach, Ohlsson (2003) argues that large cohorts of young men deprived of their livelihoods constitute the major share of rebels in third world militias. As 'angry young men' are more easily recruited to illegal activities, scarcity of renewable resources in countries with large primary sectors may increase the inclinations for individuals to join fighting in a conflict. This risk operates through three mechanisms: relative deprivation, low opportunity costs of rebel labor, and intensification of ethnic antagonism by political entrepreneurs (Ohlsson, 2003).

While climate-induced environmental stress is expected at most to exert an indirect influence on peace and security, an exception is sometimes made for freshwater, as a particularly vital renewable resource (e.g. McLoughlin, 2004). The Middle East and North Africa appear particularly frequently in the literature on 'water wars' (e.g. Gleick, 1994). For example, Egypt is crucially dependent on the Nile, which provides 95% of its needed freshwater, so any disruption of the river flow upstream could have significant consequences. Cairo has threatened on several occasions to take military actions to secure sustained water flow (Swain, 1997). So far, however, no international water dispute has escalated to the level of war. Indeed, Wolf (1998, 1999) argues that the last international war over water, in Sumeria, ocurred 5,000 years ago. Statistical research on shared rivers indicates that in an average dyad a low probability of low-level conflict is approximately doubled if the two counrtries are part of the same river basin (Gleditsch et al., 2006), but that the relationship is not significant for wars. Moreover, sharing a river basin also increases the probability of cooperation (Brochmann & Gleditsch, 2006). Water scarcity in one or both countries does not appear to be a significant factor. While India and Pakistan have been fighting over Kashmir, the two countries have cooperated successfully on sharing the water resources of the Indus. If increasing scarcities of subsistence resources increase the frequency of conflict in the future, these will most likely be fought at a local, intrastate level.

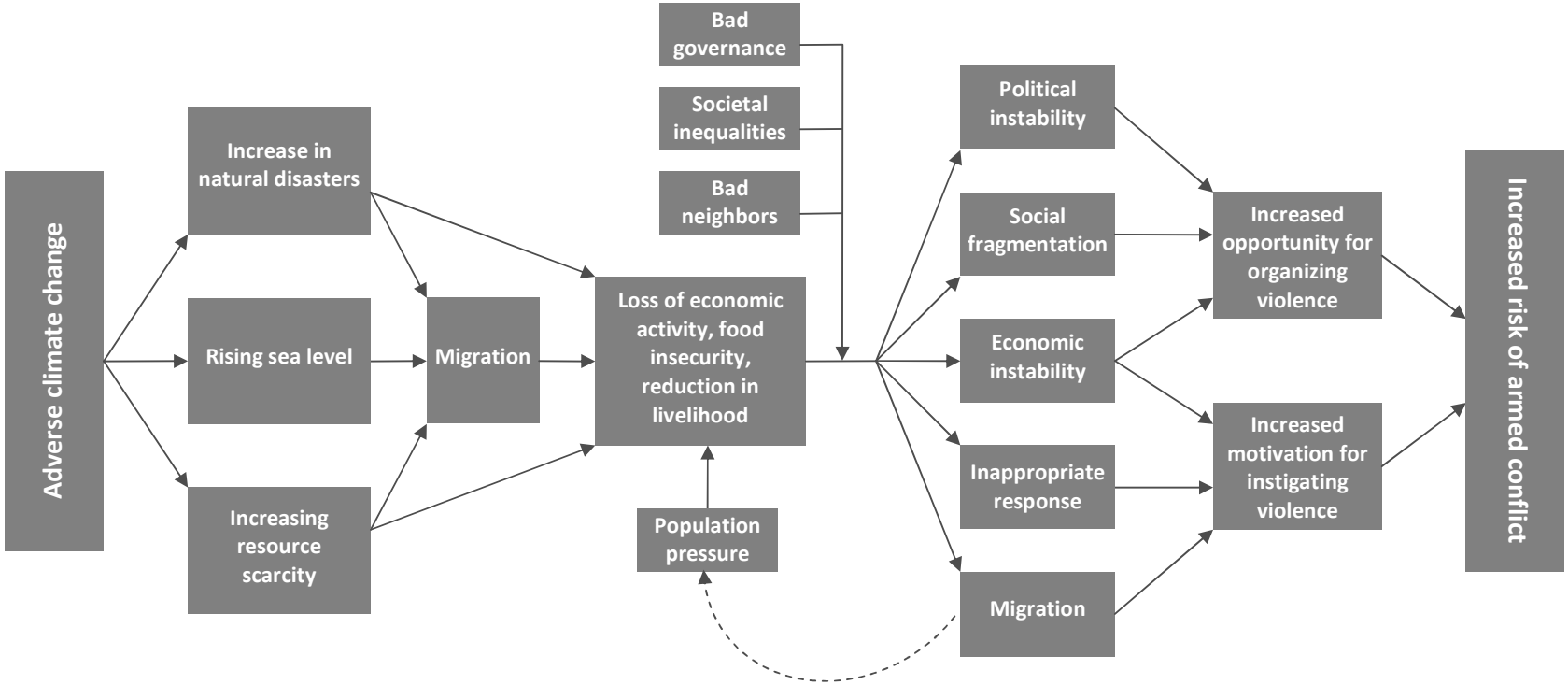
Work on how natural disasters relate to social unrest and violent conflict use a theoretical framework similar – often explicitly similar – to the environmental security literature. Accordingly, disasters are thought to exacerbate conflict risk primarily through reduction in the supply of livelihood resources, economic loss, and weakened government

institutions, particularly in societies with pre-existing tensions (e.g. Drury & Olson, 1998; Brancati, 2007). Rapid, severe disasters, such as tropical storms, floods, and land slides, typically cause massive material destruction, which means that such events are especially likely to foster instant human suffering and spontaneous large-scale (if temporary) migration. Moreover, disasters attract lootable aid (food, transport equipment, etc.) and facilitate rebel recruitment through increasing numbers of orphans.

