

Anderson, C. A., & DeLisi, M. (2011). Implications of global climate change for violence in developed and developing countries. In J. Forgas, A. Kruglanski, & K. Williams (Eds.), *The Psychology of Social Conflict and Aggression*. (pp. 249-265). New York: Psychology Press.

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Implications of Global Climate Change for Violence Developed and Developing Countries

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Rapid global climate change, taking place over decades rather than millennia, is a fact of twenty-first century life. Human activity, especially the release of greenhouse gases, has initiated a general warming trend. The 10 warmest years on record between 1880 and 2008 were the last 10. This trend is expected to continue until the atmospheric composition returns to a preindustrial era norm.

Climate change effects on specific regions are expected to vary considerably. Though most parts of the globe are warming, a few places may experience cooler climates as ocean and wind currents shift. Some regions are experiencing increased rainfall, whereas many others are having prolonged droughts. In 2007, the Intergovernmental Panel on Climate Change (IPCC) released a report that included numerous projections of likely effects by the end of this century, under varying assumptions of how world governments, industries, and people respond. The best-case scenario assumes huge reductions in net greenhouse gas production, beginning almost immediately. In this scenario, climate models predict an average global temperature increase of 1.8°C (3.24°F) and an average sea level increase of 28 cm (11 inches). The worst-case scenario, which assumes a business-as-usual approach, predicts increases of 4.0°C (7.2°F) and 43 cm (17 inches). Other projections, some of which have already become apparent, include increases in heat waves and heavy precipitation; decreases in precipitation in subtropical areas; and increases in tropical cyclones. More specific projections include (1) 5–8% increase in the proportion of Africa that is arid and semiarid; (2) major flooding of heavily populated areas of Asia from rising sea levels and storms; (3) inundation of low-

lying islands; (4) severe water shortages in Australia and New Zealand; (5) drought in southern Europe; (6) decreased soil moisture and food crops in Latin America; and (7) increased winter flooding and summer heat waves in North America. More recent research being prepared for the next IPCC report suggests that the new best-case scenario will be worse than the old worst-case scenario, with sea levels rising at least 1 meter (Vermeer & Rahmstorf, 2009). Because 13% of the world's population—hundreds of millions of people—live in low-lying coastal areas (Engelman, 2009, p. 41), this latter projection is particularly disturbing. Indonesia may lose as many as 2,000 small islands in the next 20 years to rising sea levels (Engelman, p. 3).

In addition to the changes in average temperature and rainfall, climate models also predict an increase in extreme weather events. Recent data suggest that this increase has already begun, with dramatic increases in floods, wind storms, and drought disasters in the last 20 years (Engelman, 2009, pp. 16, 30). Hurricanes, cyclones, and other tropical storms also are increasing in intensity. The problem with rising sea levels concerns not just the height of high tides but also storm surge. A once-a-century storm in New York City, for example, will occur about once every 3 years (Rahmstorf, 2009) if average sea level increases by 1 meter.

Research from psychology, sociology, political science, economics, history, and geography suggest that rapid global warming can increase the incidence of violent behavior in at least three ways. One involves direct effects of uncomfortably warm temperatures on irritability, aggression, and violence. A second involves indirect effects of global warming on factors that put children and adolescents at risk for developing into violence-prone adults. The third involves indirect effects of rapid climate change on populations whose livelihoods and survival are suddenly at risk, effects that influence economic and political stability, migration, and violent intergroup conflict. For example, various governmental and scientific reports have noted that climate change has exacerbated existing tensions and conflicts singled in the Darfur region of Sudan and in Bangladesh.

Heat and Aggression

Much research has established that uncomfortably warm temperatures can increase the likelihood of physical aggression and violence (Anderson & Anderson, 1998; Anderson, Anderson, Dorr, DeNeve, & Flanagan, 2000; for a concise review see Anderson, 2001). Three types of studies have tested and found considerable support for this heat hypothesis: experimental studies, geographic region studies, and time period studies.

Experimental Studies of the Heat Effect Early experimental studies of heat effects yielded considerable inconsistency in outcomes, perhaps because of participant suspicion and measurement issues. Later studies provided better tests and cleaner results. For example, Vrij, van der Steen, and Koppelaar (1994) conducted a field experiment in which Dutch police officers were randomly assigned to perform a training session involving a simulated burglary under hot or comfortable

conditions. Officers in the hot condition reported more aggressive and threatening impressions of the suspect and were more likely to draw their weapon and to shoot the simulated suspect.

