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Climate Change, Human Health, and Social Stability: Addressing Interlinkages

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Background: Abundant historical evidence demonstrates how environmental changes can affect social stability and, in turn, human health. A rapidly growing body of literature, largely from political science and economics, is examining the potential for and consequences associated with social instability related to current climate change. However, comparatively little of this research incorporates the effects on human health or the role of health systems in influencing the magnitude and types of instability that could occur.

Objective: The objective of this commentary is to articulate a conceptual framework incorporating health outcomes and health systems into theorized and observed linkages between climate change and social instability, illustrating in particular the health effects of natural resource shortages, infectious disease outbreaks, and migration.

Discussion: Although increasing evidence exists that climate change, health, and social instability are related, key questions remain about the pathways linking these factors, as well as the magnitude, causality, and directionality of relationships across spatial and temporal scales. Models seeking to explain and predict climate-related social unrest should incorporate the many linkages between climate change, human health, and social instability. Members of the environmental health research community should work closely with those in the political science and economics communities to help deepen understandings of climate-related stressors and shocks that affect instability and worsen health outcomes. https://doi.org/10.1289/EHP4534

Introduction

Climate Change and Social Instability

Historically, environmental health focused on identifying hazards, characterizing exposures, and assessing risks (Frumkin 2016). To the extent that environmental health examined social instability and its extreme form, armed conflict, they were typically considered factors that drove differential exposure to hazards in various environmental media. For example, exposures to hazardous chemicals, pesticides, and radiation in the context of conflict have been closely examined in the environmental health literature (Brown 2004). In recent years, however, the relationships between upstream environmental drivers related to global environmental change and insecurity in several areas, like food, water, and housing, have increasingly come to the fore (O'Brien 2006; Briggs 2008; Ericksen et al. 2009; Cook and Bakker 2012). Environmental health has struggled to develop paradigms accounting for upstream health determinants and complex, long-term dynamics linking environmental change with human security (Whitmee et al. 2015).

Although the environmental health community has been relatively slow to integrate these issues into its portfolio (Birnbaum 2017; Seltenrich 2018), the issue of how climate change may affect social stability and thus health is garnering increasing attention (Dyer 2010; Welzer 2012; Werrell and Femia 2017). A variety of pathways link climate change with social instability and adverse health outcomes, including reduced availability and accessibility of natural resources and ecosystem services, changed livelihoods, and strained government and health system resources (Barnett and Adger 2007). Social instability and conflict are not generally approached as public health issues, despite the fact that war and its sequelae are associated with substantial increases in morbidity and mortality beyond that of combatants (Wagner et al. 2018). In some cases, environmental changes have been directly linked with armed conflicts and their health effects. For instance, the recent Syrian conflict, at least partially driven by drought (Gleick 2014), has, estimated conservatively, resulted in over 143,000 deaths as of 2016 (Guha-Sapir et al. 2018).

The literature on environmental change and instability increased exponentially during the past decade, coming largely from the fields of political science and economics. Scholars incorporate instability in models in myriad ways, using events that vary by severity and spatial scale. In the climate and instability literature, specific examples of instability used in models include nonviolent demonstrations or localized civil unrest (Nardulli et al. 2015; Bellemare 2015), international conflict (Devlin and Hendrix 2014), and state failure (Gleick 2014). Political scientists note that regime type is highly predictive of instability: Full democracies and autocracies tend to be more stable than regimes that have combinations of democratic and autocratic elements, as well as factional divisions among populations (Goldstone et al. 2010). Thus, events that may precipitate instability in one country may not do so in a country with a more stable regime. Climate change and social instability research incorporates a variety of methods, including large-scale statistical models, qualitative case studies, and geographic information system-based risk mapping (Ide 2017). Often, multiple datasets incorporating social, political, and climate variables are combined to assess the effects of climate on instability.

Empirical studies on linkages between climate and security conceptualize environmental exposures in a variety of ways, including extreme weather events (e.g., Schleussner et al. 2016), short-term changes in temperature or precipitation (e.g., Devlin and Hendrix 2014; Raleigh et al. 2015), and longer-term (generally multidecadal) trends in temperature or precipitation (e.g., Devlin and Hendrix 2014). Others use climate-sensitive impacts such as food production (e.g., Wischnath and Buhaug 2014; Buhaug et al. 2015) or economic variables (e.g., food prices, which are climate-sensitive but also affected by market- and governance-related factors) to understand interactions between climate variability, socioeconomic factors, and related impacts on

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social stability (Smith 2014; Hendrix and Haggard 2015). In this literature, shorter time series of years to decades are often examined, with the results extrapolated to assess the potential impacts of longer-term climate change. In general, with some variability and inconsistency (e.g., Salehyan 2014; Buhaug 2015), this literature finds that both short-term shocks, such as natural disasters and associated losses of livelihood opportunities, as well as longer-term stressors, such as growing scarcity of resources associated with drought, can increase the risk of instability (Buhaug 2016).

Although many studies find relationships between weather or economic variables and security impacts, a gap exists in understanding relevant pathways or mechanisms (Hsiang and Burke 2014). An important hypothesized mechanism is weakened livelihoods due to extreme weather events and crop loss, increasing the costs and challenges of governance and, in some cases, spurring outmigration away from affected areas (Barnett and Adger 2007; Reuveny 2007; Scheffran et al. 2012; O'Sullivan 2015). Research reviewing climate and instability cases in East Africa found four key mechanisms: loss of livelihood opportunities, migration and pastoral mobility, tactical considerations by armed groups, and elite exploitation of grievances (van Baalen and Mobjörk 2017), although doubtless more mechanisms exist when exploring other contexts. Importantly, the literature on climate and conflict is biased as a result of sampling strategies that are convenience-based, potentially leading to inappropriate conclusions regarding the strength and robustness of climate change and social stability relationships (Adams et al. 2018).

Structural factors—some modifiable and others relatively fixed—are emerging as important drivers. The focus of climate and security research has changed over time as understanding of the relationships between climate variables and security at multiple scales has become more refined (Buhaug 2016). Although some direct relationships between climate and security likely exist, most of the empirical effects are mediated by socioeconomic outcomes, which are themselves moderated by preexisting structural factors. For instance, states that are more vulnerable to food insecurity due to weakened governance capacity and low agricultural productivity are more likely to experience conflict when food shortages occur (Jones et al. 2017). Other risk factors, such as hostile neighbors and weakened trading partners, have been linked to societal collapse (Diamond 2005). Empirical research predicting future climate-related instability is increasingly accounting for demographic, socioeconomic, and ecological heterogeneity between states that may affect the likelihood of conflict (Hegre et al. 2016; Witmer et al. 2017). Other structural issues may pertain at the community level. Prior work using a vulnerability lens to examine community-level racial and ethnic environmental health disparities theorized that psychosocial stress, likely driven by structural factors, may be the vulnerability factor linking exposure to environmental hazards with differential health impacts (Gee and Payne-Sturges 2004). Continued examination of how structural factors are related to exposure to climate-sensitive hazards and associated impacts is likely to be a useful path forward.

Another line of research has investigated the role that climate-related hazard timing and intensity, i.e., climate-related shocks, have in driving instability. Recent research has found that climate-related shocks generally do not, in and of themselves, create social unrest (Buhaug 2016). However, climate shocks may serve as points that precipitate a significant crisis when other conditions (stressors) that facilitate unrest exist. Climate change is sometimes viewed as a threat multiplier (a condition that creates additional vulnerability for a hazard or threat to become a larger risk) within the U.S. national security community, reflecting the view that climate change can affect the risk and consequences of conflict when relevant stressors exist. In other words, climate change can affect conflict, but not in all circumstances (Wallace 2018). The existence of socioeconomic or governance mediators suggests more complex and varied pathways linking climate change and instability that have direct implications for understanding the role of human health in these relationships.

Our commentary takes a broad view of this literature, examining the relationship between climate change, human health, and any form of social instability (including, but not limited to, armed conflict), with the goal of providing a framework to guide future engagement of these issues in the field of environmental health.