In sum, climate change may increase the risk of armed conflict only under certain conditions and in interaction with several socio-political factors (Figure 6). At least five social effects of climate change – whether due to a dwindling resource base, intensification of natural disasters, rising sea level, or a combination of the three – have been suggested as crucial intermediating catalysts of organized violence. First, increasing scarcity of renewable resources in subsistence-economy societies may cause unemployment, loss of livelihood, and loss of economic activity (Ohlsson, 2003), thus decreasing state income (Homer-Dixon, 1999). Second, increasing resource competition in heterogeneous societies may attract opportunistic elites who intensify social cleavages – particularly ethnic identities – and make the population more vulnerable to radicalization (Kahl, 2006). Third, reduced state income may hinder public goods delivery, reduce political legitimacy, and give rise to political challengers (Homer-Dixon, 1999). Fourth, efforts to adjust to a changing climate – or to remove the causes global warming – may have inadvertent side effects that could spur tension and conflict. Additionally, the high-profile climate change issue may serve as a scapegoat or rallying point for actors with hidden agendas (Goldstone, 2001; Salehyan, 2008). Finally, worsened environmental conditions may force people to migrate in large masses, thereby increasing environmental stress in the receiving area and increase the potential for radicalization and ethnic hatreds (Reuveny, 2007). These five potential catalysts will be presented in more detail in subsequent sections.

Whether adverse climatic changes result in any of the five suggested social effects depends largely on the characteristics of the affected country. Economically developed and politically stable societies are well able to handle and adapt to conceivable environmental conditions. We should not expect influx of environmental migrants, increasing climate variability, and sea-level rise to constitute a significant security threat in these countries. In contrast, countries that are characterized by other conflict-promoting features, notably bad governance, large and heterogeneous populations, social inequalities, bad neighborhood, and a history of violence, constitute plausible cases where climate-induced conflict might occur.

Figure 6. Possible pathways to conflict



The diagram gives a synthesized account of proposed causal linkages between climate change and armed conflict. For the sake of clarity, possible feedback loops, reciprocal effects, and contextual determinants are kept at a minimum.

3.3 Political Instability

> Ultimately, it is institutional factors that largely determine whether or not countries and their agricultural systems respond effectively to rising scarcities of land and water. (Homer-Dixon, 1999: 87)

Processes associated with climate change, such as soil degradation and drought, are recurring features in a majority of today's countries, and local disputes over access to livelihood resources abound. Yet, such events are mostly non-violent and seldom escalate to open warfare, and state collapse is a very rare phenomenon. The will and ability of the state to manage and solve resource competition are crucial in determining whether latent conflicts escalate to the use of violence. Almost all accounts of armed conflict that are explained at least partly by scarcity of fundamental resources point to the weakening of the state as an important intermediate development. There are several aspects to this. First, responding to soil degradation, crop failure, or drought is costly, and the poorest and institutionally weakest regimes may simply not be able respond in a manner that satisfies the disgruntled population. Second, increasing climatic variations may affect the redistributive capacity of governments and drain attention and capital away from other important social programs, including health, education, infrastructure, and security. Regimes may also seek to gain politically from adverse environmental developments by playing out social groups against each other. Such 'state exploitation' behavior has been argued to be a characteristic of several contemporary resource conflicts (Kahl, 2006). Inter-tribal conflicts in Kenya in the 1990s as well as the process leading up to the genocide in Rwanda in 1994 have been promoted as relevant examples (Kahl, 2006). A weakened state may also give rise to opportunistic challengers who do not themselves suffer from worsened environmental conditions. Finally, political elections in systems with little tradition for democratic rules of government are associated with enlarged levels of uncertainty and a higher risk of violence (Strand, 2007). Social tensions, including those emerging from climate-induced environmental degradation, are particularly likely to manifest themselves through anti-governmental movements during times of elections.

Just as democracies are generally free of major internal armed violence (Hegre et al., 2001), we expect democratic regimes to be able to handle the increasing challenges imposed by climate change in a largely nonviolent manner. Openness of the political system, free press, and leader accountability ensure that grave developments are responded to almost

immediately, rendering violence a sub-optimal solution (Auvinen, 1997; Gurr, 2000; Rummel, 1995). This has been used to explain why consolidated democracies may undergo severe droughts but never famine (Sen, 1987). In non-democratic systems, insufficient response and outright neglect are more probable responses. Bächler (1999) further claims that modernizing non-democratic governments are often more concerned with adhering to international standards of market liberalization than ensuring sustainable agriculture in the peripheries. The result may be a vicious circle of degradation and competition between groups in the under-prioritized areas. Several studies of conflict in Africa indicate that heavy-handedness by the state in local resource-related disputes is a severe impediment to long-term peace as involvement by the regular forces contribute to small arms proliferation and creates distrust of the central government (Martin, 2005; Mkutu, 2003; Suliman, 1999).

There is substantial empirical evidence for a connection between political instability and increased risk of armed conflict. In a comprehensive empirical evaluation of virtually every proposed conflict-inducing factors in the quantitative literature, Hegre & Sambanis (2006) find recent political instability to be among the relatively few robust correlates of civil war. A number of studies on the relationship between civil war and level of democracy find support for a curvilinear relationship (e.g. Hegre et al., 2001; Muller & Weede, 1990; Gleditsch, Hegre & Strand, 2008; but see also Vreeland, 2008). Democratic systems avoid public unrest primarily through justice, responsiveness, and protection of minority rights, whereas autocratic states deter organized violence primarily by denying the formation of effective opposition groups and by widespread repression. Thus, both ideal-type regimes are less vulnerable to climate change than are inconsistent political systems, all else considered equal.

Given the robust and powerful statistical association between regime instability and armed conflict, any systematic consequence of climate change for the type and quality of state institutions (e.g. loss of public support due to poor economic performance) is likely to have an indirect influence on the risk of armed conflict.

3.4 Poverty and economic instability

A second potential climate-induced catalyst of social instability and armed conflict is economic instability and stagnation. Food insecurity and loss of livelihood are possible consequences of adverse climatic changes in many parts of the world, resulting in poverty at the national as well as at the individual level. Poverty (typically measured as low per capita

income) has long been considered a major cause of civil war (e.g. Collier et al., 2003), and its general relative effect and statistical robustness is paralleled only by population size (Hegre & Sambanis, 2006). There are several partly overlapping explanations for this.