Anderson et al. (2000) reported a series of laboratory experiments on both hot and cold temperature effects. In separate experiments, uncomfortably warm temperatures (relative to comfortable temperature) increased participants' feelings of anger and hostility, their perceptions of hostility in observed dyadic interactions, and their initial retaliatory aggressive behavior against a person whose prior harmful behavior was of an ambiguous nature. Recent experiments by Wilkowski, Meier, Robinson, Carter, & Feltman (2009) linked heat-related imagery to a host of anger and aggression-related perceptions and judgments.

Geographic Region Studies of the Heat Effect

Studies dating back to the nineteenth century suggest that hotter regions have higher violent crime rates than cooler regions (Anderson, 1989). However, even within the same country regions differ in many ways other than climate. Some of these other differences (e.g., poverty, unemployment, age distribution, culture) are risk factors for violence. The best geographic region studies include statistical controls for such factors. Even when such factors are controlled, temperature predicts violent crime rates. For example, hotter U.S. cities have higher violence rates than cooler cities, even after statistically controlling for 14 risk factors including age, education, race, economic, and culture of violence factors (Anderson & Anderson, 1996). Recent work by Van de Vliert (2009; in press; under review) further suggests that climate and economic conditions jointly influence culture in ways that encourage or discourage aggression and violence. Particularly vulnerable are populations that live in regions that are both climatically challenging (hot, cold, or both) and impoverished.

Time Period Studies of the Heat Effect "Time period" studies compare aggression rates within the same region but across time periods that differ in temperature. Studies vary considerably in terms of the time periods for which violence and temperature are assessed. Overall, results are remarkably consistent. Hotter time periods (e.g., days, seasons, years) are associated with higher levels of violence. For example, riots in the United States are relatively more likely on hotter than cooler days (Carlsmith & Anderson, 1979). Similarly, violent crimes across a wide range of countries and measures occur more frequently during hotter seasons than cooler ones (Anderson, 1989).

Of course, other violence-related factors may differ between hotter versus cooler time periods, even within the same region. For example, in the United States large numbers of youth are out of school during the summer months, so one could argue that the routine activities of the population might account for seasonal differences in violence. Several studies have addressed this and other alternative explanations of heat-related time period effects. Although it is clear that routine activities do influence aggressive behavior, it is also clear that such alternative explanations do not parsimoniously account for many observed effects. For example, in two studies Anderson and Anderson (1984) found significant day-of-week effects on daily

violent crime rates, in addition to heat effects. Other time-related routine activities, such as youth being out of school in the summer, cannot account for the heat effect found in Study 1 (Chicago), because that study included only the summer months. Similarly, routine activity theory cannot account for the finding that Major League Baseball pitchers are more likely to hit batters with a pitched ball on hot days than on cool days, even after statistically controlling for the possibility of sweat influencing the pitcher's control (Reifman, Larrick, & Fein, 1991).

Differences in violent crime rates for hotter versus cooler days have been found within cities as varied as Houston, Chicago, and Minneapolis (Anderson & Anderson, 1984, 1998). Even after controlling for routine activity effects of time of day and day of week, violent crimes are relatively more frequent in hotter weather (e.g., Anderson & Anderson, 1998; Bushman, Wang, & Anderson, 2005a, 2005b). Interestingly, nonviolent crime (burglary, motor vehicle theft) rates are largely unrelated to heat.

When the time period is years (instead of days or seasons), the kinds of potentially confounded variables change. For example, U.S. youth are out of school in the summer regardless of whether the year is slightly warmer or cooler. When considering year-based studies and global warming effects, one might be concerned about whether aggression-related factors such as age distribution (e.g., proportion of the population that is in the high-crime age range) and income inequality (e.g., LaFree & Drass, 1996) might be confounded with time or systematic temperature changes. We conducted two new studies to examine the effects of yearly changes in temperature on violent and nonviolent crime in the United States, beginning with 1950.

Study 1: Hot Years and Violent Crime

Method

Data This study extends Anderson, Bushman, and Groom's (1997) Study 1. Major additions are 13 years of new data and several aggression-related control variables. Data for the years 1950–2008 were obtained from U.S. government sources. From the FBI's Uniform Crime Reports we created two crime measures. *Violent crime* was defined as the sum of the homicide and assault rates per 100,000 population. *Nonviolent crime* was defined as the sum of the burglary and motor vehicle theft rates per 100,000 population.¹

The primary predictor variable, annual average temperature, was computed from data from the National Oceanic and Atmospheric Administration. Control variables were year, age (proportion of the population in the 15–29 high-crime age range), prison (number of incarcerated state and federal inmates per 100,000 population), poverty (percent of families living below the poverty line), and the Gini index of income distribution inequality (perfectly equal distribution yields a

¹ As in prior studies, robbery and rape were excluded for theoretical reasons. Both appear to have a greater mixture of aggressive motives (intent to harm) and nonaggressive motives. See Anderson et al., 1997.