The Role of Environmental Health in Affecting Climate Change-Instability Relationships

The environmental health literature discusses varied relationships between climate change and human health outcomes, including through mechanisms such as thermal extremes, infectious disease, food shortages, and nutrient deficiencies (Hajat et al. 2014; Smith et al. 2014; Rosenzweig et al. 2014; Zhu et al. 2018). As with the relationships between climate change and social stability, other factors moderate the relationships between climate factors and health outcomes. Most notably, socioeconomic development and health systems (the people, policies, organizations, and resources needed for disease prevention and health protection) play a critical role in influencing whether climate-related threats become more widespread population health challenges (Sellers and Ebi 2018). Additionally, extreme weather events associated with climate change may threaten physical infrastructure, making it challenging to provide continuous care in cases where buildings are damaged or destroyed (Balbus et al. 2016) or when system function is impaired, as was the case with Puerto Rico following Hurricane Maria (Kishore et al. 2018). Moreover, when extreme events occur, reconstruction can be a challenge because property insurance coverage is often limited in many low- and middle-income settings, and rebuilding public health infrastructure is burdensome for cash-strapped governments.

Although literature linking climate change with human health and with national security exists, very little research addresses the three issues together, with the notable exception of research linking infectious disease and conflict. Climate change may increase the range of many infectious diseases, depending on local climate conditions, demographic patterns, and land use factors (Kilpatrick and Randolph 2012; Altizer et al. 2013). Key mechanisms through which infectious disease can precipitate conflict and instability include: *a*) changing the balance of power between states by affecting national wealth, *b*) creating disputes between governments over how to manage infectious disease outbreaks, and *c*) weakening domestic governance capacity (Peterson 2002). A vicious cycle may result among climate change, social instability, and infectious disease outbreaks (Beldomenico and Begon 2010). Climate change may weaken state governance and health system capacity, increasing the risk of disease outbreaks, which in turn may result in instability that further weakens state institutions, increasing the risks of future outbreaks, and so forth (Letendre et al. 2010). International coordination to reduce pathogen risks is feasible but often very challenging (Davies et al. 2015), and critiqued as disproportionately benefitting high-income countries (Davies 2008).

Other potentially relevant pathways, such as food and water shortages, linking climate change, health, and stability have not been closely examined. The most direct effects are in the short- to medium-term consequences, with risks of shortages leading to riots and social instability, as has occurred in parts of Africa and South Asia (Berazneva and Lee 2013; Wischnath and Buhaug 2014). Food price shocks were arguably a necessary (although not sufficient) cause of the Arab Spring demonstrations in 2011 (Johnstone and Mazo 2011). Cape Town is preparing to be the first major city to run out of drinking water, with plans created to establish nearly 200 distribution points around the city if the taps run dry, monitored by police, creating the potential for social unrest as citizens scuffle for access to limited water supplies (Maxmen 2018).

Nevertheless, the long-term and often largely unseen consequences of food and water shortages may be most damaging to stability and national security. Undernutrition during early childhood is associated with shorter height, lower levels of schooling, and lower income levels during adulthood (Victora et al. 2008), as well as adverse mental health outcomes (Huang et al. 2013). Maternal undernutrition and malnutrition can also lead to poor infant and child health outcomes (Black et al. 2013). Collectively, these health outcomes, which are more probable with accelerating climate change, can weaken governance capacity, economic growth, and lead to poorer human capital outcomes (Hallegatte et al. 2016). Additionally, state security may be harmed due to a less-healthy adult population eligible for military service.

Moreover, studies note that crop failure and related upstream variables like rainfall deficit can predict migration that may drive instability if migrants are competing with established populations for jobs and resources (Gray and Mueller 2012; Hunter et al. 2013). However, current evidence does not suggest that climate-driven migrants increase the risk of conflict in their destinations (Cattaneo and Bosetti 2017). Nevertheless, even if climate-driven migrant flows do not trigger wide-scale instability, these migrants are likely to experience a variety of adverse social and health outcomes (McMichael et al. 2012). The experience of these outcomes, including social marginalization, joblessness, and high rates of infectious disease and malnutrition, are likely to stretch health system capacity, potentially resulting in unrest in cases where health institutions fail to satisfactorily address population needs.

In sum, several potential mechanisms link health with climate and instability, along with many unanswered questions. A small sample of these questions is shown in Table 1, although we emphasize that this sample barely scratches the surface of key questions of interest. Below, we present a conceptual framework illustrating key shocks and stressors to consider when conceptualizing climate change, health, and social instability relationships. We then present a series of key research areas to address with a more comprehensive climate change, health, and social instability research agenda.

Conceptual Framework

Figure 1 presents a conceptual framework depicting how climate change affects human security and social stability. At its center are five interlinked distal drivers that shape local contexts: climate and environmental systems, physical geography (e.g., land area, topography, and biomes), social and economic systems, governance systems (representing governance at a variety of levels, from local to transnational), and health systems. Two rings surround these drivers. The inner ring displays ten contextual factors affecting baseline risk for instability, and the outer ring displays eight mechanisms that serve as key proximal triggers or drivers of instability. These factors are separated temporally, with the factors that change most slowly located in the center, followed by stressors, with shocks forming the outermost layer. We display the mechanisms in a ring to highlight their interacting nature and to note that multiple distal factors affect baseline instability risk and that many potential interactions among distal and proximal factors vary across settings. The order or location of each factor on the rings is not important. Operationally, each of the factors can be considered individually as either driving or mitigating risk in a given setting. The potential exists for interaction among factors at a particular level, as well as interactions among factors across levels. Generally, distal driver factors (stressors) tend to be longer term and harder to modify through public policy, whereas proximal factors (shocks) tend to be shorter term and more amenable to change through specific policy interventions.

Distal Driver Factors (Stressors)

The role of factors in the middle ring deserves additional elaboration focused specifically on climate change:

1. **Health status and vulnerabilities:** As noted above, adverse population health impacts associated with climate change can, by extension, affect social stability and human well-being (Smith et al. 2014).
2. **Public health and health systems:** Well-functioning health systems play a critical role in anticipating, identifying, communicating, and addressing emerging health issues. Health systems that adaptively manage climate change, targeting resources toward populations most likely to be affected by climate-related hazards, are likely to reduce the risks of related health harms (Ebi 2011).
3. **Human capital:** Educational attainment can affect employment opportunities and decision-making capacity (Muttarak and Lutz 2014), which in turn can influence decisions around migration and adaptation to climate change (Van der Land and Hummel 2013).
4. **Demography:** Demographic conditions can increase the risk of social unrest. Most commonly discussed in the literature are the effects of "youth bulges," in which young men, who are often socially and economically marginalized, are a disproportionate share of the population, increasing the risk of conflict (Urdal 2006) and of transitions to less democratic forms of governance (Weber 2013).
5. **Dependence on natural resources:** Livelihood dependence on natural resources and ecosystem services likely to be harmed by climate change can increase vulnerability and place societies at greater risk of instability (Adger 2000).
6. **Inequality:** Social and economic inequality, particularly between established ethnic or other established groups within countries, can increase the risk of conflict (Østby 2008). Elite capture of natural resources, ecosystem services, and political power can breed social and economic resentment, increasing the risk of instability (Verhoeven 2011).
7. **Poverty/standard of living:** Poverty affects the resources individuals have to migrate or otherwise adapt their livelihoods when shocks and stresses occur (Government Office for Science 2011). Many millions of people around the world have incomes just above the poverty line, and unexpected events (including climate shocks) can push these populations into poverty, increasing the risk of social instability (Hallegatte et al. 2016).
8. **Resource availability:** Availability of natural resources, such as fresh water, can affect vulnerability to climate shocks and social instability (Busby et al. 2014; Almer et al. 2017).
9. **Governance quality and institutional capacity:** Metrics of governance quality (e.g. corruption, rule of law, emphasis on equity) are associated with health outcomes (Kickbush and Gleicher 2012). Institutional capacity, i.e., the ability of governments and related social actors to

Table 1. Key questions to answer concerning climate–health–instability relationships.

