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# Climate Change and Collective Violence

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## Abstract

Climate change is causing increases in temperature, changes in precipitation and extreme weather events, sea-level rise, and other environmental impacts. It is also causing or contributing to heat-related disorders, respiratory and allergic disorders, infectious diseases, malnutrition due to food insecurity, and mental health disorders. In addition, increasing evidence indicates that climate change is causally associated with collective violence, generally in combination with other causal factors. Increased temperatures and extremes of precipitation with their associated consequences, including resultant scarcity of cropland and other key environmental resources, are major pathways by which climate change leads to collective violence. Public health professionals can help prevent collective violence due to climate change (*a*) by supporting mitigation measures to reduce greenhouse gas emissions, (*b*) by promoting adaptation measures to address the consequences of climate change and to improve community resilience, and (*c*) by addressing underlying risk factors for collective violence, such as poverty and socioeconomic disparities.

### Keywords

climate change; public health; collective violence; war; armed conflict

## INTRODUCTION

Climate change—or, perhaps more accurately, global climate disruption—is profoundly affecting life on earth in many interrelated ways. The health and environmental risks posed by climate change are interlinked with conditions of poverty and socioeconomic inequalities, with population growth and migration, with emerging diseases and hazardous chemicals, and with ecosystem damage and biodiversity loss. This article focuses on the increasing



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body of evidence concerning the relationships between aspects of climate change and collective violence. It also explores what public health professionals can do to expand the knowledge base concerning these relationships and what can be done to prevent collective violence caused, or contributed to, by climate change.

# CONSEQUENCES OF CLIMATE CHANGE

Global climate change results in major environmental and health consequences.

## Environmental Consequences

The Intergovernmental Panel on Climate Change (IPCC) has assessed the likelihood that various environmental phenomena have occurred as a result of climate change and the likelihood that humans have contributed to these observed changes (Table 1). The IPCC has projected that warmer and/or more frequent hot days and nights over most land areas are likely in the early part of this century and will be virtually certain in the late part of this century (Table 2) (29). Using computer models based on varying climate scenarios, the IPCC has projected ranges of likely global mean temperature increase by 2081–2100 (as compared with 1986–2005) that vary from 0.3–1.7°C to 2.6–4.8°C (30).

The IPCC has projected that heavy precipitation events (*a*) will likely increase in frequency, intensity, and/or amount of heavy precipitation over many land areas in the early part of this century and (*b*) will likely increase over most of the midlatitude land masses and wet tropical regions in the late part of this century (Table 2) (29). Heavy precipitation events are often accompanied by coastal storm surges and flooding. The IPCC has stated that it is “virtually certain” that increases in intense tropical cyclone activity have occurred in the North Atlantic since 1970 and “more likely than not” will also occur in the western North Pacific in the late part of this century (29) (Table 2). (Hurricanes, cyclones, and typhoons are different names for the same weather phenomenon occurring in different places.)

The magnitude and severity of the environmental consequences of climate change need to be considered in the context of human activity, such as poor land-use policies that can exacerbate the environmental consequences of both natural and human-made disasters. For example, human destruction of the natural wetlands buffer zone contributed to the consequences of Hurricane Katrina in New Orleans in 2005, and large-scale deforestation contributed to major mudslides during Hurricane Mitch in Honduras in 1998.

## Health Consequences

Adverse health consequences associated with climate change can be categorized as (*a*) direct health effects, including heat-related disorders, respiratory and allergic disorders, infectious diseases, and injuries from extreme weather events; (*b*) indirect health effects from food insecurity, forced migration, and collective violence; and (*c*) mental health disorders affecting individuals, communities, and entire nations (34).

**Direct health effects.—**Heat-related consequences include heat-related disorders, such as heat exhaustion, heat stroke, and dehydration, as well as complications of chronic diseases, such as chronic obstructive pulmonary disease, coronary artery disease, and diabetes mellitus. Each year in the United States there are, on average, more than 600 deaths that are clinically reported as associated with excessive exposure to natural heat, although the actual number may be much greater because deaths from heat-related disorders are often not reported unless a heat wave is occurring (10). Groups that are at high risk for morbidity or mortality during heat waves include older people who live alone, people who reside in public housing and/or without air conditioning, and outdoor workers.

As a result of climate change, respiratory and allergic disorders will increase, owing primarily to higher concentrations of ozone (largely due to vehicular exhaust and warm ambient temperatures), smoke from wildfires, increased production of pollen and longer pollen seasons, and increased exposure to mold (as a result of residential water damage from flooding). In addition, infectious diseases resulting from climate change include vector-borne disease (as a result of wider distribution of disease-carrying vectors and longer transmission seasons), waterborne disease (largely due to sewage contamination of water supplies as a result of floods and to scarcity of water during severe droughts, leading to the use of unsafe water sources), and foodborne disease (because higher temperatures increase growth and persistence of pathogens and because of food contamination from contaminated water).