Gini index of 0, perfect inequality = 1.0). Year effects might reflect a host of cultural and population changes, such as increased reporting of assaults and improvements in trauma care. The other control variables have obvious theoretical links to violence.

Correlated Residuals Time-series data often have a problem in which the residuals are correlated with time. The most common version is when the residuals at any given time period (T) are correlated with the residuals at the subsequent time period ($T + 1$). Such "autocorrelations" make ordinary least squares (OLS) procedures inappropriate for estimating regression parameters. With a sufficiently large sample of time periods, autoregression (AR) techniques can be used to reduce or eliminate autocorrelations among residuals and can thus yield more accurate results. In all regression analyses, chi-square tests (Ljung & Box, 1978) were used to assess goodness of model fit regarding the presence of correlated residuals. When the chi-square statistic suggested that the model provided a poor fit to the data, autoregressive parameters were added. This process was iteratively repeated until the chi-square test statistic indicated nonsignificant autocorrelations in the new residuals.

The present study addresses five alternative explanations for heat-related time period effects on violent behavior: (1) seasonal fluctuations; (2) correlated residuals; (3) coincidental crime, year, and global warming trends; (4) coincidental age distribution shifts; and (5) coincidental income and poverty shifts. The first alternative explanation is dealt with by using year as the unit of analysis. The remaining alternatives are handled by statistical controls. Nonviolent crime analyses are included as a point of comparison.

Results Table 16.1 presents descriptive statistics and zero-order correlations among the variables. Average annual temperature has increased during this 59-year period ($r = .54$). Note the substantial zero-order correlations among violent crime, temperature, and year. This suggests that in addition to checking for autocorrelated residuals a conservative statistical procedure would also control for year effects. Finally, note that nonviolent crime was not strongly correlated with temperature.

Table 16.2 presents the results of OLS and AR analyses on violent crime (top section) and nonviolent crime (bottom section). OLS regression revealed a large effect of temperature on violent crime; each 1°F increase in average annual temperature was associated with 79 more serious and deadly assaults per 100,000 people. However, the AR test revealed significant autocorrelations among the residuals ($\chi^2(6) = 196, p < .05$). We added AR parameters to the model until the autocorrelation test became nonsignificant (three parameters were needed). This greatly reduced the slope relating temperature to violent crime, but this heat effect remained statistically and practically significant. In the next step we controlled for year. The temperature effect on violent crime remained essentially unchanged. The year effect also was significant; each year added 4.90 violent crimes per 100,000 people. We examined a host of models with the other control variables (age, prison rate, poverty, Gini). Only prison rate yielded a significant effect. With three autoregressive parameters—temperature, year, and prison—in the model the temperature

TABLE 16.1 Correlations Among the Predictor and Outcome Variables, Study 1, 1950–2008

	Year	Temp	Age	Prison	Pov	Gini	Vio	NVio
Year	1.00	0.54	0.04	0.90	-0.75	0.88	0.87	0.52
Temp	0.54	1.00	-0.19	0.61	-0.18	0.61	0.48	0.11
Age	0.04	-0.19	1.00	-0.36	-0.44	-0.30	0.25	0.78
Prison	0.90	0.61	-0.36	1.00	-0.43	0.97	0.69	0.13
Pov	-0.75	-0.18	-0.44	-0.43	1.00	-0.36	-0.71	-0.79
Gini	0.88	0.61	-0.30	0.97	-0.36	1.00	0.72	0.16
Vio	0.87	0.48	0.25	0.69	-0.71	0.72	1.00	0.75
Nvio	0.52	0.11	0.78	0.13	-0.79	0.16	0.75	1.00

Descriptive Statistics								
Mean	1979	57.85	0.227	231	16.1	0.382	239.1	1300
St.Dev.	17.2	0.78	0.025	153	5.6	0.027	127.7	544
Min.	1950	56.60	0.195	93	11.1	0.348	55.7	385
Max.	2008	59.70	0.272	512	32.5	0.432	451.3	2163

Notes: $N = 59$. If $r > .25$ then $p < .05$. Temp, annual average temperature. Age, proportion of U.S. population in the 15–29 age range. Prison, number of incarcerated state and federal inmates per 100,000 population. Pov, percent of families living below the poverty line. Gini, index of income distribution equality (perfectly equal distribution yields a Gini index of 0; perfect inequality = 1.0). Vi, serious and deadly assaults per 100,000 population. Nvio, burglaries and motor vehicle thefts per 100,000 population.