Areas of study	Questions
Social stability consequences of climate-related malnutrition	Does climate-related malnutrition reduce domestic conflict due to effects on health (dampening participation in rebel movements)?
	Is climate-related malnutrition associated with increased outmigration due to localized food scarcity/need to secure other livelihoods?
	Is climate-related malnutrition associated with reduced outmigration due to poorer health status and associated difficulties in traveling?
	Is climate-related malnutrition (especially among children) likely to have effects on military/ police recruitment due to long-term health consequences?
Social stability consequences of infectious disease outbreaks	Is stronger health and governance capacity associated with reduced public panic/instability during infectious disease scares?
	How effective are international institutions likely to be in addressing a climate-driven infectious disease outbreak?
	What are effective strategies for reducing public panic/instability when health resources (e.g., vaccine supplies) are limited and must be rationed?
Social stability consequences of higher temperatures	How are extended periods of higher temperatures likely to affect crime or other forms of social instability, particularly in northerly latitude settings less accustomed to such temperatures?
	What are effective health system and governance responses to higher temperatures that can prevent social unrest?
Social stability consequences of weather and climate disasters	How might the changing frequency, severity, and co-occurrence of weather and climate disasters affect livelihoods, health, and migration?
	How might loss and damage associated with weather and climate disasters affect investments in the health and other sectors with implications for health protection?
Health consequences of instability	What is the global magnitude of death and disease burden associated with climate-related instability?
	Are characteristics of victims of climate-related instability likely to change in the coming decades? If so, how (e.g., changes in age, sex, place)?
	How can health systems, particularly where universal health coverage does not exist, mitigate adverse health outcomes experienced by migrants?

respond to public needs and provide quality services, such as education, defense, and infrastructure, can affect social stability (Hendrix 2010). Effective provision of social welfare services in particular can reduce the risk of social unrest (Taydas and Peksen 2012). As these concepts are somewhat abstract, political scientists often use indexes to operationalize them in models. Political participation and institutional structure and quality are measured using either objective measures, expert judgments, or both (see Table 2 for examples).

10. **Institutional interconnectedness:** We consider institutional interconnectedness as the number and quality of interlinkages between state and nonstate institutions in different countries. These relationships can influence collective action capacity to address climate-related challenges. Although difficult to measure quantitatively, intersectoral coordination can help more effectively address shocks and stresses, particularly in the health sector (Bowen and Ebi 2015). Collaboration between different states can also support effective responses (Bulkeley et al. 2012; Fünfgeld 2015). States with poor relationships or frameworks for dealing with interstate environmental challenges may be at greater risk of conflict (De Stefano et al. 2012). This concept can also be operationalized through indexes, such as those measuring trade agreements, foreign investment, treaty membership, and other indicators of international interdependence.

Proximal Driver Factors (Shocks)

Concerning the mechanisms that may trigger instability or unrest, the following eight categories and examples encapsulate the key pathways:

1. **Disruptive migration flows:** Rapid and large-scale migration can prove destabilizing to receiving societies, due to distrust of the newcomers, resentment against the resources expended on migrants, or cultural or ethnic differences between migrants and established populations (Reuveny 2007). As evidenced by recent large-scale flows of migrants into Europe, driven in part by environmental factors, rapid migration can also strain institutions. For instance, many migrants there are experiencing uncertainty about their legal status due to difficulties and delays in processing (Kersch and Mishtal 2016), as well as challenges in accessing important services, such as health care (van Loenen et al. 2018), slowing integration and worsening outcomes for migrants and receiving societies.
2. **Changes in the balance of power:** Changes in power balances within and between nation-states may trigger instability. Increases in the relative access to resources of one group may result in rebel violence, for instance (Bagozzi et al. 2017). International relations scholars who take a realist position argue that states seek to maximize their military and economic strength relative to other nations, as that strength best ensures their national security (Mearsheimer 1994). If a climate shock undermines a country's ability to compete economically, through adverse demographic, health, and economic impacts, this change may affect a country's relative gains over other states, potentially increasing the long-term risk of interstate conflict.
   Among subnational groups, resource concentration potentially increases the risk of localized conflict (Adano et al. 2012). For example, research on pastoral cattle raids in Kenya found that when rainfall patterns in one year disproportionately benefitted a particular tribe, that benefit provided them with motivation to expand their gains in resources through the use of cattle raids. At the same time, tribes that did not benefit from rainfall patterns were motivated to raid because of relative poverty and a need to survive, leading to changing resource distributions motivating raids from two perspectives (Schilling et al. 2012).
3. **Changes in government leadership or policy:** Shifts in government leadership or policy direction can affect the probability of unrest. In examining different vulnerabilities

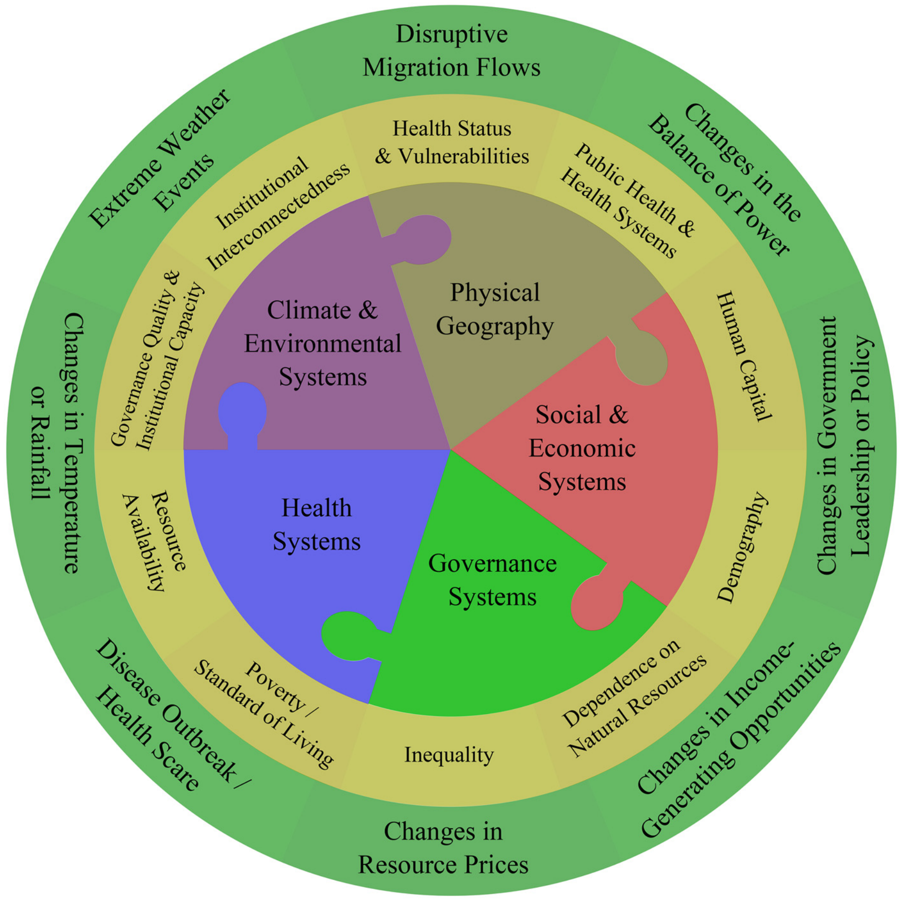

Figure 1. Conceptual framework linking climate and environmental systems, physical geography, socioeconomic systems, governance systems, and human health systems. Innermost factors are least likely to change; middle ring represents medium/long-term stressors, and outer ring represents near-term shocks.

to social unrest, researchers note that government policies that mitigated increases in resource prices, such as food or fuel subsidies or price controls, reduced the risk of conflict (Berazneva and Lee 2013; Hendrix and Haggard 2015). In particular, democracies, where policies may be less stable due to more frequent changes in governments and where often inbuilt preferences toward rural constituencies exist, experience a greater risk of unrest when food prices increase (Hendrix and Haggard 2015).