Individual-level dynamics

Political economists usually attribute the poverty-conflict association to factors that increase individuals' inclination to criminal behavior relative to normal economic activity (e.g. Berdal & Malone, 2000; Collier & Hoeffler, 2004; Grossmann, 1991). Along this line of reasoning, poor opportunities for legal income earning (i.e. low wages, high unemployment rate), as well as food insecurity more generally, lower the threshold for joining a rebellion. Accordingly, scarcity-induced loss of livelihood in agricultural societies increases the pool of potential rebel recruits, resulting in a higher conflict risk. Climate-related phenomena, such as more frequent droughts, increased soil degradation, and higher temperatures, may decrease the expected returns to farming compared to joining criminal and insurgent groups (Mehlum et al., 2004). In addition, loss of income may force affected people to migrate, which constitutes a separate, indirect potential for population pressure, resource competition, and rebel recruitment (see companion paper by Raleigh et al., 2008).

Group-level dynamics

Civil conflicts are often explained by a relative deprivation perspective, where increasingly marginalized segments of society take up arms to alter the status quo. Social inequality can be categorized as either vertical or horizontal. Vertical inequality denotes systematic differences in opportunities and privileges between the least and most well-off individuals of a society. Horizontal inequality taps systematic differences in opportunities and privileges between different groups within a society. While both forms of inequality may give rise to social unrest, the group aspect of horizontal inequality is generally regarded as more conflict-prone (e.g. Gurr 1970; Stewart, 2000; Stewart et al., 2005; Østby, 2006, 2008).

Although most statistical research on inequality and conflict has focused on vertical inequality (due to data limitations), there is some evidence in favor of the horizontal inequality proposition. For example, Murshed & Gates (2005) find a very strong relationship between horizontal inequalities and the location and intensity of civil violence in Nepal. And in a statistical study of all politically excluded ethnic groups in Eurasia and North Africa, Buhaug et al. (2008) find that the risk of rebellion is strongly and positively associated with group size (which presumably captures extent of deprivation) and distance from the seat of

government. At the country level, Besançon (2005) finds that inequalities in access to governmental processes and social privileges increase the risk of ethnic civil wars.

Given its discriminatory spatial impact, climate change has the potential to affect horizontal inequalities, particularly in agrarian societies. If these changes correspond with and amplify existing socio-economic fault lines (and other risk factors are present), the probability of social instability and armed conflict increases significantly.

State-level dynamics

Supplementing the economic individualist explanation of the poverty-conflict nexus, political scientists tend to stress the weakening capacity of the state as the immediate result of failing national income (e.g. Fearon & Laitin, 2003). Accordingly, the concentration of civil wars in poor countries is explained as much by unusually favorable conditions for insurgency (i.e. poor counter-insurgency capability, limited infrastructure, and lack of local governance) as by rational calculus of opportunistic individuals. Further, a lack of economic growth reduces popular support for the regime. In consolidated democracies and harsh authoritarian systems, this may not be harmful, but in unstable and democratizing states, a decline in political legitimacy easily translates into a distrust of the political system at large and provides opportunities for non-democratic challengers. Overall, national poverty is highly correlated with a deficit of democratic institutions, but the *causal* relationship between economy and democracy is still disputed (see Robinson, 2006 for a review).

A changing climate with increasing variability will have the largest short-term effects on traditional cultures and economies dependent on exports of renewable primary commodities. Some societies will be better off, but many countries in the developing world will experience reduced agricultural yields. Some of the reduction in productivity of a commodity may be compensated for by an increasing unit value. Nonetheless, poor economic performance means an increasing 'ingenuity gap' between the developed and the developing world, whereby the latter have less to spend on adaptive buffers against more extreme weather related events, such as more resilient infrastructure, irrigation systems, and desalinization plants for freshwater generation (Homer-Dixon, 1999).

If climate change results in increased poverty and widespread loss of livelihood in the developing world, it is also likely to have a substantial negative impact on prospects for (sustained) peace in these countries – provided no appropriate international action is taken.

3.5 Social fragmentation

Whether and how ethnicity affects armed conflict remains a hotly debated topic in academia. Some claim a positive link between heterogeneity and risk of civil war (Blimes, 2006), others argue that particular configurations of the heterogeneous population are important (e.g. dominance: Collier & Hoeffler, 2004; polarization: Esteban & Ray, 2008; Reynal-Querol, 2002; exclusion: Cederman & Girardin, 2007), some say that ethnicity is irrelevant for conflict (Fearon et al., 2007), and some reject the very notion of a (given) ethnic identity (Bowen, 1996). So far, systematic, statistical research has not succeeded in converging on this issue.

Regardless of the origin of civil war, ethnicity is widely regarded as a facilitator for mobilization, and language, religion, and nationality often serve as lines of demarcation between contending groups. In Bächler (1999) and Kahl's (2006) view, common ethnic identity is a crucial opportunity factor for building organizations, finding allies, and turning protest into collective violence. There is often a mutually reinforcing relationship between ethnic identity and hostilities. For example, Gurr (2000) argues that the notion of a shared Eritrean nationality grew only slowly during the prolonged war of independence, thus being more a product of than a precondition for the conflict. Similarly, Suliman (1997) and Prunier (2007) emphasize the historically low ethnic barriers in Darfur. This underscores the importance and feasibility of taking effective action at an early stage in local resource conflicts, before cultural differences become 'tectonic' fault lines.

Climate change is not likely to affect the ethnic composition of countries in the short run, with a possible exception for rapid in- or out-migration as a consequence of natural disasters (though this form of migration is typically temporary in nature). In a slightly longer perspective, however, we may witness substantial intra- and interstate migration, partly in response to worsening climatic conditions.[13] Illegal immigration from Bangladesh to the Indian state of Assam over the past few decades has caused ethnic tension between the locals and the newcomers, but the level of violence has remained at a low level (Suhrke, 1997). More probable within a limited temporal scope, adverse environmental changes may have a

[13] Estimates on the number of 'environmental refugees' abound, though few seem to be based on transparent and sound calculations. For example, a report by Christian Aid (2007) predicts that 1 billion people will be forced from their homes before 2050, though most of them due to changes resulting from economic development.

discriminating impact on various groups within a country (see Section 3.4), thereby increasing horizontal economic inequalities and possible sentiments of relative deprivation.