TABLE 16.2 Destructive Testing Results Using Auto-Regressive Parameters and Competitor Variables, Study 1, 1950–2008

Violent ^a	AR Test	Temperature Effect					Year Effect			Prison Effect		
		χ^2	df	b	SE	t						
Model												
OLS	196*	6	79	19.1	4.15*							
AR-3	3.80	3	4.11	1.25	3.30*		b	SE	t			
AR-3	4.07	3	4.16	1.25	3.33*	4.90	1.68	2.91*		b	SE	t
AR-3	3.27	3	4.19	1.21	3.47*	8.34	1.88	4.43*	-42	.203	-2.07*	

NonVio ^b	AR Test	Age Effect				
		χ^2	df	b	SE	t
Model						
OLS	186*	6	16,646	1778	9.37*	
AR-3	4.85	3	9645	3321	2.90*	

Temp, annual average temperature. Age, proportion of U.S. population in the 15–29 age range. AR, autoregression. OLS, ordinary least squares.

^a Serious and deadly assault: Assault + homicide.

^b Nonviolent crime: Burglary + motor vehicle theft.

* $p < .05$. + $p < .10$ if $t > 1.67$.

effect remained significant ($b = 4.19$). Finally, the greater the proportion of the U.S. population that was imprisoned, the smaller the violent crime rate.

A host of OLS and AR models on nonviolent crime did not yield a single significant temperature effect. Indeed, after appropriate AR parameters were in the model, only age was a significant predictor of nonviolent crime rates. For every 1% increase in the proportion of high-crime age individuals in the population, there was an increase of 96 nonviolent crimes per 100,000 people.

Study 2: Hot Summers and Violent Crime

Method

Data This study extends Anderson et al.'s (1997) Study 2. It examines violent crime in the summer months in the United States relative to nonsummer months. Major additions are 9 years of new data and several aggression-related control variables. Data for the years 1950–2004 were collected from numerous governmental sources. Seasonal data were unavailable after 2004.

Basically, the dataset is the same as for the prior study, with two major exceptions. First, the outcome variable is the difference between the percent of the year's crimes that were committed during the summer months (June, July, August) and the average of the other three seasons, adjusted for number of days in each season. If violent crimes were equally likely to occur regardless of season, then the summer months would account for exactly 25% of them, and the summer effect score used in this study would be zero. If violent crimes were relatively more (less) likely in the summer months, the summer effect would be greater (less) than zero. A similar summer effect was computed for nonviolent crimes.

The second major difference from Study 1 was the temperature measure. Across a sample of cities, we recorded the number of hot days (maximum temperature was $\geq 90^\circ\text{F}$) per year. The vast majority of hot days in the continental United States occur during the summer months, so this measure is a good indicator of the hotness of each of the 55 summers.

Predictions We expected the summer effect on violent crime to be significantly greater than zero, when averaged across years. Furthermore, we expected years with more hot days to yield larger summer effects on violent crime than years with fewer hot days.

Results As expected, the average summer effect on violent crime was significantly greater than zero ($M = 2.57$, $t(54) = 18.52$, $p < .05$). Violent crimes are overrepresented in the summer months. In fact, in only 2 of the 55 years was the summer effect negative.

Concerning the second hypothesis, there was no evidence of autocorrelations among the residuals in any of the analyses of violent crime, so OLS analyses were appropriate. The only variable that significantly predicted the size of the summer effect on violent crime was the number of hot days ($b = .068$, $t(53) = 3.07$, $p < .05$). None of the control variables (including year) had a significant effect, nor did they

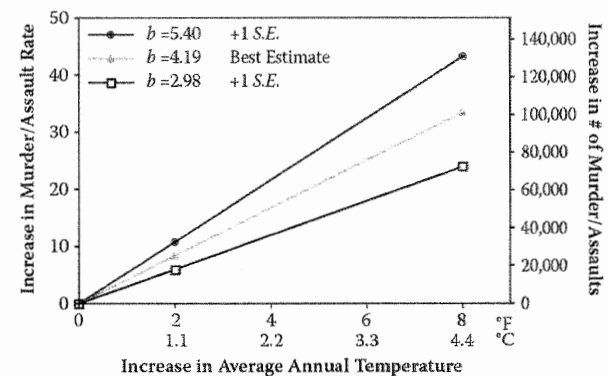


Figure 16.1. Heat Effects on Violent Crime in the U.S., 1950-2008.

substantially reduce the size of the hot days effect. Nonviolent crime was unaffected by number of hot days.