4. **Changes in income-generating opportunities:** Difficulties in earning income, due to crop or livestock losses or a reduction in the abundance of natural resources or ecosystem services used to sustain livelihoods, can result in household-level economic challenges and potentially generate instability, particularly if abundance elsewhere incentivizes migration. Strong deviations in environmental factors directly associated with livelihoods, such as rainfall, are associated with civil unrest (Hendrix and Salehyan 2012). States with poor human capital profiles or imbalanced age structures may be at greater risk of instability if their populations are unable to shift livelihood activities away from those heavily affected by climate shocks.
5. **Changes in resource prices:** Changes in resource prices (as measured in cash or in time to collect or access resources), and distinct from changes in opportunities to generate income, are also a key trigger of instability. Importantly, unlike changes in income-generating opportunities that are generally affected by spatially proximate climate shocks, resource prices may be affected by climate shocks elsewhere. Increases in food prices (although not necessarily food price volatility) are often associated with increases in unrest (Smith 2014; Bellemare 2015).
6. **Disease outbreak/health scare:** Although infectious disease outbreaks can trigger interstate conflict, domestic civil unrest can also result from sudden health scares. For instance, during the 2013–2016 Ebola outbreak in West Africa, health workers were repeatedly attacked by local mobs, in part from pervasive distrust of health professionals and the rapid spread of misinformation about the disease (Cohn and Kutalek 2016). Little imagination is needed to envision similar forms of unrest occurring during other disease outbreaks associated with increases in the geographic range, seasonality, or intensity of transmission of climate-sensitive infectious diseases.
7. **Changes in temperature or rainfall:** Changes in temperature or rainfall are the most widely studied proximate factors driving instability or conflict, often because those changes serve as proxies for agricultural income or access to resources. However, beyond this important link, scholars have also argued that changes in temperature or seasonality may directly affect the magnitude and location of violence. For instance, studies from urban settings in the United States and South Africa note that higher temperatures are associated with increased rates of crime, particularly in socioeconomically disadvantaged communities (Breetzke and Cohn 2011; Mares 2013).
8. **Extreme weather events:** Separate from changes in temperature or rainfall, large-scale disasters such as hurricanes

Table 2. Potential indicators or proxy measures of stressors at the country level.

Stressors	Example Indicators	Index or Source	Additional Information
Health status and vulnerabilities	Burdens of climate-related causes of morbidity/mortality (diarrheal disease, undernutrition, thermal stresses)	Institute for Health Metrics and Evaluation Global Burden of Disease Study[a]	Roth et al. (2018); http://ghdx.healthdata.org/
	Infant/child mortality rates	UN Inter-Agency Group for Child Mortality Estimation	http://www.childmortality.org/
	Food insecurity index	Economist Intelligence Unit Global Food Security Index	https://foodsecurityindex.eiu.com/
	Underweight and stunting prevalence	UNICEF Multiple Indicator Cluster Surveys[a]	http://mics.unicef.org/
	Access to improved sanitation services	UNICEF/WHO Joint Monitoring Program[a]	https://washdata.org/
Public health and health systems	Health spending per capita	WHO World Health Statistics	https://www.who.int/gho/publications/world_health_statistics/en/
Human capital[b]	Literacy rates & reading comprehension	UNESCO Institute for Statistics	http://data.uis.unesco.org/
		Progress in International Reading Literacy Study[a]	https://timssandpirls.bc.edu/
		PISA Study[a]	http://www.oecd.org/pisa/data/
	Math/science achievement	Trends in International Mathematics and Science Study[a]	https://timssandpirls.bc.edu/
		PISA Study[a]	http://www.oecd.org/pisa/data/
	School enrollment	UNESCO Institute for Statistics	http://data.uis.unesco.org/
	Formal educational attainment by age/sex	International Institute for Applied Systems Analysis	Lutz et al. (2014); http://www.oeaw.ac.at/fileadmin/subsites/Institute/VID/dataexplorer/index.html
	Educational spending	UNESCO Institute for Statistics	http://data.uis.unesco.org/
Demography	Population by age and sex	United Nations Department of Economic and Social Affairs	https://population.un.org/wpp/
		International Institute for Applied Systems Analysis	Lutz et al. (2014); http://www.oeaw.ac.at/fileadmin/subsites/Institute/VID/dataexplorer/index.html
		Integrated Public Use Microdata Series International Census Database[a]	Minnesota Population Center (2018); https://international.ipums.org/international/
	Sex ratio	United Nations Department of Economic and Social Affairs	https://population.un.org/wpp/
		International Institute for Applied Systems Analysis	Lutz et al. (2014); http://www.oeaw.ac.at/fileadmin/subsites/Institute/VID/dataexplorer/index.html
	Dependency ratio	United Nations Department of Economic and Social Affairs	https://population.un.org/wpp/
		International Institute for Applied Systems Analysis	Lutz et al. (2014); http://www.oeaw.ac.at/fileadmin/subsites/Institute/VID/dataexplorer/index.html
	Average life expectancy	United Nations Department of Economic and Social Affairs	https://population.un.org/wpp/
		International Institute for Applied Systems Analysis	Lutz et al. (2014); http://www.oeaw.ac.at/fileadmin/subsites/Institute/VID/dataexplorer/index.html
	Population density	Gridded Population of the World[a]	http://sedac.ciesin.columbia.edu/data/collection/gpw-v4
		WorldPop[a]	https://www.worldpop.org/
Dependence on natural resources	Household income share from agriculture/natural resource activities	World Bank Living Standards and Measurement Study[a]	http://microdata.worldbank.org/index.php/catalog/lsms
	Share of community employment from agriculture/natural resource activities	Demographic and Health Surveys[a]	https://dhsprogram.com/
	Number of crop varieties grown/sold by household and/or community	World Bank Living Standards and Measurement Study[a]	http://microdata.worldbank.org/index.php/catalog/lsms
Inequality	Gini coefficient	World Bank	https://data.worldbank.org/
	Differences in living standards between key ethnic/racial groups (index)	Ethnic Inequality Index	Alesina et al. (2016)
Poverty/standard of living	GDP per capita	World Bank	https://data.worldbank.org/
	Poverty rate	World Bank	https://data.worldbank.org/
Geographic/spatial	Elevation, slope, aspect	Advanced Spaceborne Thermal Emission and Reflection Radiometer Global Digital Elevation Model[a]	https://asterweb.jpl.nasa.gov/gdem.asp
	Forest cover	Global Forest Change[a]	Hansen et al. (2013); https://earthenginepartners.appspot.com/science-2013-global-forest

Note: All the websites in this table are accessed on 15 March 2019.
[a]These data sources may contain statistically representative information at the subnational level.
[b]Additional education data can be found in many Demographic and Health Surveys, Multiple Indicator Cluster Surveys, and Living Standards and Measurement Study waves.

Table 2. (*Continued.*)

Stressors	Example Indicators	Index or Source	Additional Information
	Soil quality indicators	Harmonized World Soil Database[a]	Fischer et al. (2008); http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/
	Water quality indicators	GEMStat[a]	https://gemstat.org/
Institutional effectiveness	Democratic freedom indexes	Freedom House Index	https://freedomhouse.org/report-types/freedom-world
		Economist Intelligence Unit Democracy Index	https://www.eiu.com/topic/democracy-index
		Unified Democracy Scores	Pemstein et al. (2010); http://www.unified-democracy-scores.org/
		Polity IV	http://www.systemicpeace.org/polityproject.html
	Government responsiveness indexes	World Bank World Governance Indicators	http://info.worldbank.org/governance/wgi/#home
		World Bank Decentralization Indexes	Ivanya and Shah (2012)
Institutional interconnectedness	Globalization index	KOF Index of Globalization	https://www.kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html
	Treaty signatures (for use in composite metric)	United Nations Treaty Collection	https://treaties.un.org/

can have material effects on health and social stability. For instance, after Hurricane Katrina, the lack of law enforcement and effects of displacement resulted in increased rates of gender-based violence (Thornton and Voigt 2007; Anastario et al. 2009). However, in other circumstances, disasters may reduce the likelihood of violence. In the Philippines, typhoons reduced recruiting for rebel groups by disrupting supply lines and organizational hierarchy (Walch 2018).