**Indirect health effects.—**Indirect health consequences resulting from climate change will affect primarily people in middle-income and low-income countries. Impacts include (*a*) malnutrition due to food shortages and resultant higher food prices, which will likely occur as a result of increasing temperatures and precipitation extremes, leading to droughts and floods; (*b*) health consequences due to forced migration because individuals and entire communities will likely be displaced, within their own countries or to other countries, owing to cropland damage, sea-level rise, and food and water shortages; and (*c*) collective violence, as described below, partially due to political, economic, and social instability arising from food insecurity, forced displacement, and other crises (37).

The global consequences of climate change, as described above, are generally consistent with the scientific assessment by the US Global Change Research Program concerning the impacts of climate change on human health in the United States (13). The executive summary of its 2016 report states,

> Climate change is a significant threat to the health of the American people. The impacts of human-induced climate change are increasing nationwide. Rising greenhouse gas concentrations result in increases in temperature, changes in precipitation, increases in the frequency and intensity of some extreme weather events, and rising sea levels. These climate change impacts endanger our health by affecting our food and water sources, the air we breathe, the weather we experience, and our interactions with the built and natural environments. As the climate continues to change, the risks to human health continue to grow. (13, p. 2)

## Impact of Climate Change on Human Rights and Social Justice

Climate change has profound consequences for human rights and social justice (35). Large inequalities exist among countries in regard to their levels of greenhouse gas (GHG) emissions as well as the magnitude and severity of adverse consequences due to climate change. Countries that contribute the least to GHG emissions will likely continue to experience the greatest consequences due to climate change (21, 54, 71). The greatest impact of climate change will occur in poor countries.

If carbon dioxide concentrations and rapid climate change continue on a business-as-usual path, the economies of poor countries will likely be seriously impaired; the mean annual growth rate of these countries will likely decrease from 3.2% to 2.6% by 2100 (44). Poor countries will probably suffer economically from climate change much more than rich countries for the following reasons: (*a*) They are more often exposed to very high temperatures; (*b*) they heavily rely on agriculture, extraction of natural resources, and other industrial sectors that are vulnerable to extreme weather variability; and (*c*) various approaches to risk management, ranging from air conditioning to insurance, are less available in poor countries than in rich countries (44).

A variety of socioeconomic, demographic, health-related, geographic, and other risk factors make populations and subgroups within populations more vulnerable to the health consequences of climate change. These risk factors include poverty, female gender, minority status, young or old age, and various diseases and disabilities. In addition, health consequences resulting from climate change will likely continue to be concentrated in low-income populations residing at low latitudes, where major climate-sensitive disorders, such as malaria, diarrheal disease, and malnutrition, are highly prevalent and where vulnerability to these disorders is the greatest (41).

Measures designed to mitigate climate change and its adverse effects can have unintended consequences that adversely affect social justice and environmental justice. For example, US agricultural policy that has supported biofuel production to promote sustainable energy and energy independence has contributed to the volatility of grain-crop prices, has impacted commodity prices of food grains (such as by linking corn to ethanol prices), and has been linked to food price shocks, which have aggravated food insecurity, especially for poor people (63).

In addition, workers in many occupations are at an increased risk for the health consequences of climate change. Those at risk include (*a*) outdoor workers who perform tasks in extreme heat; (*b*) other workers who are exposed to extremes of temperature or precipitation; (*c*) workers exposed to air pollutants, infectious agents, wildfires, and/or extreme weather events; and (*d*) workers in specific industries, such as utilities, transportation, health care, emergency response, environmental remediation, construction and demolition, landscaping, agriculture, forestry, and wildlife management (56).

## OVERVIEW OF COLLECTIVE VIOLENCE GLOBALLY

Violence has been defined as “the intentional use of physical force or power, threatened or actual, against oneself, another person, or against a group or community that either results in or has a high likelihood of resulting in injury, death, psychological harm, maldevelopment or deprivation” (70). Violence includes self-inflicted violence, interpersonal violence, and collective violence. Collective violence, which includes armed conflict, state-sponsored violence (such as torture and genocide), and organized violent crime (such as gang warfare), has been defined as “the instrumental use of violence by people who identify themselves as members of a group…against another group or set of individuals, in order to achieve political, economic or social objectives” (32, p. 215). Collective violence causes much morbidity and mortality directly (such as by gunfire and explosive devices) and indirectly by (*a*) damage to the health-supporting infrastructure of society (supplies of safe food and water, medical care and public health services, transportation, communication, and power generation and supply); (*b*) forced displacement of individuals and communities (creating both refugees and internally displaced persons); (*c*) damage to the physical environment; (*d*) diversion of human and financial resources; and (*e*) additional violence (36, 61). Although the definition of collective violence applies globally, collective violence and its consequences are manifested differently in different regions and different countries. For example, from 2004 to 2013, state-based conflict occurred mainly in Africa and “Asia and Oceania,” and nonstate conflict occurred mainly in Africa (62). As another example, of the 21.3 million refugees worldwide, 41% have come from just 3 war-torn countries: Syria (4.9 million), Afghanistan (2.7 million), and Somalia (1.1 million); and just 6 countries host 7.6 million refugees: Turkey (2.5 million), Pakistan (1.6 million), Lebanon (1.1 million), Iran (979,400), Ethiopia (736,100), and Jordan (664,100) (68).