General Discussion of the Heat Effect on Aggression

In sum, the heat hypothesis has been repeatedly confirmed. Laboratory studies suggest that this is largely the result of heat induced increases in irritability and in hostile interpersonal perception biases. There is additional evidence that these effects can be further traced to thermoregulation and emotion regulation areas of the brain (Anderson, 1989; Boyanowsky, 1999, 2008; Boyanowsky, Calvert-Boyanowsky, Young, & Brideau, 1981). The implication for global warming is that at the level of the individual person increased exposure to uncomfortably hot temperatures will increase the likelihood of interpersonal conflict and violence. It is difficult to estimate with confidence how big an impact global warming will have on violent crime in modern societies, but Figure 16.1 provides some rough estimates based on the results of Study 1. If average annual temperature in the United States increases by 8°F (4.4°C), the best estimate of the effect on the total murder and assault rate is an increase of about 34 per 100,000 people, or over 100,000 more such serious and deadly assaults per year in a population of 305 million.

One response to high heat in industrialized countries is increased use of air conditioning in buildings, cars, buses, and trains. Although such actions might mitigate heat-induced increases in aggression, they increase the production of greenhouse gases.

There are no comparable daily, seasonal, or annual data on the heat effect on violent crime in less developed countries. However, the findings summarized in previous sections suggest that uncomfortably hot temperatures can have a fairly direct effect on aggressive and violent tendencies, perhaps through neuro and hormonal pathways that are common to thermoregulation and emotion (see Chapter 9 in this volume).

DEVELOPMENT OF VIOLENCE-PRONE INDIVIDUALS

Global climate change will likely increase the proportion of children and youth exposed to risk factors known to increase the likelihood of becoming a violence-prone individual—someone who frequently uses physical aggression or violence to deal with conflict, to get desired resources, and to impulsively and shortsightedly satisfy one's wants (Gottfredson & Hirschi, 1990; Moffitt, 1993). Studies of violent youth and criminals reveal a host of psychological, neuropsychological, genetic, and environmental risk factors that play a major role in determining who becomes a violence-prone person. These interrelated risk factors include male gender; strongly heritable antisocial traits including impulsivity, sensation seeking, low intelligence, and poor self-regulation; poverty; poor prenatal and childhood nutrition; familial dysfunction; growing up in violent neighborhoods; psychopathy; low education; and disorganized and unstable neighborhood (DeLisi, 2005).

Food, Violence, and Antisocial Behavior

Potentially one of the most catastrophic effects of rapid climate change centers on food availability. Today, one in eight U.S. households with infants is food insecure—the family has limited or uncertain availability of nutritionally adequate and safe foods. In many parts of the world, food insecurity is a much larger problem. This means that a robust proportion of impoverished children (notwithstanding the multifaceted independent effects of poverty on antisocial behavior) face the specter of poor nutrition or malnutrition—conditions with severe long-term consequences for crime and violence. A recent study is illustrative. Jianghong Liu and colleagues examined the longitudinal relationship between malnutrition and subsequent externalizing and antisocial behaviors using a birth cohort of children from the island of Mauritius, off the coast of Africa. Children who were malnourished at age 3 were significantly more aggressive and hyperactive at age 8, more aggressive and prone to externalizing (acting out) behaviors at age 11, and more hyperactive and more likely to exhibit symptoms of conduct disorder at age 17 (Liu, Raine, Venables, & Mednick, 2004).

It is not merely armchair conjecture to assert that food scarcity will result in increased violence-prone individuals; history has already told such a story. From October 1944 to May 1945, residents of the western Netherlands experienced moderate to severe food scarcity caused by a German army blockade. Over 100,000 Dutch men born between 1944 and 1946 were studied to examine the effects of gestational nutritional deficiency on subsequent proneness to violence (Neugebauer, Hoek, & Susser, 1999). Men exposed to severe maternal nutritional deficiency during the first and second trimesters were 2.5 times more likely than men not exposed to severe maternal nutritional deficiency to develop antisocial personality disorder, a psychiatric diagnoses characterized by recurrent use of violence and other antisocial behaviors. Other studies linking poverty to poor developmental outcomes are reviewed by Huston and Bentley (2009). Similarly, recent work by Chen, Cohen, and Miller (2010) reveals that poverty effects on children's stress levels (assessed by cortisol) is exacerbated by perceived threat and by chaos in their daily living conditions.