There are several possible applications of this framework, including hypothesis generation, explanation of observations, and planning and management. One particularly important application, however, is in statistical and mechanistic modeling. Although a fully elaborated example is beyond the scope of this commentary, in Table 2 we present a nonexhaustive list of indicators and data sources that might be used to derive new variables to represent each stressor (i.e., factors located on the inner ring of Figure 1). All the data sources listed in this table provide information at the national level, with some sources also providing representative data at subnational levels.

Discussion

We have developed a synthetic framework linking environmental change with social instability describing potential mechanisms linking distal drivers and proximal triggers that can be used for predictive and explanatory models. Our framework builds on those of others (e.g., Scheffran et al. 2012; Busby et al. 2014) to illustrate in depth the role of health and health systems, arguably underemphasized in earlier literature, and to include not only the sectors that are likely to affect climate and stability relationships, but also the contextual factors and potential interactions among distal drivers and proximal triggers. The framework also suggests mechanistic pathways. Not all environmental and health stressors or shocks result in instability, their effects will vary by context, and in some cases, emphasizing health in models is unlikely to result in material improvement to our understanding of instability, whereas in others, such as in the case of Syria noted above, understanding the role of health is essential.

This work supplements earlier research on climate change and instability that emphasizes different but related concepts in predicting when instability is likely to occur, such as when social or natural system tipping points are reached (Scheffran et al. 2012; Lenton 2013), or in instances where vulnerability is particularly high and adaptation capacity low (Seter 2016). Our framework complements these existing approaches by expanding the scope of the types of contexts and mechanisms likely to result in instability via interactions with population health. As our framework illustrates, addressing climate change, human health, and social instability linkages is inherently complex and requires an understanding of socioeconomic and political metrics and trends that are beyond the expertise of many environmental health practitioners, highlighting the increasing importance of interdisciplinary research to advance the field's goals.

A primary goal in presenting this framework is to provide a pathway for eventually developing a robust predictive model for understanding the contributions of the health systems to climate-related instability that could be used for health policy interventions. One example application is the development of early warning systems; several already exist for aspects of the pathways we discuss. For instance, USAID developed the Famine Early Warning Systems Network (FEWS NET), that provides food insecurity risk assessments for 34 countries, using a combination of climate, economic, governance, and health data (Brown and Brickley 2012). Using historical climate and disease incidence data, health researchers have developed early warning systems for infectious diseases such as malaria (Thomson et al. 2005). The U.S. Department of Defense commissioned the Integrated Crisis Early Warning System (ICEWS) that uses news reports, social media data, and historical conflict information to predict future instability (O'Brien 2010). However, to our knowledge, these systems have not been joined together or used to holistically predict social instability associated with climate change.

An expanded predictive model would incorporate elements from each of these systems and new knowledge into a single tool that can be combined with expert judgement to make regular assessments about the effects of stressors on instability and health risks. These assessments can inform policymakers about the risk of instability when system dynamics shift toward increasing the probability of a shock occurring. In addition to prediction, these elements could be combined into a model designed to explain previous instances of climate-related instability and the role that health and health systems may have played in triggering these situations. Creating the evidence base for such models will require the use of a range of research methods, including different modeling frameworks (systems dynamics, Bayesian hierarchical, agent-based, etc.), regression and geospatial analyses, and qualitative studies. Our framework allows governments to engage in scenario planning or stress testing exercises by examining their strengths and vulnerabilities and mapping out potential pathways to instability based on local conditions (Stern et al. 2013).

We believe that any effective predictive models should be employed in the service of health protection generally. Such models could be used by high-income countries to better prepare for and understand both internal security dynamics as well as the potential spillover impacts of climate-driven instability on their own countries. However, we believe that, appropriately applied, the use of modeling efforts that provide insight into climate-driven instability will be most helpful to individuals and institutions in low- and middle-income settings that are especially vulnerable to the effects of climate change. Being able to predict and assess instability that may occur in such settings can facilitate the development and implementation of interventions to prevent or ameliorate potential conflicts, including through resource transfers to stabilize or expand health system capacity.

Multiple critical unknowns remain concerning climate instability–health relationships, particularly the mechanisms, timing, and magnitudes of these linkages, including, but not limited to, the following:

Developing Causal Pathways and Dose-Response Curves

Frameworks can be used to scope the range of variables and factors included in causal pathways. Once these pathways are elaborated, relationships between variables can be quantified and uncertainties can be assessed, and questions related to model and parametric sources of uncertainty can be considered. Understanding the dose–response relationships affecting climate-sensitive health outcomes remains an ongoing challenge. This challenge is because health outcomes and instability associated with climate change: *a*) are often multicausal and/or nonlinear, *b*) exhibit threshold effects, and *c*) vary depending on local geography, and/or socioeconomic and political structures. Moreover, some hazards, such as sea level rise, lack historical precedent, making prediction of the timing and magnitude of health and instability impacts associated with these hazards, including widespread human migration, very challenging.

Effects of Risk Reduction Steps

Although researchers generally understand that health and related systems (e.g., agriculture, education, housing, etc.) can proactively adapt to climate change and thereby improve population health outcomes (Ebi and Prats 2015), how to quantitatively represent adaptation activities in models linking climate change with health and instability remains unclear. Existing levels of development are likely to reduce exposure to climate-related hazards, reducing the vulnerability of individuals in high-income countries to health impacts associated with climate-related instability. Understanding the effects of adaptation measures on health requires baseline data (such as geocoded locations of health facilities, measures of housing quality, dietary intake, etc.) that are limited or unavailable in many settings.

Effects of Public Policies to Manage Risk

Public policies have the potential to incentivize climate adaptation steps that reduce health risks. However, these effects are contingent on risk being appropriately priced (IPCC 2012). If perverse incentives exist for households exposed to climate-related hazards, then they are less likely to adapt because their risk is being cross-subsidized by policyholders or taxpayers. This circumstance is arguably the case in the United States National Flood Insurance Program, where policies for the highest-risk and most expensive properties are generally underpriced (Kousky 2018). How failure to adapt due to risk mispricing affects population health outcomes, health disparities, and social stability remains an open question.

The framework articulated above serves as a starting point for this research. However, it does not hypothesize which linkages are most important or significant in fostering instability, given heterogeneity in these relationships in different contexts, nor does it purport to be exhaustive, as additional and unknown relationships likely exist that are important but not displayed because their evidence base is currently limited. Moreover, feedbacks—positive and negative—are likely to occur that may improve or worsen outcomes over time. For instance, a deteriorating security environment can worsen the health and socioeconomic indicators that can be predictive of instability or vice versa.

Discussing human health with increased vigor within the climate and security literature is necessary to develop a more holistic understanding than currently exists of the factors that result in social instability. In particular, scholars and practitioners should consider the importance of health conditions and health systems as key mediators among meteorological impacts, institutional capacity, and social instability. Given that climate, health, and instability affect each other in a variety of ways, strengthening the capacity of actors in countries at all levels of development to address relationships linking these three sectors will result in improved human and environmental welfare outcomes.

References

Adams C, Ide T, Barnett J, Detges A. 2018. Sampling bias in climate–conflict research. Nat Clim Change 8:200–203, https://doi.org/10.1038/s41558-018-0068-2.

Adano WR, Dietz T, Witsenburg K, Zaal F. 2012. Climate change, violent conflict and local institutions in Kenya's drylands. J Peace Res 49(1):65–80, https://doi.org/10.1177/0022343311427344.

Adger WN. 2000. Social and ecological resilience: are they related? Prog Hum Geogr 24(3):347–364, https://doi.org/10.1191/030913200701540465.

Alesina A, Michalopoulos S, Papaioannou E. 2016. Ethnic inequality. J Polit Econ 124(2): 428–488, https://doi.org/10.1086/685300.

Almer C, Laurent-Lucchetti J, Oechslin M. 2017. Water scarcity and rioting: disaggregated evidence from Sub-Saharan Africa. J Environ Econ Manag 86:193–209, https://doi.org/10.1016/j.jeem.2017.06.002.

Altizer S, Ostfeld RS, Johnson PTJ, Kutz S, Harvell CD. 2013. Climate change and infectious diseases: from evidence to a predictive framework. Science 341(6145):514–519, PMID: 23908230, https://doi.org/10.1126/science.1239401.