## REVIEW OF RESEARCH ON THE ASSOCIATION BETWEEN CLIMATE CHANGE AND COLLECTIVE VIOLENCE

### Historical Studies

In three studies based on data stretching back 1,000 years, Zhang and colleagues demonstrated the following concerning the relationship between climate change and violence. First, in the preindustrial era in the northern hemisphere, climate change was the major underlying cause of armed conflict and other major humanitarian crises. The authors demonstrated that decreasing temperatures led sequentially to lower agricultural production, price inflation, war, famine, and population decline. They also demonstrated that contemporaneous social mechanisms failed to prevent these crises (73). Second, in Europe between 1560 and 1660, lower temperatures were the underlying cause of agroecological, socioeconomic, and demographic catastrophes (74). Finally, the frequency of warfare over the past 1,000 years in Eastern China was significantly associated with temperature oscillations, especially in periods of lower temperatures, when there was lower agricultural production (75).

In a study in Europe on the association of both temperature and precipitation with violent conflict during the past 1,000 years, Tol & Wagner (66) concluded that when temperatures were lower, conflict was more intense. [Notably, they demonstrated that this association was weaker during the industrial era (since 1750).] They concluded that their results do not provide “a clear-cut picture” (p. 77). They predicted that global warming would not likely lead to increased violent conflict in temperate climates (66).

## Studies in the Modern Era

**Influence of temperature on violence.—**Studying conflict in the tropics from 1950 to 2004, Hsiang and colleagues demonstrated that the likelihood of new civil conflicts increased from 3% to 6% during years of the El Niño Southern Oscillation (ENSO), when much of the land area in the continental tropics becomes considerably warmer and drier, as compared with La Niña years. They also found that, in more temperate latitudes, the impact of ENSO was usually less extreme. They concluded that, since 1950, ENSO may "have had a role" in the development of 21% of civil conflicts (28, p. 438).

Studying conflict in sub-Saharan Africa between 1981 and 2002, Burke and colleagues found a significant association between warmer temperature and civil war. On the basis of their findings, they projected an approximately 54% increase in armed conflict in Africa by 2030, with an additional 393,000 battle-related deaths, assuming wars in the future are as deadly as recent wars (8). In critiquing this study, Buhaug (7) asserted that, during the previous 30 years, while temperature increased in most of Africa, the incidence of civil war decreased and the estimated annual number of conflict fatalities for the average civil war in sub-Saharan Africa decreased, from approximately 6,100 to 1,600. He also argued that the association claimed by Burke and colleagues disappeared completely when their initial analysis was broadened to include a more recent time period (7). In response to criticisms by Buhaug and others, Burke and colleagues (9) revised the model they used for their study and developed further results, which confirmed that variations in the occurrence of large wars in the 1980s and 1990s in sub-Saharan Africa could be explained, in part, by temperature change. Burke and colleagues acknowledged that their results do not hold for the 2003–2008 period; they believe that international peacekeeping, economic development, and better domestic governance may have mitigated these effects (9).

Studying violence in East Africa between 1990 and 2009, O'Loughlin and colleagues (51) found that substantially warmer than normal temperatures significantly increased the risk of violence. However, when they compared these data with political, economic, and physical geographic predictors, they concluded that warmer temperatures were a relatively modest predictor of violence. They also found major variations in the association between climate and conflict among the countries studied and across time periods (51).

Studying conflict in Somalia between 1997 and 2009, Maystadt and colleagues (40) demonstrated that drought led to decreases in the price of livestock, which fueled conflict. On the basis of their findings, they projected that if by 2100 the average temperature in eastern Africa increased by ~3.2°C (5.8°F) (the median IPCC scenario for this region by 2100), then cattle prices would decrease about 4% and violent conflict would increase by ~58%. They concluded that climate change will worsen security challenges in Somalia and require effective measures to strengthen resilience to drought and conflict, especially in pastoralist communities (40).

O'Loughlin and colleagues (50) performed research on temperature and precipitation variability and the impact of these variables on the probability of violence from 1980 to 2012 in sub-Saharan Africa. They found that temperature was significantly associated with violence, but there were inconsistencies in the association between temperature extremes and occurrence of conflict. In addition, they found that location and time of violence were less influenced by temperature and precipitation variability than they were by economic, political, and geographic factors (50).