Even if climate change alters the ethnic composition or social cohesion in heterogeneous countries, current statistical research provides little consistent evidence to suggest that this will have a profound impact on human security and armed conflict.

3.6 Migration

Migration may be both a cause and effect of worsening environmental conditions; hence, it enters the causal models (Figure 6) in two stages. Migration can be *rapid* or *gradual*, reflecting the speed of the emerging perceived environmental push and pull factors. It can be *permanent* or *temporary*, also reflecting the nature of the threat (sudden alterations, such as from natural disasters, are more likely to cause temporary displacement). Migrants can also be separated into those who move only as far as necessary to avoid the immediate danger and those who travel long distances and (attempt to) settle in the safe, developed world. Furthermore, the underlying mechanisms of refugees – when there is no choice but to leave (in order to not risk one's life) – and conventional migration – when staying is a viable option – are qualitatively different. For example, inhabitants of small island-states ultimately have to relocate if some of the more dire predictions about future sea-level rise come true, while people living in increasingly dry areas may have less extreme adaptation strategies at hand. Moreover, there may be numerous overlapping environmental, political, and economic push factors, as well as pull factors in the receiving area that influence the decision whether, where, and when to move.

Climate-induced migration is argued to lead to violent conflict in receiving areas through at least four complementary processes (Reuveny, 2007). First, the arrival of newcomers can lead to competition over diminishing natural and economic resources, especially if property rights are underdeveloped. Second, a wave of migrants of different ethnic origin than the local population may give rise to ethnic tension and solidification of identities. Third, large flows of migrants may case mistrust between the sending and receiving state. Finally, climate-induced migration may create or exacerbate traditional fault lines, for instance when migrant pastoralists and local sedentary farmers compete over the use of land. While there exist some evidence for a link between transnational refugee flows and outbreak of armed conflict (Buhaug & Gleditsch, 2008; Salehyan, 2007), it is not obvious that environment-induced population flows will have the same security implications for the host

population as migrants escaping armed violence. Due to data limitations and lack of conceptual clarity, no empirical study has been able explore the general consequences of 'environmental migration' across cases. See companion paper by Raleigh et al. (2008) for a thorough assessment of climate change and migration.

3.7 Inappropriate response

A final potential catalyst of instability and armed violence, less acknowledged in the literature that the ones presented above, concerns inadvertent consequences of human reactions to climate change. At a macro level, draconian measures to reduce CO_2 emissions may have large, unforeseen (or underestimated) effects on the global and regional economic systems. For instance, in high-growth developing countries like China and India, such measures might make trading-state strategies less attractive relative to strategies of territorial warfare (see Rosecrance, 1986). It would also very likely lead to a stagnation or even reversal of their economic growth, with political instability and civil unrest as probable outcomes. Heavy taxation on international air travel could also have devastating impacts on small, tourism-dependent economies.

On a smaller scale, dam building and development of irrigation systems to counter projected changes in precipitation patterns may also have inadvertent consequences, especially for down-stream communities. Moreover, the expansion of biofuel programs could have serious implications for the regional, if not necessary global, food situation. In fact, according to the International Food Policy Research Institute (IFPRI), 2007 saw a sharp rise in the cost of wheat, rice, corn, and soya after decades of falling food prices. And in Mexico last fall, a reported 70,000 people took to the streets to protest against mounting tortilla prices caused by increasing US demands for Mexican corn for biofuel production (*The Guardian*, 4 December 2007). So far, research on security implications of climate change has not paid much attention to these potential catalysts.

Additionally, climate change could influence how armed conflicts are perceived and justified. In struggling, illiberal regimes, global warming may constitute a much-needed political escape, as no single country is to blame for the adverse environmental developments and no country can be expected to mitigate these problems single-handedly. A relevant example is provided by the current debate on causes of the Darfur conflict. Some, including the regime in Khartoum, claim that the origins of the conflict can be traced back to the decades-old Sahelian drought (see e.g. UNEP, 2007). While such claims may have some

merit (though see de Waal, 2007), they are nonetheless highly problematic as they suggest a near deterministic relation between the environment and armed conflict, thereby relieving the main actors of their own responsibility. In fact, even the UN has been accused for using climate change as an excuse for its inability to halt the killings in Darfur (*The Times*, 23 June 2007). Moreover, the high profile of the climate issue entails a high risk that political actors with hidden agendas rally around the popular notion of global warming constituting the greatest security challenge of our time (see Goldstone, 2001; Salehyan, 2008).

3.8 Contextual effects

> Not even windstorm, earth-tremor, or rush of water is a catastrophe. A catastrophe is known by its works; that is, to say, by the occurrence of disaster. So long as the ship rides out the storm, so long as the city resists the earth-shocks, so long as the levees hold, there is no disaster. It is the collapse of the cultural protections that constitutes the disaster proper. (Carr, 1932: 211)

The potential mechanisms whereby climate change and variability increases the risk of conflict, as laid out in Sections 3.3 to 3.7 above, are not likely – or even plausible – to play out in all societies. In fact, many of the same social entities that risk being negatively affected by changing environmental conditions also determine the likelihood and extent to which such consequences will to materialize.

General research on civil war has shown that the risk of conflict is significantly and robustly associated with low national income, large and ethnically diverse populations, weak and inconsistent political institutions, unstable neighborhood, and a previous history of large-scale violence (see Hegre & Sambanis, 2006 for a review). Negative security impacts of future climatic changes are likely to be observed primarily in countries and regions that host today's armed conflict: i.e. the East-Central parts of Africa, the Middle East, and Central and East Asia. Accordingly, this is where international peace-building and development efforts should have their centers of gravity.

The physical consequences of climate change, like many contemporary armed conflicts, do not follow state boundaries. There are several complementary explanations for the clustering of armed conflict, including proliferation of small arms and know-how, transnational ethnic linkages, refugee flows, and negative economic externalities of violence (Buhaug & Gleditsch, 2008). However, whereas the extent and intensity of civil war are influenced by such factors as type of conflict and fighting capacity, population distribution and relocation, cultural delineation, terrain, and the location of strategically important

features, climatic variations tend to follow topographic and meteorological boundaries and macro-level climatic patterns. Just as the regional context may affect whether adaptation turns violent or not, adverse local changes may also have negative spillovers throughout the region. Accordingly, concerted efforts at addressing potential, harmful societal consequences of climate change also need to apply a regional perspective. It makes little sense to invest heavily in peace making and development in Chad without simultaneously handling the situation in neighboring Sudan. And the Kurdish question in Iraq cannot be discussed without acknowledging the role of neighboring Turkey and Iran. Isolated peace-building initiatives in unstable corners of the world are at best suboptimal. More likely, they are unsuccessful. Hence, understanding the regional dynamics of conflict and human security are vital in securing sustainable development and solidification of the political system in societies emerging from armed conflict.