Anastario M, Shehab N, Lawry L. 2009. Increased gender-based violence among women internally displaced in Mississippi 2 years post-Hurricane Katrina. Disaster Med Public Health Prep 3(1):18–26, PMID: 19293740, https://doi.org/10.1097/DMP.0b013e3181979c32.

Bagozzi BE, Koren O, Mukherjee B. 2017. Droughts, land appropriation, and rebel violence in the developing world. J Polit 79(3):1057–1072, https://doi.org/10.1086/691057.

Balbus J, Berry P, Brettle M, Jagnarine-Azan S, Soares A, Ugarte C, et al. 2016. Enhancing the sustainability and climate resiliency of health care facilities: a comparison of initiatives and toolkits. Rev Panam Salud Publica 40(3):174–180, PMID: 27991975.

Barnett J, Adger WN. 2007. Climate change, human security and violent conflict. Polit Geogr 26(6):639–655, https://doi.org/10.1016/j.polgeo.2007.03.003.

Beldomenico PM, Begon M. 2010. Disease spread, susceptibility and infection intensity: vicious circles? Trends Ecol Evol 25(1):21–27, PMID: 19782425, https://doi.org/10.1016/j.tree.2009.06.015.

Bellemare MF. 2015. Rising food prices, food price volatility, and social unrest. Am J Agric Econ 97(1):1–21, https://doi.org/10.1093/ajae/aau038.

Berazneva J, Lee DR. 2013. Explaining the African food riots of 2007–2008: an empirical analysis. Food Policy 39:28–39, https://doi.org/10.1016/j.foodpol.2012.12.007.

Birnbaum LS. 2017. Updating the NIEHS Strategic Plan. Environ Health Perspect 125(7):071001, PMID: 28749368, https://doi.org/10.1289/EHP2502.

Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, de Onis M, et al. 2013. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet 382(9890):427–451, PMID: 23746772, https://doi.org/10.1016/S0140-6736(13)60937-X.

Bowen KJ, Ebi KL. 2015. Governing the health risks of climate change: towards multi-sector responses. Curr Opin Environ Sustain 12:80–85, https://doi.org/10.1016/j.cosust.2014.12.001.

Breetzke GD, Cohn EG. 2011. Seasonal assault and neighborhood deprivation in South Africa: some preliminary findings. Environ Behav 44(5):641–667, https://doi.org/10.1177/0013916510397758.

Briggs DJ. 2008. A framework for integrated environmental health impact assessment of systemic risks. Environ Health 7:61, PMID: 19038020, https://doi.org/10.1186/1476-069X-7-61.

Brown VJ. 2004. Battle scars: global conflicts and environmental health. Environ Health Perspect 112(17):A994, PMID: 15579406, https://doi.org/10.1289/ehp.112-a994.

Brown ME, Brickley EB. 2012. Evaluating the use of remote sensing data in the U.S. Agency for International Development Famine Early Warning Systems Network. J Appl Remote Sens 6(1):063511, https://doi.org/10.1117/1.JRS.6.063511.

Buhaug H. 2015. Climate–conflict research: some reflections on the way forward. WIREs Clim Change 6(3):269–275, https://doi.org/10.1002/wcc.336.

Buhaug H. 2016. Climate change and conflict: taking stock. Peace Econ Peace Sci Public Policy 22(4):331–338, https://doi.org/10.1515/peps-2016-0034.

Buhaug H, Benjaminsen TA, Sjaastad E, Theisen OM. 2015. Climate variability, food production shocks, and violent conflict in Sub-Saharan Africa. Environ Res Lett 10(12):125015, https://doi.org/10.1088/1748-9326/10/12/125015.

Bulkeley H, Andonova L, Bäckstrand K, Betsill M, Compagnon D, Duffy R, et al. 2012. Governing climate change transnationally: assessing the evidence from a database of sixty initiatives. Environ Plann C Gov Policy 30(4):591–612, https://doi.org/10.1068/c11126.

Busby JW, Cook KH, Vizy EK, Smith TG, Bekalo M. 2014. Identifying hot spots of security vulnerability associated with climate change in Africa. Clim Change 124(4):717–731, https://doi.org/10.1007/s10584-014-1142-z.

Cattaneo C, Bosetti V. 2017. Climate-induced international migration and conflicts. CESifo Econ Stud 63(4):500–528, https://doi.org/10.1093/cesifo/ifx010.

Cohn S, Kutalek R. 2016. Historical parallels, Ebola virus disease and cholera: understanding community distrust and social violence with epidemics. PLoS Curr 8: ecurrents.outbreaks.aa1f2b60e8d43939b43fbd93e1a63a94, PMID: 26865987, https://doi.org/10.1371/currents.outbreaks.aa1f2b60e8d43939b43fbd93e1a63a94.

Cook C, Bakker K. 2012. Water security: debating an emerging paradigm. Glob Environ Change 22(1):94–102, https://doi.org/10.1016/j.gloenvcha.2011.10.011.

Davies SE. 2008. Securitizing infectious disease. Int Affairs 84(2):295–313, https://doi.org/10.1111/j.1468-2346.2008.00704.x.

Davies SE, Kamradt-Scott A, Rushton S. 2015. *Disease Diplomacy: International Norms and Global Health Security*. Baltimore, MD: Johns Hopkins University Press.

De Stefano L, Duncan J, Dinar S, Stahl K, Strzepek KM, Wolf AT, et al. 2012. Climate change and the institutional resilience of international river basins. J Peace Res 49(1):193–209, https://doi.org/10.1177/0022343311427416.

Devlin C, Hendrix CS. 2014. Trends and triggers redux: climate change, rainfall, and interstate conflict. Polit Geogr 43:27–39, https://doi.org/10.1016/j.polgeo.2014.07.001.

Diamond J. 2005. *Collapse: How Societies Choose to Fail or Succeed*. New York: Penguin Books.

Dyer G. 2010. *Climate Wars: The Fight for Survival as the World Overheats*. London, UK:Oneworld Publications.

Ebi K. 2011. Climate change and health risks: assessing and responding to them through 'adaptive management'. Health Aff (Millwood) 30(5):924–930, PMID: 21555476, https://doi.org/10.1377/hlthaff.2011.0071.

Ebi KL, Prats EV. 2015. Health in national climate change adaptation planning. Ann Glob Health 81(3):418–426, PMID: 26615077, https://doi.org/10.1016/j.aogh.2015.07.001.

Ericksen PJ, Ingram JSI, Liverman DM. 2009. Food security and global environmental change: emerging challenges. Environ Sci Policy 12(4):373–377, https://doi.org/10.1016/j.envsci.2009.04.007.

Fischer G, Nachtergaele F, Prieler S, van Velthuizen HT, Verelst L, Wiberg D. 2008. *Global Agro-ecological Zones Assessment for Agriculture (GAEZ 2008*). Laxenburg, Austria and Rome, Italy: International Institute for Applied Systems Analysis (IIASA) and the Food and Agriculture Organization of the United Nations (FAO). http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/ [accessed 15 March 2019].

Frumkin H. 2016. *Environmental Health: From Global to Local*. 3rd ed. San Francisco, CA: Jossey-Bass.

Fünfgeld H. 2015. Facilitating local climate change adaptation through transnational municipal networks. Curr Opin Environ Sustain 12:67–73, https://doi.org/10.1016/j.cosust.2014.10.011.

Gee GC, Payne-Sturges DC. 2004. Environmental health disparities: a framework integrating psychosocial and environmental concepts. Environ Health Perspect 112(17):1645–1653, PMID: 15579407, https://doi.org/10.1289/ehp.7074.

Gleick PH. 2014. Water, drought, climate change, and conflict in Syria. Weather Climate Soc 6(3):331–340, https://doi.org/10.1175/WCAS-D-13-00059.1.

Goldstone JA, Bates RH, Epstein DL, Gurr TR, Lustik MB, Marshall MG, et al. 2010. A global model for forecasting political instability. Am J Polit Sci 54(1):190–208, https://doi.org/10.1111/j.1540-5907.2009.00426.x.