Bollfrass & Shaver (5), conducting an analysis based on a subnational-level data set, demonstrated that temperature is significantly associated with the occurrence of conflict in both agricultural and nonagricultural sample provinces throughout the world. They determined that a rise in mean annual temperature of 11.1°C (20°F) is associated with an approximately 2% rise in the probability of deadly conflict. They also found that decreased farm output due to increased temperature is not likely to explain the entire rise in substate violence (5).

Hot temperatures have been associated with forms of violence other than collective violence. For example, Nitschke and colleagues (49) found that, during heat waves, there was a 13% significant increase in assault-related injuries among people 15–64 years of age. Li and colleagues (39) found an association of borderline significance with intentional self-harm (suicide and attempted suicide), with a threshold at 27.2°C (81°F). Page and colleagues (53) found that, for each 1°C increase in mean temperature above a threshold of 18°C (64.4°F), there was a 3.8% significant increase in suicide.

Despite evidence of a temperature threshold for suicide or attempted suicide specific to these two studies, we believe that it is unlikely that a universal temperature threshold will be found for collective violence, given that collective violence is generally caused by multiple factors that vary among episodes of collective violence.

**Influence of rainfall on violence.—**Some research has demonstrated that a significant decrease in rainfall, associated with drought, leads to increased conflict. Levy and others (38) discovered that, when there was a significant decrease in rainfall, the probability of high-intensity internal war beginning in the next year was significantly increased. However, they did not find a significant association between deviations in rainfall and low-intensity internal war. In sub-Saharan Africa between 1990 and 2008, Fjelde & von Uexkull (16) found that major deviations in rainfall as compared with historic norms were associated with an increased probability of communal conflict. They also found that the impact of decreased rainfall on the probability of communal conflict is increased in areas where members of ethnic and political groups who have been politically excluded reside. In Africa between 1997 and 2011, Harari & La Ferrara (22) found that, during the growing seasons of main crops, adverse climate shocks were associated with a substantial and persistent impact on the incidence of conflict at the subnational level, especially violence against civilians. They projected that, under "a midrange emissions scenario," severe climate shocks in growing seasons would more than double during the next two decades, resulting in a 7% increase in the incidence of conflict (p. 34). Finally, Opiyo and colleagues (52), who studied violent conflicts in drought-prone pastoral areas in Kenya, found that while violent conflicts are caused by a complex interaction of political, economic, and sociocultural factors, frequent droughts aggravated competition for scarce natural resources and led to the development of violent conflicts in the study areas.

Drought due, in part, to climate change has been associated with sudden increases in food prices (food price shocks), which have resulted in violence in the form of food riots (see sidebar, Climate Change Contributes to Food Price Shocks and Their Violent Consequences). Drought resulting, in part, from climate change also contributed to causing the civil war in Syria (see sidebar, Climate Change Contributed to the Civil War in Syria).

Climate change is widely accepted as being a risk multiplier. In this context, decreases in rainfall due to climate change will worsen existing shortages of freshwater, most particularly in countries in the Middle East, North Africa, and South Asia, where in many locations severe water shortages and droughts already exist. In general, water shortages have been shown to increase conflict. For example, Gleick (20), who has accumulated data on interstate and intrastate conflicts over water for several decades, found that these conflicts have been increasing substantially; there were 38 water-related conflicts throughout the world between 1960 and 1989 (on average, 1.3 per year) and 83 such conflicts between 1990 and 2007 (on average, 4.6 per year).

However, some research has failed to find an association between decreased rainfall (and/or drought) and the development of conflict. In Afghanistan between 1960 and 2004, Theisen and colleagues (65) failed to find any association between drought and civil war; they concluded that the primary causes of intrastate conflict were political in nature. Adano and colleagues (1), after studying violent conflicts in pastoral areas in Kenya, concluded that climate change is not a primary causative factor of conflict there. In the Sahel in West Africa, Benjaminsen and colleagues (3) found that factors that were not directly related to resource scarcity and the environment, such as corruption within government, were the most likely explanations for violent conflict there. Lastly, after reviewing data concerning climate and civil war in Africa, Buhaug (6) concluded that variability of climate poorly predicts armed conflict and that, in Africa, civil war is attributable mainly to poor national economies and the exclusion of ethnic and political groups. He acknowledged, however, that much research is based on national data that may mask subnational data on rainfall and conflict.

Although many studies have found that decreased rainfall, with associated drought, is associated with violence, some studies have demonstrated that increased rainfall can also be associated with violence. Globally between 1979 and 2006, Salehyan & Hendrix (57) found that an abundance of water was associated with political violence. They asserted that political violence occurs more often when basic needs of populations are met and when "the tactical environment is more conducive to attacks—conditions that hold when water is more abundant." In 47 countries in sub-Saharan Africa between 1991 and 2007, these same authors demonstrated that rainfall was associated with insurgency and civil war. They also found that extreme deviations in rainfall (especially abundant rainfall) were strongly associated with violence. More broadly, they found a strong association between environmental shocks and unrest (23). Finally, in Kenya between 1989 and 2004, Theisen (64) found that wetter years were associated with large-scale violence. He stated that this finding was most likely due to large-scale violence not being feasible in periods when there is extreme scarcity, reasoning that reconciliation, cooperation, and peace are goals in pastoralist communities in the presence of drought. In addition, he also found that election years were associated with violence and that major intergroup violence between groups is influenced primarily by "calculation and political gain" as opposed to competition over scarce land and water resources (64, p. 81).