Environmental–Genetic Interplay

Children in regions of famine, prolonged droughts, civil unrest, and wars (see next section) are exposed to many known risk factors for the development of violence-prone adolescents and adults. Longitudinal studies have shown that even fairly brief exposures (e.g., a few months) to some of these risk factors can put the individual child (or fetus) on a high-risk developmental trajectory.

Caspi and colleagues (2002) examined the interaction between monoamine oxidase A (MAOA)—an enzymatic degrader that modulates neurotransmitters—and childhood maltreatment on later antisocial outcomes. For all antisocial outcomes, the association between maltreatment and antisocial behavior was conditional on the MAOA genotype. Just 12% of the sample had both the genetic risk (low-activity MAOA levels) and maltreatment; they accounted for 44% of the total convictions for violent crime. Moreover, 85% of those who had both risk factors developed some form of antisocial behavior. In the absence of maltreatment, the genotypic risk factor did not manifest itself behaviorally. Similar gene–environment interactions have been found for early life, environmental adversity, and psychiatric outcomes (Caspi et al., 2003; Uher & McGuffin, 2010).

If global warming brings about a world of dramatically increased environmental risk and an unknown number of environmental pathogens, then it is likely that a proportional proliferation of behavioral risks will result as these pathogenic environments moderate genetic and neuropsychological risks within individuals. Recall the pernicious and long-term effects of malnutrition and violent and antisocial behavior. Malnutrition, particularly when it is endured during gestation, causes a host of neuropsychological deficits relating to neuronal reduction, brain toxicity, altered neurotransmission, and other physiological effects. These neuropsychological deficits also interact with genes to predict antisocial behavior. For example, Beaver, DeLisi, Vaughn, and Wright (2010) found that neuropsychological deficits (such as those implicated by prenatal nutritionally deficiency) interacted with the low-activity polymorphism in the MAOA gene to predict violent behavior, delinquency, and low self-control across two time periods.

Terrorism Susceptibility

Recent research into terrorism and suicide bombers has led to a better understanding of the social and environmental conditions that are conducive to the development of individuals willing to use such extreme tactics (Kruglanski, Chen, Dechesne, Fishman, & Orehek, 2009; see also Chapter 10 in this volume). Briefly, these researchers have shown that such extremely violent tactics can emerge from a “quest for personal significance,” triggered by failure to satisfy basic human motives to belong to a significant group and to contribute to its welfare. A variety of events can lead to feelings of failure and exclusion, events such as personal trauma, loss of family through violence, and social humiliation. Under the right (or wrong) circumstances, including (1) an available ideology to justify violence against the perceived perpetrators of trauma, humiliation, and violent loss; and (2) social pressures to engage in violence

against the perpetrators as a means of gaining or restoring one's own significance to one's group, even suicidal terrorism becomes a viable option to the individual (see Chapter 3 in this volume for a related discussion of aggression and ostracism).

CIVIL UNREST, ECOMIGRATION, GENOCIDE, AND WAR

Both of the heat effect and the development of violence-prone individuals focus on violence at the individual level. This third link between climate change and violence focuses on larger groups of people—communities, tribes or clans, societies, and countries. This is a particularly complex set of phenomena. Emerging research from several fields suggests that rapid climate change (heating or cooling) often leads to increases in violence. There are several ways this can happen. For example, in subsistence economies rapid changes in climate lead to a decreased availability of food, water, and shelter. Depending on the level of social-political organization, such shortages can lead to civil unrest and civil war, to migration to adjacent regions and conflict with the people who already live in that region, and even to genocide and war. Although it would be overly simplistic to blame the bloody conflicts in Africa and Asia during the latter twentieth and this first decade of the twenty-first century on climate change and environmental disasters, it also would be incorrect to ignore the role played by the economic hardships (including starvation) wrought by the prolonged droughts and resulting resource shortages. Civil unrest, revolutions, and wars require recruits and leaders who are willing to risk much to gain valuable resources.