Government Office for Science. 2011. *Foresight: Migration and Global Environmental Change Final Project Report*. London, UK: Government Office for Science.

Gray CL, Mueller V. 2012. Natural disasters and population mobility in Bangladesh. Proc Natl Acad Sci U S A 109(16):6000–6005, PMID: 22474361, https://doi.org/10.1073/pnas.1115944109.

Guha-Sapir D, Schlüter B, Rodriguez-Llanes JM, Lillywhite L, Hicks MH-R. 2018. Patterns of civilian and child deaths due to war-related violence in Syria: a comparative analysis from the Violation Documentation Center dataset, 2011–16. Lancet Glob Health 6(1):e103–e110, PMID: 29226821, https://doi.org/10.1016/S2214-109X(17)30469-2.

Hajat S, Vardoulakis S, Heaviside C, Eggen B. 2014. Climate change effects on human health: projections of temperature-related mortality for the UK during the 2020s, 2050s and 2080s. J Epidemiol Community Health 68(7):641–648, PMID: 24493740, https://doi.org/10.1136/jech-2013-202449.

Hallegatte S, Bangalore M, Fay M, Kane T, Narloch U, et al. 2016. *Shock Waves: Managing the Impacts of Climate Change on Poverty*. Washington, DC: World Bank.

Hansen MC, Potapov PV, Moore R, Hancher M, Turubanova SA, Tyukavina A, et al. 2013. High-resolution global maps of 21st-century forest cover change. Science 342(6160):850–853, https://doi.org/10.1126/science.1244693.

Hegre H, Buhaug H, Calvin KV, Nordkvelle J, Waldhoff ST, Gilmore E, et al. 2016. Forecasting civil conflict along the shared socioeconomic pathways. Environ Res Lett 11(5):054002, https://doi.org/10.1088/1748-9326/11/5/054002.

Hendrix CS. 2010. Measuring state capacity: theoretical and empirical implications for the study of civil conflict. J Peace Res 47(3):273–285, https://doi.org/10.1177/0022343310361838.

Hendrix CS, Haggard S. 2015. Global food prices, regime type, and urban unrest in the developing world. J Peace Res 52(2):143–157, https://doi.org/10.1177/0022343314561599.

Hendrix CS, Salehyan I. 2012. Climate change, rainfall, and social conflict in Africa. J Peace Res 49(1):35–50, https://doi.org/10.1177/0022343311426165.

Hsiang SM, Burke M. 2014. Climate, conflict, and social stability: what does the evidence say? Clim Change 123(1):39–55, https://doi.org/10.1007/s10584-013-0868-3.

Huang C, Phillips MR, Zhang Y, Zhang J, Shi Q, Song Z, et al. 2013. Malnutrition in early life and adult mental health: evidence from a natural experiment. Soc Sci Med 97:259–266, PMID: 23313495, https://doi.org/10.1016/j.socscimed.2012.09.051.

Hunter LM, Murray S, Riosmena F. 2013. Rainfall patterns and U.S. migration from rural Mexico. Int Migr Rev 47(4):874–909, PMID: 25473143, https://doi.org/10.1111/imre.12051.

Ide T. 2017. Research methods for exploring the links between climate change and conflict. WIREs Clim Change 8(3):e456, https://doi.org/10.1002/wcc.456.

IPCC (Intergovernmental Panel on Climate Change). 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Field, C. B., V. Barros, T. F. Stocker, D. Qin, D. J. Dokken, K. L. Ebi, M. D. Mastrandrea, K. J. Mach, G.-K. PLattner, S. K. Allen, M. Tignor, and P. M. Midgley, eds. Cambridge, UK: Cambridge University Press.

Ivanyna M, Shah A. 2012. How close is your government to its people? Worldwide indicators on localization and decentralization. World Bank Policy Research working paper 6138. Washington, DC: World Bank.

Johnstone S, Mazo J. 2011. Global warming and the Arab Spring. Survival 53(2):11–17, https://doi.org/10.1080/00396338.2011.571006.

Jones BT, Mattiacci E, Braumoeller BF. 2017. Food scarcity and state vulnerability: unpacking the link between climate variability and violent unrest. J Peace Res 54(3):335–350, https://doi.org/10.1177/0022343316684662.

Kersch A, Mishtal J. 2016. Asylum in crisis: migrant policy, entrapment, and the role of non-governmental organisations in Siracusa, Italy. Refugee Surv Q 35(4):97–121, https://doi.org/10.1093/rsq/hdw017.

Kickbush I, Gleicher D. 2012. Governance for Health in the 21st century. Geneva, Switzerland: World Health Organization.

Kilpatrick AM, Randolph SE. 2012. Drivers, dynamics, and control of emerging vector-borne zoonotic diseases. Lancet 380(9857):1946–1955, PMID: 23200503, https://doi.org/10.1016/S0140-6736(12)61151-9.

Kishore N, Marqués D, Mahmud A, Kiang MV, Rodriguez I, Fuller A, et al. 2018. Mortality in Puerto Rico after Hurricane Maria. N Engl J Med 379(2):162–170, PMID: 29809109, https://doi.org/10.1056/NEJMsa1803972.

Kousky C. 2018. Financing flood losses: a discussion of the National Flood Insurance Program. Risk Manag Insur Rev 21:11–32, https://doi.org/10.1111/rmir.12090.

Lenton TM. 2013. What early warning systems are there for environmental shocks? Environ Sci Policy 27(Suppl 1):S60–S75, https://doi.org/10.1016/j.envsci.2012.06.011.