## Meta-Analyses

Two meta-analyses, each based on numerous studies, provide robust evidence of a causal association between climate change and collective violence.

Hsiang and colleagues (27) performed a meta-analysis based on 60 longitudinal studies, 30 of which focused on intergroup conflict, 15 of which focused on interpersonal conflict, and 15 of which focused on institutional breakdown and population collapse. Of the 30 studies on intergroup conflict, 7 were global, 11 focused on part or all of sub-Saharan Africa, 3 on Europe, 3 on China, and 6 on other geographic locations. Of these 30 studies, 23 used years as time units, 4 used decades, 2 used months, and 1 used centuries. The authors concluded that deviations from mild temperatures and normal precipitation significantly increased conflict risk, most notably in poorer populations. On the basis of their findings, they estimated that each standard deviation of greater rainfall or warmer temperatures increased intergroup conflict by 14% and, in some geographic locations, by more than 50%. They projected that, with increasing temperatures, there would likely be substantial increases in conflict (27). Some observers criticized this meta-analysis, stating that it suffers from selection bias and conflates weather with climate (4). (Weather is defined[1] as "the state of the air and atmosphere at a particular time and place…with respect to heat or cold, wetness or dryness, calm or storm, clearness or cloudiness." In contrast, climate is defined2 as "the weather conditions prevailing in an area in general over a long period." Climate scientists frequently use a period of 30 years to distinguish between climate and weather.)

In another meta-analysis, Hsiang & Burke (26) examined 50 quantitative research studies regarding the association between climate variables and both violent conflict and sociopolitical instability. They included quantitative research studies that employed the most robust experimental or quasi-experimental designs, limiting their focus to investigations that met "modern standards for measuring causal effects" (p. 43). On the basis of their criteria for including studies in this meta-analysis, they believed that independent climate variables were not likely correlated with other variables that were not observed that might have influenced the conflict variable. They found "strong linkages between climate anomalies and conflict and social instability" (p. 52). Specifically, they demonstrated that in most studies, when temperature is high and precipitation is extremely high or extremely low, both conflict and sociopolitical instability increase. However, they also found that, when average temperature is temperate, anomalously low temperature may decrease social stability. They concluded that "climate's influence on security persists in both historical and modern periods, is generalizable to populations around the globe, arises from climatic events that are both rapid and gradual, and influences numerous types of conflict that range across all spatial scales" (26, p. 52).

[1]http://www.merriam-webster.com/dictionary/weather.
[2]http://www.oxforddictionaries.com/us/definition/american_english/climate

## Influence of Sea-Level Rise on Violence

By 2100, sea level is likely to rise 0.5 to 1.4 m (~20–55 inches) above the 1990 level (55). A recent study suggests that sea-level rise by 2100 could be as much as 1.83 m (6 feet), given that Antarctica could contribute more than 1 m (3.3 feet) of sea-level rise by then (14). People living in coastal areas, where ~20% of people worldwide live, and those residing in small-island nations will suffer the greatest impact of sea-level rise. Some island nations may totally disappear and some coastal areas may become uninhabitable, which may force many people to become internally displaced within their own countries or refugees in neighboring countries or elsewhere. In addition to displacing people from their homes and communities, sea-level rise will damage cropland, create saltwater incursion into river deltas and groundwater aquifers, and cause shortages of food and freshwater. As a result, there will likely be major political, economic, and social disruptions, sometimes associated with violence, as people compete for control of land and other resources.

Millions of climate refugees will be forced to flee their homes and communities because of the consequences of climate change. In 2009, the head of UNHCR: The UN Refugee Agency stated that in 2008 more than 20 million people had been forcibly displaced—in most cases, temporarily—due to factors related to climate change, mostly due to storms and floods (17). An estimated 50–250 million people may be forced to leave their homes and communities by 2050. An estimated 162 million people are now at risk of being forcibly displaced because of sea-level rise: in China, 73 million; in Bangladesh, 26 million; in India, 20 million; in Egypt, 12 million; and in low-lying small-island nations, 31 million. In addition, at least 50 million people could be at high risk of displacement because of drought and other consequences of climate change (46, 47, 69). Whereas migration due to short-term severe climate events is generally temporary and usually occurs over short distances within countries, migration due to drought, sea-level rise, and other long-term impacts of climate change is very likely to be permanent; these migrants are not likely to return to their homes and communities (2, 42).

## Summary and Implications of Research Findings

The weight of research evidence demonstrates that climate change, especially as manifest by increases in temperature and extremes of precipitation, is often causally associated with collective violence. This research has been performed by many different investigators in many geographic locations over varying periods of time.