4. Assessing the Empirical Literature

4.1 Summary of main findings

In contrast to the rich causal stories presented in the case literature, statistical comparative studies on the subject tend to model the scarcity-conflict relationship in rather simplistic ways. The first true multivariate assessment, conducted by Hauge & Ellingsen (1998), found that land degradation, freshwater scarcity, population density, and deforestation all have direct, positive effects on the incidence of civil war. Although no interactive effects were reported, the authors mention in a footnote that no such indirect associations were uncovered. In contrast, the contemporaneous Phase II of the State Failure Task Force (SFTF; now the Political Instability Task Force, PITF) project (Esty et al., 1998) did not find any direct relationship between indicators of environmental scarcity and state failure. While differences in data and research design provide some explanation for the lack of correspondence between these pioneering studies, a recent article by Theisen (2008) shows that the Hauge & Ellingsen results cannot be reproduced even with the original data.

The most severe short-term social consequences of climate change are likely to arise from increased climate variability with more extreme weather patterns, resulting in more frequent flooding and droughts. Such events may have dramatic consequences for livelihood, settlement patterns, and regime stability in the developing world, potentially increasing the risk of armed conflict. In a statistical study of conflict involvement among countries in Sub-

Saharan Africa, Miguel et al. (2004) find that negative deviation in annual precipitation substantially reduces national economic growth, and thereby indirectly increases the risk of civil war. Similar findings are reported by Hendrix & Glaser (2007) and Levy (2007). In contrast, a paper by Theisen & Brandsegg (2007), which looks at perhaps the most likely form of scarcity-induced violence, non-state conflict, finds no robust effect of population density or precipitation patterns on inter-group conflicts in Sub-Saharan Africa.

Other studies have focused more explicitly on how population pressure (high population density, high population growth, and large youth cohorts) relates to civil conflict. For example, Urdal (2005) finds that high pressure on potential cropland is *negatively* related to civil conflict, but that population growth and density jointly increase the risk of conflict, if only marginally. de Soysa (2002a,b) and Raleigh & Urdal (2007), too, report a positive effect of population density on the baseline risk of conflict, though others, notably the comprehensive statistical analysis by Hegre & Sambanis (2006), provide no support to the neo-Malthusian population pressure hypothesis.

Some studies even find empirical evidence directly opposing the causal pathways proposed in the case-based environmental security literature. For example, de Soysa (2002a) finds that rural population density in combination with renewable resource *wealth* increase the conflict risk. Similarly, Binningsbø et al. (2007) report that higher levels of accumulated consumption of renewable resources (the so-called ecological footprint) is associated with a lowered risk of civil conflict, even after controlling for economic development.

In the most comprehensive re-evaluation of the topic to date, Theisen (2008) demonstrates that several earlier findings are either not replicable or do not hold with improved data. Moreover, no tested link between resource scarcity and civil conflict remain robust across various data operationalizations and model specifications. Tellingly, since the ten-year old SFTF report (Esty et al., 1998), two more recent reports from the Political Instability Task Force have abandoned the issue of environmental scarcity altogether.

Finally, it is worth mentioning that the general literature on microfoundations of civil war provides little systematic evidence for the grievance conception common in the environmental security literature that rebels consist primarily of poor, deprived individuals of society who resort to violence in a desperate effort to improve conditions (see e.g. Arjona & Kalyvas, 2006 for the Colombian civil war, and Humphreys & Weinstein, forthcoming for the case of Sierra Leone).

Table 2. Empirical findings on scarcity, population pressure, and internal conflict

	Dependent variable(s)	Sample size	Method and data	Main findings
Country-level studies				
Hauge & Ellingsen (1998)	Civil war, intrastate armed conflict	Global; 1980–92, 1989–92	Logit; panel data	Soil degradation, population density, water scarcity, deforestation all increase risk
Esty et al. (1998)	State failure, infant mortality	Global; 1955–96	Several, mainly logit; panel data	No direct effects, some mediated through infant mortality
Collier & Hoeffler (1998)	Civil war	Global; 1960–92	Probit, Tobit; panel data	No effect of population density
De Soysa (2002b)	Intrastate armed conflict	Global; 1989–2000	Probit; cross-sectional	Population density increases risk, scarcity no effect on economic growth
Miguel et al. (2004)	Civil war, intrastate armed conflict	Sub-Saharan Africa; 1981–99	Regression, 2SLS; panel data	Negative rainfall deviation (instrument for economic shock) increases risk
Collier & Hoeffler (2004)	Civil war	Global; 1960–99	Logit; panel data	No effect of population density
Urdal (2005)	Intrastate armed conflict	Global; 1950–2000	Logit; panel data	Land pressure decreases risk in some models, land pressure*population growth increases risk for ‘70s
Hegre & Sambanis (2006)	Civil war, intrastate armed conflict	Global; 1945–2000	Logit; panel data	No effect of environmental factors or population density
Binningsbø et al. (2007)	Civil war, intrastate conflict	Global; 1961–99	Logit; panel data	Accumulated consumption decreases risk
Hendrix & Glaser (2007)	Civil war, intrastate armed conflict	Sub-Saharan Africa; 1981–99	Logit; panel data	Rainfall dev. increases risk, climate zone and land degradation has no effect, water scarcity decreases risk
Theisen (2008)	Civil war, intrastate armed conflict	Global; 1979–2001	Logit; panel data	Land degradation increases risk, water scarcity and drought close to significant, no effect of pop. dens and pop. growth
Local-level studies				
Urdal (2008)	Intrastate armed conflict	India; 1956–2002	Logit, negative binomial; panel data	Population density and land pressure increases risk
Buhaug & Rød (2006)	Intrastate armed conflict (by type)	Africa; 1970–2001	Logit; cross-sectional	No effect of population density when controlling for distance to capital
Meier et al. (2007)	Pastoral conflict	Karamoja cluster; 2004–06	OLS; panel data	Forage scarcity increases severity, high vegetation cover increases frequency of raids.
Raleigh & Urdal (2007)	Intrastate armed conflict	Global; 1990–2004	Logit; cross-sectional	Pop. density & growth, soil degrad., water scarcity, some interactions increases risk. Less effect in LDCs