Letendre K, Fincher CL, Thornhill R. 2010. Does infectious disease cause global variation in the frequency of intrastate armed conflict and civil war? Biol Rev Camb Philos Soc 85(3):669–683, PMID: 20377573, https://doi.org/10.1111/j.1469-185X.2010.00133.x.
Lutz W, Butz WP, KC S (eds.). 2014. *World Population and Human Capital in the Twenty-First Century*. Oxford, UK: Oxford University Press.
Mares D. 2013. Climate change and levels of violence in socially disadvantaged neighborhood groups. J Urban Health 90(4):768–783, PMID: 23435543, https://doi.org/10.1007/s11524-013-9791-1.
Maxmen A. 2018. As Cape Town water crisis deepens, scientists prepare for 'Day Zero'. Nature 554(7690):13–14, PMID: 29388966, https://doi.org/10.1038/d41586-018-01134-x.
McMichael C, Barnett J, McMichael AJ. 2012. An ill wind? Climate change, migration, and health. Environ Health Perspect 120(5):646–654, PMID: 22266739, https://doi.org/10.1289/ehp.1104375.
Mearsheimer JJ. 1994. The false promise of international institutions. Int Secur 19(3):5–49.
Minnesota Population Center. 2018. *Integrated Public Use Microdata Series, International: Version 7.1* [Data set] Minneapolis, MN:IPUMS, https://doi.org/10.18128/D020.V7.1 [accessed 15 March 2019].
Muttarak R, Lutz W. 2014. Is education a key to reducing vulnerability to natural disasters and hence unavoidable climate change? Ecol Soc 19(1):42, https://doi.org/10.5751/ES-06476-190142.
Nardulli PF, Peyton B, Bajjalieh J. 2015. Climate change and civil unrest: the impact of rapid-onset disasters. J Confl Resolut 59(2):310–335, https://doi.org/10.1177/0022002713503809.
O'Brien K. 2006. Are we missing the point? Global environmental change as an issue of human security. Glob Environ Change 16(1):1–3, https://doi.org/10.1016/j.gloenvcha.2005.11.002.
O'Brien SP. 2010. Crisis early warning and decision support: Contemporary approaches and thoughts on future research. Int Stud Rev 12:87–104, https://doi.org/10.1111/j.1468-2486.2009.00914.x.
O'Sullivan TM. 2015. Environmental security is homeland security: climate disruption as the ultimate disaster risk multiplier. Risk Hazards Crisis Public Policy 6(2):183–222, https://doi.org/10.1002/rhc3.12084.
Østby G. 2008. Polarization, horizontal inequalities and violent civil conflict. J Peace Res 45(2):143–162, https://doi.org/10.1177/0022343307087169.
Pemstein D, Meserve SA, Melton J. 2010. Democratic compromise: A latent variable analysis of ten measures of regime type. Political Analysis 18(4):426–449.
Peterson S. 2002. Epidemic disease and national security. Secur Stud 12(2):43–81, https://doi.org/10.1080/0963-640291906799.
Raleigh C, Choi HJ, Kniveton D. 2015. The devil is in the details: an investigation of the relationships between conflict, food price and climate across Africa. Glob Environ Change 32:187–199, PMID: 28149004, https://doi.org/10.1016/j.gloenvcha.2015.03.005.
Reuveny R. 2007. Climate change-induced migration and violent conflict. Polit Geogr 26(6):656–673, https://doi.org/10.1016/j.polgeo.2007.05.001.
Rosenzweig C, Elliott J, Deryng D, Ruane AC, Müller C, Arneth A, et al. 2014. Assessing agricultural risks of climate change in the 21st century in a global gridded crop model intercomparison. Proc Natl Acad Sci USA 111(9):3268, PMID: 24344314, https://doi.org/10.1073/pnas.1222463110.
Roth GA, Abate D, Abate KH, Abay SM, Abbafati C, Abbasi N, et al. 2018. Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980–2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet 392(10159):1736–1788, PMID: 30496103, https://doi.org/10.1016/S0140-6736(18)32203-7.
Salehyan I. 2014. Climate change and conflict: making sense of disparate findings. Polit Geogr 43:1–5, https://doi.org/10.1016/j.polgeo.2014.10.004.
Scheffran J, Brzoska M, Kominek J, Link PM, Schilling J. 2012. Climate change and violent conflict. Science 336(6083):869–871, PMID: 22605765, https://doi.org/10.1126/science.1221339.
Schilling J, Opiyo FE, Scheffran J. 2012. Raiding pastoral livelihoods: motives and effects of violent conflict in north-western Kenya. Pastor Res Policy Pract 2(1):25, https://doi.org/10.1186/2041-7136-2-25.
Schleussner C-F, Donges JF, Donner RV, Schellnhuber HJ. 2016. Armed-conflict risks enhanced by climate-related disasters in ethnically fractionalized countries. Proc Natl Acad Sci USA 113(33):9216–9221, PMID: 27457927, https://doi.org/10.1073/pnas.1601611113.
Sellers S, Ebi KL. 2018. Climate change and health under the Shared Socioeconomic Pathway Framework. Int J Environ Res Public Health 15(1):3, PMID: 29267204, https://doi.org/10.3390/ijerph15010003.
Seltenrich N. 2018. Down to earth: the emerging field of planetary health. Environ Health Perspect 126(7):072001, PMID: 30007903, https://doi.org/10.1289/EHP2374.
Seter H. 2016. Connecting climate variability and conflict: Implications for empirical testing. Polit Geogr 53:1–9, https://doi.org/10.1016/j.polgeo.2016.01.002.
Smith TG. 2014. Feeding unrest: disentangling the causal relationship between food price shocks and sociopolitical conflict in urban Africa. J Peace Res 51(6):679–695, https://doi.org/10.1177/0022343314543722.
Smith KR, Woodward A, Campbell-Lendrum D, Chadee DD, Honda Y, Liu Q, et al. 2014. Human health: impacts, adaptation, and co-benefits. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel of Climate Change*. Field CB, Barros VR, Dokken DJ, et al., eds. Cambridge, UK:Cambridge University Press, 709–754.
Stern PC, Ebi KL, Leichenko R, Olson RS, Steinbruner JD, Lempert R, et al. 2013. Managing risk with climate vulnerability science. Nature Clim Change 3(7):607–609, https://doi.org/10.1038/nclimate1929.
Taydas Z, Peksen D. 2012. Can states buy peace? Social welfare spending and civil conflicts. J Peace Res 49(2):273–287, https://doi.org/10.1177/0022343311431286.
Thomson M, Mason S, Phindela T, Connor S. 2005. Use of rainfall and sea surface temperature monitoring for malaria early warning in Botswana. Am J Trop Med Hyg 73(1):214–221, PMID: 16014862.
Thornton WE, Voigt L. 2007. Disaster rape: vulnerability of women to sexual assaults during Hurricane Katrina. J Public Manag Soc Policy 13(2):23–49.
Urdal H. 2006. A clash of generations? Youth bulges and political violence. Int Studies Q 50(3):607–629, https://doi.org/10.1111/j.1468-2478.2006.00416.x.
van Baalen S, Mobjörk M. 2017. Climate change and violent conflict in East Africa: integrating qualitative and quantitative research to probe the mechanisms. Int Stud Rev 20(4):547–575, https://doi.org/10.1093/isr/vix043.
Van der Land V, Hummel D. 2013. Vulnerability and the role of education in environmentally induced migration in Mali and Senegal. Ecol Soc 18(4):14, https://doi.org/10.5751/ES-05830-180414.
van Loenen T, van den Muijsenbergh M, Hofmeester M, Dowrick C, van Ginneken N, Mechili EA, et al. 2018. Primary care for refugees and newly arrived migrants in Europe: a qualitative study on health needs, barriers and wishes. Eur J Public Health 28(1):82–87, PMID: 29240907, https://doi.org/10.1093/eurpub/ckx210.
Verhoeven H. 2011. Climate change, conflict and development in Sudan: global neo-Malthusian narratives and local power struggles. Dev Change 42(3):679–707, PMID: 22069801, https://doi.org/10.1111/j.1467-7660.2011.01707.x.
Victora CG, Adair L, Fall C, Hallal PC, Martorell R, Richter L, et al. 2008. Maternal and child undernutrition: consequences for adult health and human capital. Lancet 371(9609):340–357, PMID: 18206223, https://doi.org/10.1016/S0140-6736(07)61692-4.
Wagner Z, Heft-Neal S, Bhutta ZA, Black RE, Burke M, Bendavid E, et al. 2018. Armed conflict and child mortality in Africa: a geospatial analysis. Lancet 392(10150):857–865, PMID: 30173907, https://doi.org/10.1016/S0140-6736(18)31437-5.
Walch C. 2018. Weakened by the storm: rebel group recruitment in the wake of natural disasters in the Philippines. J Peace Res 55(3):336–350, https://doi.org/10.1177/0022343317741535.
Wallace D. 2018. Introduction: Security and Global Climate Change. In: *Climate Change, Policy and Security: State and Human Impacts*. New York, NY: Routledge, 1–40.
Weber H. 2013. Demography and democracy: the impact of youth cohort size on democratic stability in the world. Democratization 20(2):335–357, https://doi.org/10.1080/13510347.2011.650916.
Welzer H. 2012. *Climate Wars: What People will be Killed for in the 21st Century*. Cambridge, UK: Polity Press.
Werrell C, Femia F. 2017. *Epicenters of Climate and Security: The New Geostrategic Landscape of the Anthropocene*. Washington, DC:The Center for Climate and Security.
Whitmee S, Haines A, Beyrer C, Boltz F, Capon AG, de Souza Dias BF, et al. 2015. Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. Lancet 386(10007):1973–2028, PMID: 26188744, https://doi.org/10.1016/S0140-6736(15)60901-1.
Wischnath G, Buhaug H. 2014. Rice or riots: on food production and conflict severity across India. Polit Geogr 43:6–15, https://doi.org/10.1016/j.polgeo.2014.07.004.
Witmer FD, Linke AM, O'Loughlin J, Gettelman A, Laing A. 2017. Subnational violent conflict forecasts for sub-Saharan Africa, 2015–65, using climate-sensitive models. J Peace Res 54(2):175–192, https://doi.org/10.1177/0022343316682064.
Zhu C, Kobayashi K, Loladze I, Zhu J, Jiang Q, Xu X, et al. 2018. Carbon dioxide (CO_2) levels this century will alter the protein, micronutrients, and vitamin content of rice grains with potential health consequences for the poorest rice-dependent countries. Sci Adv 4(5):eaaq1012, PMID: 29806023, https://doi.org/10.1126/sciadv.aaq1012.