Although climate change is often found to be causally associated with collective violence, it is only one of several major causative factors. Other major causes of collective violence include socioeconomic and political instability, disputes over political power and land ownership, poverty and socioeconomic disparities, high unemployment, authoritarian governments, violation of human rights and other manifestations of social injustice, and ethnic hatred (36).

Community resilience can serve to buffer the consequences of climate change by enabling a community to accommodate or adjust to these consequences or recover from them. Community resilience includes (*a*) the functionality of the built environment after an event (physical resilience); (*b*) the physical and psychological health of people (individual resilience); and (*c*) the governance structure, networks of trust and communication, flexibility, and redundancy of the community (organizational resilience) (18, 45). Evidence from the aftermath of natural disasters suggests that social cohesion in a community before a disaster (a component of community resilience) may help to prevent or minimize some postdisaster consequences, such as post-traumatic stress disorder (24).

Owing to multiple interconnected and cross-sectoral pathways, the cumulative impact of climate change is much greater than the sum of its impacts on health, agriculture, air quality, water supply, housing, and other societal sectors. In addition, because climate change is a risk multiplier, it increases the risk of collective violence due to already-existing causative factors. Therefore, the role of climate change in causing or contributing to collective violence is greatest in places that are already at high risk of collective violence. For example, within low-income countries, climate change often exacerbates socioeconomic disparities, making the poor poorer and those who are vulnerable more vulnerable. This effect is best illustrated in low-income countries where many people support themselves and their families with subsistence agriculture. As climate change damages cropland and adversely affects livestock production (owing to increased temperatures, droughts, floods, and sea-level rise), farmers suffer from reduced access to food, lost income, and food-price shocks, and they often migrate to urban areas, thereby creating social and political instability and increasing the risk of violence (see sidebar, Climate Change Contributed to the Civil War in Syria).

Although the consequences of climate change and the onset of collective violence cannot be predicted with precision, we believe that in many instances the probability of collective violence induced by climate change can be determined. We believe that a probability index could be developed and used to predict collective violence induced by climate change and thereby to implement interventions to minimize the impact of climate change and prevent the onset of collective violence.

Because climate change contributes to the development of collective violence, it represents a security threat to the United States and other nations—a threat that has long been recognized by the US military. For example, in 2007, several former leading American military officers termed climate change a “threat multiplier for instability” (11, 12). The severity and widespread nature of this threat heighten the urgency of mitigating climate change and implementing effective adaptation measures to address climate change. In addition, the causative association between climate change and collective violence focuses additional attention on the critically important need to understand and reduce the underlying causes of collective violence.

## Future Research Needs and Challenges

Much further research needs to be done (*a*) to clarify and understand the causative association between climate change and collective violence, including the pathways or mechanisms by which various components of climate change cause violence to occur (26), and (*b*) to assess the effectiveness of various approaches to prevent climate change from causing violence. Research needs to be done to better understand the complex interaction of factors that turn disputes into violent conflicts and to better identify opportunities and create more effective mechanisms to settle conflicts by nonviolent means. Research challenges include gathering data on local climate conditions on sufficiently large populations so that valid conclusions can be drawn and performing studies with sufficiently long timeframes.

Analytical frameworks can help us to understand various interactive environmental factors associated with climate change that can contribute to collective violence. Scheffran and colleagues have developed such a framework (Figure 1) (58, 59).

More research needs to be done on the role of scarcity of key environmental resources in causing violence. Homer-Dixon (25) has demonstrated that the scarcity of these environmental resources, primarily cropland but also forests, river water, and fish, can lead to severe social stresses that create urban unrest, clashes among cultural and ethnic groups, and insurgency campaigns.

For example, using biomass fuel for household cooking contributes to scarcity of key environmental resources—a major issue in Ethiopia, where biomass fuels account for 92% of the national energy supply (60). Use of wood for fuel results in substantial deforestation and higher prices for wood, which leads farmers to use animal dung as a biomass fuel for household cooking. This practice reduces the availability of dung for use as a fertilizer, which exacerbates deficiencies in soil nutrients (43). Improving access to renewable energy from microgrids (small off-grid electricity sources for cooking, illumination, and powering of water pumps, flour grinders, and other devices that are operated by electric motors powered by renewable energy) can reduce reliance on biomass fuels, retard deforestation, improve soil conditions, and increase family incomes.

More research can help determine and demonstrate the cobenefits of using renewable energy in rural areas of low-income countries. These cobenefits could include enhanced lighting for childhood education, more time for women who are otherwise tasked with collecting firewood, improved cold storage for food and medicine, increased electric power for irrigation, decreased indoor air pollution from cooking, and reduced risk of collective violence.