4.2 Critique

The empirical literature on resource scarcity and conflict has improved considerably over the last decade, but there is still much room for improvement. First, large-N studies have so far failed to adequately account for proposed indirect and conditional effects of climate change, even though recent additions to the literature are beginning to explore the role of intervening factors (e.g. Raleigh & Urdal, 2007). Of the mediating factors presented in Figure 6 above, at best only simple interaction terms have been used. However, there is no *a priori* reason why such intermediate effects should be linear and multiplicative in nature; rather, they may be characterized by threshold effects and only apply under certain contextual conditions.

Second, large-N investigations of environmental scarcity and armed conflict – as in fact most research on civil war in general – suffer from overly aggregated research designs (Buhaug, 2007; Buhaug & Lujala, 2005; O'Lear & Diehl, 2007). A cursory glance at actual civil wars, however, reveals that violence rarely engulfs entire states. The separatist insurgency in Assam, for example, is limited to the province, and does not affect inhabitants of core areas such as New Delhi. Likewise, 'failing' states do not go from being fully effective across their entire territories to being completely ineffective. State capacity is better seen as a matter of degree, and as a factor that may vary across different areas of a state's territory. Many of the non-findings and conundrums in the existing cross-national research may follow partly from a nearly exclusive reliance on country-level attributes and aggregates. This potential for ecological fallacies – or explaining local phenomena from aggregated data – is particularly problematic in cases with large and geographically diverse units. Consider, for example, the tsunami that struck the northwestern shores of Sumatra in December 2004.[14] While the consequences for Aceh were truly devastating (the sudden ending of hostilities in the area represents an unexpected exception) and the economic losses for the region have been estimated at 97% of its total income, the corresponding loss for the Indonesian economy as a whole was a mere 2% of GDP, according to official Indonesian sources (BBC, 2005). Research on disasters and conflict carried out to date are clearly innovative and speak to the debate on climate change and conflict (e.g. Brancati, 2007; Nel & Righarts, 2008). So far, however, no study has tested their arguments using information on sub-national units.

[14] The tsunami was caused by an underwater earthquake in the Indian Ocean and was unrelated to climate change. Yet it illustrates how environmental disasters can be highly discriminatory in their impact across space.

Another aspect of the aggregation problem overlooked by the literature concerns whether the effect of resource scarcity is (expected to be) uniform across various types of resources and various forms of violence. Yet, assuming that an international land use dispute between El Salvador and Honduras are shaped by many of the same causal mechanisms as a coup d'état in a water-scarce Lesotho (Homer-Dixon, 1999: 138ff) is not attractive. Just as illegal narcotics production appears to prolong conflicts but not increase the risk of conflict onset whereas the opposite is true for secondary diamond wealth (Ross, 2006), it is not inconceivable that increasing variability/scarcity of particular renewables could lead to particular social outcomes – be it forms of cooperation or conquest or both. Yet another aspect of the aggregation problem concerns the nature and dynamics of resource scarcity – indeed, the very concept of scarcity. In some cases, scarcity is meant to imply a low per capita access to a natural commodity; in other cases, the distributional ('structural') aspect of the resource is promoted as the key issue, and little consideration is given as to under which conditions each scenario is particularly hazardous.

A third significant limitation of previous research concerns the dependent variable. Almost all statistical assessments of environmental scarcity and conflict look only at the most severe forms of organized violence: civil and interstate war. Yet, these conflicts are arguably the least likely to emerge from an increasing scarcity of renewable resources. The cost of fighting the government army is considerable, so deprived groups may simply be too weak to engage in serious conflict with state forces (Klare, 2001). This suggests that violent conflicts between groups – without direct involvement of the state – will be the most frequent form of conflict under worsening climatic conditions. Indeed, much of the case literature that claim a causal link between scarcities of renewable resources and armed violence refer to local, small-scale inter-ethnic conflicts (e.g. Kahl. 2006; Martin, 2005; Suliman, 1999). Besides, almost all research on scarcity and civil war limit their scope to the onset (or occurrence) of conflict. The theoretical scarcity literature, too, is traditionally occupied with the potential for new conflict. Yet, outbreak of hostilities between governments and groups with no history of violent struggle is extremely rare. Recall that more than half of today's armed conflicts originated in the 1980s or earlier. From an analytical point of view, as well as from a policy perspective, systematic research on the consequences of climate change for on-going conflict (e.g. nature of violence, severity, diffusion, prospects for resolution) is a high priority.

Fourth, research in the field has long suffered from a dearth of reliable environmental data.[15] For example, the SFTF phase II report (Esty et al., 1998) admits that data on water quality were available for 38 countries only, and indicators of other forms of scarcity also varied greatly in coverage. In fact, the SFTF's conclusions regarding the role of environmental factors were based on statistical models that exclude nearly half of the world's independent states due to missing data. The temporal dimension – so crucial if we are to gauge the dynamics in resource availability – is another inherent challenge. In Hauge & Ellingsen's (1998) pioneering study, measures of both soil degradation and freshwater availability are entirely static, severely restricting the breadth of possible inferences. The climate debate, in contrast, is all about *changes* to current environmental conditions. A third data limitation concerns the level of spatial resolution. Environmental data are often aggregated and released at the country level; yet, the underlying data may well be collected at a higher resolution (for example FAO's data on forest cover). In other cases, researchers fail to exploit the richness of available sub-national data. In a widely cited study, Miguel et al. (2004) construct a country-level proxy for economic shock from geo-referenced rainfall data that were collected at a much higher degree of spatial resolution.