Case Studies

Historical research shows that environmental disasters, many linked to relatively rapid climate changes, can lead to increases in group-level violence. Of course, not all environmental disasters are caused by climate change. For example, earthquakes, tsunamis, and volcanoes can and do cause environmental disasters but are not directly related to climate change. However, floods due to excessive rainfall or melting glaciers, droughts, hurricanes, and cyclones are climate-change related.

This section concerns whether environmental disasters increase violence rates and severity, regardless of whether the environmental disaster was the direct result of climate change.

In the recent past, evidence of such effects comes from the U.S. Dust Bowl of the 1930s, clashes in Bangladesh and India since the 1950s, and Hurricane Katrina in the United States in 2005 (Reuveny, 2008). The cases differ in many ways, including political organization and strength. But in each case, there is evidence that environmental disaster led to increased interpersonal violence, a result of *ecomigration* (migration of a large number of people as a result of ecological disaster).

Hurricane Katrina When Katrina hit Louisiana and Mississippi in fall 2005, it flooded about 80% of New Orleans and destroyed much of the Biloxi-Gulfport

area. More than a million people left the area. This ecomigration was to at least 30 different states, with Texas (especially Houston) absorbing the most, at least initially. Texas officials ran 20,000 criminal checks and found minimal criminal data on their Katrina immigrants. Nonetheless, Houston recorded huge increases in homicides in the following months, relative to the same months in the year prior to Katrina (Reuveny, 2008). There were other indicators (e.g., polls) of tension between the long-time residents and the newcomers. However, there was no outbreak of civil war and no evidence of armed intergroup conflict. This seems to be generally true of ecomigrations in well-organized highly industrialized countries.

U.S. Dust Bowl In the 1930s, poor farming practices combined with a prolonged drought and strong winds to produce an environmental disaster in the Great Plains, particularly Oklahoma. About 2.5 million people left the area, primarily for adjacent states, but about 300,000 went to California. There are numerous reports of hostility and violence between the residents and the ecomigrants, including police efforts to block the migrants or to scatter them from their settlements, beatings, and shack burnings (Reuveny, 2008).

Bangladesh Population pressures from a very high fertility rate combined with unsustainable farming practices and environmental disasters (possibly related to climate change) led to large-scale migrations to adjacent regions in Bangladesh and across the border to India. From 1976 to 2000 about 25 million people were affected by droughts, 270 million by floods, and another 41 million by rain and wind storms. Making matters worse, in 1975 the Indian Farakka Barrage began diverting water from the Ganges River to other parts of India, decreasing the amount flowing into its historic tributaries in Bangladesh. The resulting salt-water intrusion from the Indian Ocean and increased silting of the riverbed resulted in additional floods, erosion, and environmental degradation.

An estimated 12 to 17 million Bangladeshis have migrated to adjacent states in India since the 1950s. Clashes between the residents and the migrants have occurred along socioeconomic, religious, ethnic, and national lines, resulting in thousands of deaths, especially after the 1983 elections. Indeed, 1,700 Bengalis were killed in a 5-hour rampage in 1983.

1967 Arab-Israeli War There is historical evidence of water issues contributing to conflict in the Middle East at least as early as the seventh century B.C. (Gleick, 1993). Since the establishment of Israel in 1948 the region has periodically been at war, for a variety of political and religious reasons. But water issues also play an important role in the conflicts, especially issues concerning the Jordan River basin. This basin is shared by Israel, Jordan, Lebanon, and Syria. According to Gleick (p. 85), "one of the factors directly contributing to the 1967 War was the attempt by members of the Arab League in the early 1960s to divert the headwaters of the Jordan River away from Israel." (For additional examples of important water conflicts, historical as well as contemporary, see Gleick; Postel & Wolf, 2001).

Time-Period Studies

Little Ice Age Effects Following the Medieval Warm Period, the Little Ice Age (roughly 1300–1850) ushered in cooler temperatures, shorter growing seasons, and a host of other climate-related changes. Scholars from a variety of disciplines have begun examining the relationships among relatively rapid shifts in climate and a host of human population events, including war. Fagan (2000) weaves a careful story of climate shifts and their impact on Europeans, linking farming practices and outcomes, social and cultural changes, civil unrest, and war. Though careful to avoid extreme claims of environmental determinism, he makes a strong case for viewing rapid climate change (in this case, cooling) as contributing to war and other forms of violence. Briefly, rapid climate change disrupted food production, leading to food shortages, famines, civil unrest, and war. This process seems particularly important in agrarian societies that do not have the political and economic resources to effectively deal with food shortages and famine. Indeed, according to Fagan the French revolution was fueled in part by food shortages that were largely the result of the failure of farming practices to adapt to the changed climate.