## HOW PUBLIC HEALTH PROFESSIONALS CAN HELP PREVENT COLLECTIVE VIOLENCE DUE TO CLIMATE CHANGE

Public health professionals and their organizations have important roles to play in preventing health consequences due to collective violence. These actions include (*a*) documenting the health consequences of armed conflict and other forms of collective violence; (*b*) raising awareness about, and communicating the details and implications of, these health consequences to professional and nongovernmental organizations, government policy makers, and the general public; (*c*) developing and advocating for prevention and intervention measures, public policies, and other approaches to reduce collective violence and related health consequences; (*d*) working to reduce poverty, income inequality, ethnic hatred, and other underlying causes of collective violence; and (*e*) helping to resolve conflicts and disputes by nonviolent means (36). These are all important activities in which public health workers need to play active roles. However, because the focus of this article is on collective violence caused by climate change, the remainder of this section focuses on the important roles that public health professionals and their organizations can play in (*a*) mitigating and adapting to climate change and (*b*) assessing and reducing the risk of collective violence.

Roles of public health professionals and their organizations include

1. Primary prevention (mitigation). This form of prevention supports the reduction of emissions of carbon dioxide, methane, and other GHGs and other activities to reduce climate change, such as preventing deforestation and promoting the growth of new forests;
2. Secondary prevention (adaptation). This form of prevention supports measures to prevent or reduce the health consequences of climate change, such as (*a*) designing and implementing surveillance systems to detect infectious diseases, (*b*) promoting plans for preparedness and emergency response to reduce the impact of a heat wave or an extreme weather event, and (*c*) promoting collaboration among community groups, organizations, and others to plan and implement these measures and to improve social cohesion and enhance other aspects of community resilience; and
3. Tertiary prevention. This form of prevention helps people recover after disasters related to climate change, such as droughts and floods (18, 19).

Additional important public health activities to address climate change include (*a*) raising awareness, educating, and encouraging ongoing communication for other health professionals, policy makers, and the general public; (*b*) performing and supporting research on the health impacts of climate change and on approaches to protecting public health; (*c*) investigating disease outbreaks that may be related to climate change, such as outbreaks of vector-borne disease; (*d*) assessing the vulnerability and the resilience of communities in the face of climate change; (*e*) evaluating mitigation, adaptation, and other measures; and (*f*) promoting increases in the resources and capacities of state and local health departments to address climate change.

We agree with Frumkin and others (18, 19) who have recommended that the public health response to climate change should be (*a*) grounded in a generally strong public health system; (*b*) based on risk characterization and assessment; (*c*) emphasizing all-hazards preparedness; (*d*) emphasizing resilience of the built environment, individual people (physically and psychologically), and organizations; (*e*) built on the potential of cobenefits, such as active transport and shifting away from meat-intensive diets to diets higher in grains, fruits, and vegetables; (*f*) based on strong, cross-sectoral partnerships; and (*g*) focused on institutional learning.

In addition, as Frumkin and others (18) have noted, it is essential in addressing climate change that mitigation, adaptation, and other measures advance equity and fairness (climate justice), strive to reduce socioeconomic disparities within countries, and protect human rights.

Finally, it is critically important that public health professionals and their organizations hold their governments accountable for the commitments that they made at the Conference of Parties (COP21) in Paris in December 2015 to reduce GHG emissions and that high-income countries provide low-income countries with the necessary resources to effectively address climate change.

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## CLIMATE CHANGE CONTRIBUTES TO FOOD PRICE SHOCKS AND THEIR VIOLENT CONSEQUENCES

Volatility in commodity prices and sudden unpredictable price spikes (sharp increases) seriously threaten food security. Poor people living in urban areas are especially vulnerable to food price shocks because they purchase most of their food (as opposed to growing it). While poor farmers in rural areas may ultimately benefit financially from incremental increases in crop prices, they often do not benefit initially from unexpected dramatic price changes (15). In low-income countries, the poorest households may spend as much as 80% of their income on food, in contrast to 6% in the average U.S. household (72); therefore, price shocks have a considerable impact on households in low-income countries.

Spikes in commodity prices, together with political instability as well as desperation and distrust among the population, result in deaths and nonfatal injuries. Food riots also adversely impact social and political stability, further exacerbating food insecurity. The events of the Arab Spring, starting in late 2010, were consistent with this scenario (33).

### CLIMATE CHANGE CONTRIBUTED TO THE CIVIL WAR IN SYRIA

Climate change is likely to have contributed to the development of the civil war in Syria, which began in 2011 and has since caused an estimated 400,000 deaths, forced more than 9 million Syrians to flee their homes, and created a major humanitarian crisis. From 2006 through 2009, a severe drought transformed approximately 60% of the land area into desert. Studies estimate that approximately 80% of cattle died. Hundreds of thousands of farmers and their family members—perhaps as many as 1.5 million people—abandoned their farms and moved to cities, which were already burdened with more than 1 million Iraqi refugees. By the end of 2010, Syria's urban population was 13.8 million, 50% more than it had been in 2002. Most of the farmers were unable to find employment and felt that they were being mistreated by the government of Bashar al-Assad (48, 67).