Fifth, the case study literature tends to select cases on the dependent and main independent variables; i.e. to study only countries where both conflict and scarcity are prevalent. Gleditsch (1998) also argues that much of this literature suffers from complex, untestable models, confusion of level of analysis, and inference based on speculations and anecdotal evidence. Other criticisms points to a possible but unacknowledged spurious link between resource scarcity and armed conflict (Peluso & Watts, 2001), and general ignorance of the agency of the actors involved in the conflict. In addition, the sometimes explicit refusal to attempt to rank the uncovered causal factors (e.g. Homer-Dixon, 1999: 7) puts significant limitations to inference, as well as effective policy recommendations.

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[15] For example, the frequently used GLASOD measure of soil degradation has been criticized for overestimating the extent of soil degradation in Africa, as it only concerns the degradation of farmed land. Niemeijer & Mazzucato (2002) find small changes in soil fertility for the period 1969–96 when using field data on Burkina Faso, while the GLASOD estimates report a high degree of soil degradation for the very same area. Benjaminsen (2008) also points to the highly subjective concept of degradation, as conflicting views might hold starkly different positions on how the land should be used, resulting in different assessments as to whether an area is considered degraded or not.

Finally, the public debate on the security implications of climate change has been dominated by NGO reports (Christian Aid, 2007), national security (CNA, 2007), and statements by national and international public officials. While extensive research in the natural sciences has laid a solid foundation for the emerging consensus about global warming and the man-made contributions to it, the social implications of climate change are much less well researched. In particular, most of the statements in the public debate on the security aspects of climate change are rather speculative and build on a limited number of sources, few of them peer-reviewed. To date, the IPCC assessment reports have not dealt with the security issues in a comprehensive ad systematic fashion. Conceivably, the IPCC could decide to leave the security implications on the sideline in its own reports and leave that issue to be investigated by others. The schedule of the reports published to date would indicate that there is time for a fifth assessment in 2010 or after, but the decision whether or not to invest major intellectual energy in the deliberation of the security implications of climate change needs to be made much earlier. If the IPCC decides not to make a major investigation of this issue, the task may fall to the World Bank, which in recent years has sponsored a great deal of research on civil war.

5. The Way Forward: Guidelines for Future Research

The empirical foundation for a general relationship between resource scarcity and armed conflict is indicative at best and numerous questions regarding the exact nature of the proposed causal association remain to be answered. Case-based research, which largely belongs to the environmental security literature, offers several in-depth analyses of conflicts where environmental degradation (man-made as well as due to climate variability) plausibly has had some influence on the initiation of violence. Nonetheless, Thomas Homer-Dixon, a leading scholar within this research tradition, warns against making simplistic claims, explicitly stating that environmental stress is likely to cause conflict only in combination with other socio-economic risk factors. Quantitative, cross-national research on the environment and conflict has generally failed to uncover correlational linkages that stand up to conventional robustness tests. Although we cannot rule out the possibility that no general association exists, Section 4.2 provided some plausible explanations for the lack of correspondence between the general sentiments of the two research traditions. Moreover,

since rapid climate change is still mostly a feature of the future, empirical research of historical associations (or lack thereof) may be of limited value.

There is considerable room for improvement within the case study tradition. Yet, in our view, the most important immediate challenges lie within generalizable, statistical research. Data limitations, rigid research designs, and overly bold assumptions have so far effectively prevented direct and thorough evaluations of prevailing causal models. These challenges are not insurmountable. Recent and ongoing advances in data collection and statistical software (notably within geographic information systems, GIS), coupled with constant refinement of theoretical models, facilitate more precise and localized analysis of environment-conflict linkages than what has so far been published. Eventually, a multidisciplinary research program, combining the best of the two research traditions, would be the preferred mode of assessment of climate change and armed conflict.

Below, we identify nine areas of improvement that should guide future research in the field:

- CATALYSTS: Scarcities, migration, and disasters do not by themselves cause conflict. Rather, they may increase the risk of conflict only under specific conditions and through their impacts on economic and social aspects of society. In Section 3.2, we presented a synthesized causal model of climate change and conflict that explicitly identifies five potential intermediate catalysts of organized violence: political instability, economic instability, social fragmentation, migration, and scapegoating. Future research should investigate this first step of the causal chain in more depth, exploring potential non-linear, discontinuous, and threshold effects. As the relevance and relative importance of catalysts will vary between cases, this assessment may require a combination of research methods.
- NATURAL DISASTERS: Current research on environmental factors and armed conflict focuses mostly on scarcity and diminishing access to renewable resources. Future research – in-depth case analyses as well as cross-sectional assessments – should pay more attention to security implications of disasters, which in addition to reducing the resource base of societies may cause massive destructions to infrastructure and instigate rapid, large-scale population flows. The local nature of many climatic disasters (e.g. landslides, tropical storms) implies that disaggregated quantitative research designs are particularly promising.

- AGENCY: More emphasis should be placed on in-depth investigation of the agency of actors involved in conflict. At present, the qualitative literature does not offer sufficient individual-level explanations for why and how resource-poor people decide to join violent movements to improve on their living conditions. This priority also includes exploring latent or low-level conflicts that did not escalate, thus providing insights into how resource conflicts can be solved before they become more intractable.
- DYNAMIC SCARCITY: In the environmental security literature, scarcity often implicitly implies a reduction access to a resource (what we may call dynamic scarcity) rather than scarcity per se (i.e. static scarcity). While good measures of dynamic scarcity of e.g. freshwater or crop yields are severely hindered by data quality, increasing use of satellite imagery, meteorological data, and detailed surveys imply that reasonable, time-varying measures of local environmental conditions are increasingly available. Future research should strive to develop good time-varying measures of processes associated with climate change.
- LOCAL MECHANISMS: The impacts of scarcities and migration are felt most intensely at the local level. Conflicts, too, are usually spatially concentrated sub-national events. Future research should move away from the habitual state-centeredness and explore sub-national variations in livelihood resource availability, armed conflict, and relevant intermediate factors.
- REGIONAL PERSPECTIVE: The physical aspects of climate change are inherently transnational in nature. So, too, are many of today's conflicts. So far, empirical research in the area has ignored important determinants of spillovers and the reciprocal relationship between resource competition and migration. Future research should pay more attention to the proposed migration mechanism and explore new data on the geography of ethnicity in order to assess regional security implications of climate change.
- LOW-LEVEL VIOLENCE: Scarcities and migration are much more to likely to result in low-level violence where the state does not take an active part in the fighting than conventional civil wars. Until quite recently, a lack of systematic data on non-state and one-sided violence hindered systematic research on such conflicts. Now, such conflict data are increasingly becoming available, allowing for more pertinent evaluation of causal theories of violence presented in the qualitative literature. Future

research should also seek to collect better data on local institutions, both formal and informal, as these often play vital roles in local conflict management.