Kelley and colleagues (31) demonstrated that the extreme severity of the drought in Syria was part of a long-term drying trend, which was consistent with models of increases in GHGs (human-induced climate change). They concluded that the drought contributed to political unrest in this country, which has had poor governance and unsustainable agricultural and environmental policies. They projected continued intensification of heat and drought for the Eastern Mediterranean region (31).

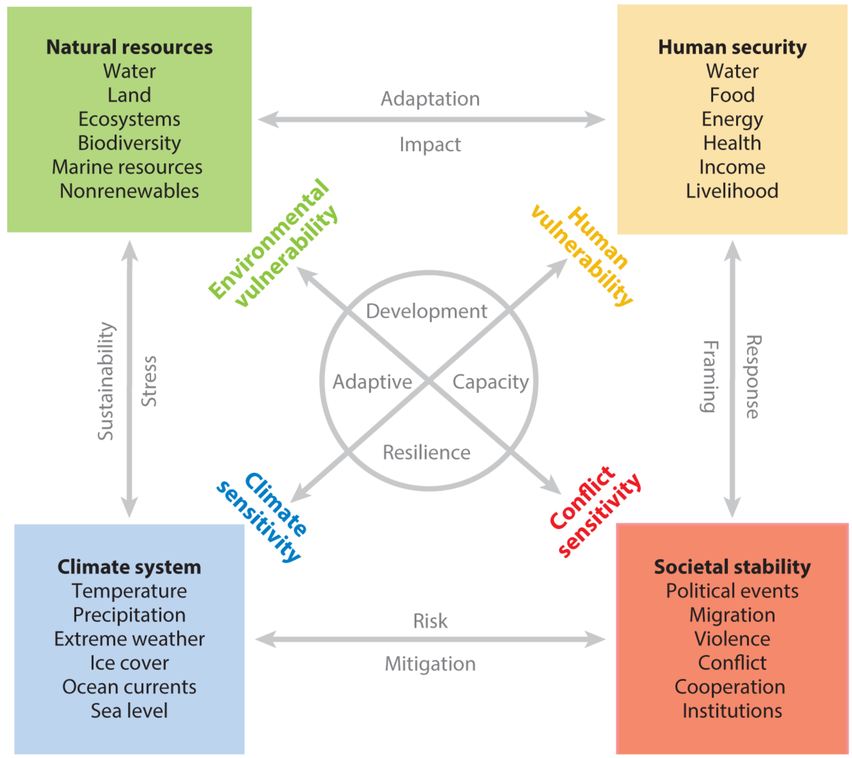


**Figure 1.**
Analytical framework of linkages among the climate system, natural resources, human security, and societal stability. From Reference 58.

**Table 1**

Assessment that various changes have occurred and of a human contribution to observed changes

| Phenomenon and direction of trend | Assessment that changes occurred (typically since 1950 unless otherwise indicated) | Assessment of a human contribution to observed changes |
|---|---|---|
| Warmer and/or fewer cold days and nights over most land areas | Very likely | Very likely |
| Warmer and/or more frequent hot days and nights over most land areas | Very likely | Very likely |
| Warm spells/heat waves: frequency and/or duration increases over most land areas | Medium confidence on a global scale. Likely in large parts of Europe, Asia, and Australia | Likely |
| Heavy precipitation events: increase in frequency, intensity, and/or amount of heavy precipitation | Likely more land areas with increases than decreases | Medium confidence |
| Increases in intensity and/or duration of drought | Low confidence on a global scale. Likely changes in some regions | Low confidence |
| Increases in intense tropical cyclone activity | Low confidence in long-term (centennial) changes. Virtually certain in North Atlantic since 1970 | Low confidence |
| Increased incidence and/or magnitude of extreme high sea level | Likely (since 1970) | Likely |

Table reproduced from *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (30).

**Table 2**

Assessment of the likelihood of further changes in the early and late twenty-first century

| Phenomenon and direction of trend | Early twenty-first century | Late twenty-first century |
|---|---|---|
| Warmer and/or fewer cold days and nights over most land areas | Likely | Virtually certain |
| Warmer and/or more frequent hot days and nights over most land areas | Likely | Virtually certain |
| Warm spells/heat waves: frequency and/or duration increases over most land areas | Not formally assessed | Very likely |
| Heavy precipitation events: increase in the frequency, intensity, and/or amount of heavy precipitation | Likely over many land areas | Very likely over most of the midlatitude land masses and over wet tropical regions |
| Increases in intensity and/or duration of drought | Low confidence | Likely (medium confidence) on a regional to global scale |
| Increases in intense tropical cyclone activity | Low confidence | More likely than not in the western North Pacific and North Atlantic |
| Increased incidence and/or magnitude of extreme high sea level | Likely | Very likely |

Table reproduced from *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (30).