- COURSE AND OUTCOME OF CONFLICT: So far, research has been preoccupied with questions concerning the onset of organized violence. Yet, onset of armed conflict is a very rare event – a majority of contemporary intrastate conflicts predates the collapse of the Cold War. Moreover, the most vulnerable and conflict-prone countries of today are among the countries with the largest projected negative implications of future climate change. Future research should expand the scope of research to include conflict processes beyond those associated with outbreak of hostilities. Exploring how increasing climate variability in the developing world may affect ongoing armed conflicts should be top priority. How resource factors affect the risk of conflict recurrence is another case in point worth investigating.
- ACCOUNTING FOR CAUSAL COMPLEXITY: Most in-depth case studies point to a complex web of causes between scarcity and conflict whereas statistical studies testing this use frameworks that are unsuitable for testing complex relationships. Semi-structured designs, such as the Boolean logical sets could, be used to identify and extract general patterns from multiple single-case analyses without imposing too severe limitations on the underlying, modeled theory, and could thus contribute significantly to bridging the gap between qualitative and statistical research.

6. Implications for Policy

Climate change has many probable consequences for our physical environment and each of these has a variety of potential consequences for man's livelihood. The scope of these challenges to human societies adds to the urgency of the climate change debate. There is hardly a single facet of our daily life that does not have some latent effect on our ability to deal with climate change. The good news is that support for policies of mitigation and adaptation can mobilize a broad section of the public because climate change is relevant virtually to everybody. The bad news is that such broad debates are in danger of being hijacked by those with special agendas, be it NGOs in the area of disaster relief or think-tanks involved in studies of national security.

Popular conceptions of climate change, boosted by massive media attention, alarmist claims by high-profile actors, and a recent Nobel Peace Prize award, seem to indicate that

climate change is strongly and irreversibly linked to questions of peace and war. Paradoxically, recent trends in armed conflict, as well as empirical research on environmental scarcity and civil war, provide very little evidence to substantiate the depth of these claimed associations. To the extent that policy advice from the academic community should be founded on robust findings in peer-reviewed research, the literature on environmental conflict has surprisingly little to offer. However, the indirect nature of the environment-conflict nexus offers some insights into where future development and peacebuilding efforts should be targeted.

Adverse environmental changes are expected to act as a threat multiplier by adding strains to already vulnerable populations in poor and fragile societies. Moreover, today's most fragile and conflict-prone societies are among the countries expected to be most severely hit by adverse climatic changes in the coming decades. These societies do not have the resources and political capacity necessary to adapt successfully to the added challenges imposed by increasing climatic variability. This has two important consequences. First, the indirect effect of climate change via economic and institutional aspects of development implies that policies designed to promote sustainable economic growth and strengthen political institutions implicitly address important general risk factors. As rightly stated by International Alert (2007: 4): 'peacebuilding and adaptation are effectively the same kind of activity.' Second, the substantial spatial overlap between today's most unstable and conflict-prone societies and the areas expected to be hit most adversely by a changing climate is a strong signal that this is where the potential benefit of international assistance will be the highest.

Recommendations

1. **Invest in vigorous, systematic research.** Despite numerous accounts of single events and well-developed theoretical models, we still know very little about *general* linkages between environmental factors and various forms of armed conflict. Case studies can provide some advance warning of deteriorating problems in selected areas. But global climate change policy is crucially dependent upon the early warning of events in areas that have not necessarily had such problems in the past. For this, we need better generalizable knowledge. Precise point predictions are not realistic, but general models can provide guidance as to the probability of future problems and thus help to select priority areas for remedial action.

2. **Promote more systematic environmental accounting.** The debate so far has rightly focused on negative impacts of climate change. This is defensible, given that the prevailing opinion is that the negative effects will outweigh the positive. However, in order target countermeasures and mitigation most effectively, the policy community needs to have a more systematic assessment of negative and positive effects. How much of the loss in agricultural capacity in some areas is likely to be offset by gains in other areas? Heat waves are likely to claim additional lives in some environments, while milder climates may prevent the loss of life in very cold environments.

3. **Assess the security effects of countermeasures to climate change.** Some of the proposed measures to restrict the greenhouse effect may also have security effects and these need to be assessed in order to find the best countermeasures overall. For instance, draconian measures to reduce CO_2 emissions in high-growth developing countries like China and India might make trading-state strategies less attractive relative to strategies of territorial warfare. It would also very likely lead to a stagnation or even reversal of their economic growth, with political instability and civil unrest as probable outcomes.

4. **Use development policies for peacebuilding.** Any negative security implication of climate change is thought to work through economic and sociopolitical aspects of society. Besides, national poverty is one of the strongest correlates of civil war, and low per capita income is also strongly linked to lack of democratic governance. Until systematic research succeeds in uncovering specified and robust associations between

climate change and armed conflict, investing in sustainable development in vulnerable societies may be the best instrument for promoting peace and security.

5. **Prioritize the most vulnerable societies.** There is substantial spatial overlap between today's conflict-prone societies and the areas expected to be hit most adversely by future climate change. The East-Central parts of Africa, the Middle East, and Central and East Asia, which already suffer disproportionally from instability and violence, face a double security challenge through additional climate-imposed strains on human health and livelihood. This is likely to exacerbate the differences between those who are able to adapt to a changing environment and those who are caught in the 'conflict trap'.

6. **Include security issues in the next round of IPCC assessments.** The natural science aspect of climate change is founded on hundreds of solid, peer-reviewed studies. By contrast, the social implications of climate change are rather speculative and build on a limited number of sources, many of them not peer-reviewed. If the security implications of climate change are to be taken seriously in the policy debate, the IPCC should take the lead in investigating them systematically. If the IPCC decides not to make a major investigation of the issue, this task should be taken up by other international agencies.

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