Zhang and colleagues (Zhang, Brecke, Lee, He, & Zhang, 2007; Zhang, Zhang, Lee, & He, 2007) took a more statistical approach to examining the question of whether rapid shifts in climate from 1000 to 1900 were linked to wars. Using data from the Northern Hemisphere and from China, they found statistical support for their model, which is very similar to Fagan's (2000).

It might seem strange to include studies of rapid cooling in a work that is focused on global warming and violence. However, the basic model is the same regardless of whether a rapid shift in climate is warming or cooling, flooding or drought. A systematic change in climate that threatens basic human resources puts stress on economic and social systems. That stress can lead to emigration and conflict or directly to war over resources.

Civil War in Africa Burke, Miguel, Satyanath, Dykema, and Lobell (2009) recently analyzed civil wars in Africa from 1981 to 2002. Some models included per capita income and form of government as well as temperature and precipitation. Overall, the results showed a strong positive relation between temperature increases and civil war. For a 1°C increase in temperature, there was a 5.9% increase in civil war. Given the base rate of civil war in this dataset (11%), this represents a 54% relative increase in the likelihood of civil war for each 1°C increase in temperature. The authors noted that a 1°C increase is projected by 2030 and that if future wars are as deadly as past ones an additional 393,000 battle deaths can be expected in this region.

Additional Ecomigration and War-Related Forms of Violence

A recent report by the United Nations (Engelman, 2009) highlighted a number of additional ways global climate change can lead to increased violence. Perhaps the most notable is the likely increase in violent crimes committed against women and children as a consequence of their increased vulnerability in subsistence

economies that suffer an ecological disaster. With the breakdown of societal norms and increased economic stress come increases in rape, assault, and homicide. As far as we know, there are no studies directly linking global warming to such effects, but such outcomes have been documented in the aftermath of severe floods, food shortages, and war ("civil" or otherwise).

IMPLICATIONS

Collectively, these three ways global climate change increases human violence suggest a rather dire future. We prefer to end on a more positive note. Action can be taken, by individuals, groups, and governments. One obvious action is to reduce greenhouse gas emissions, thereby reducing the magnitude and speed of climate change. Many individuals, groups, and governments are taking actions, albeit somewhat belatedly.

In addition to the technological and lifestyle changes being actively developed, discussed, and implemented, it also seems worthwhile to consider an infrequently discussed option, the potential benefits of better population control. One thousand years ago the world population was about 300 million. Currently it is about 7 billion. Some have estimated that the world population will peak at around 10 billion. Most of that increase will take place in developing countries, with huge increases in greenhouse gas emissions as a result of carbon-intensive industrialization and increasing consumption. Generally speaking, as a country becomes more industrialized and wealthy, the carbon footprint per person increases dramatically, and population growth eventually slows. The conundrum we face is how to reduce total greenhouse gas emissions while improving the quality of life of the large proportion of people currently living in poverty. One recent study found that, "dollar-for-dollar, investments in voluntary family planning and girls' education would also in the long run reduce greenhouse-gas emissions at least as much as the same investments in nuclear or wind energy" (Engelman, 2009, p. 26).

Developed and developing countries will be affected differently by global warming. In some ways, developed countries will be less affected, in part because of their locations but more importantly because they have more resources per capita to deal with the changes. It is unlikely that famines will strike the richest countries, for example. However, no country will be immune to the violence consequences of global climate change. The heat effect on individual levels of aggression and violence applies to all countries. Similarly, it seems obvious that even wealthy countries are likely to see increases in the proportion of children exposed to known risk factors for the development of violence-prone youth and adults. It is less obvious how wealthy countries will be affected by the third process, which leads to increases in civil unrest, emigration, genocide, and war. But even if developed countries do not experience sufficient economic and social stress to induce war (civil or international), civil unrest and emigration within them will likely lead to increases in violent crime, especially after ecological disasters such as floods. Furthermore, increased poverty, civil dissolution, and wars in developing countries have an impact on developed countries. In some cases, the impact derives from the global economy and the need for resources. Also, differences

between the have and have-not countries create breeding grounds for international terrorist groups.

What actions could reduce the likelihood of climate change induced violence? There is some limited evidence that the heat-aggression effect on individuals can be reduced by simply making people aware that when they are uncomfortably hot they tend to react to minor provocations in inappropriately hostile ways. However, given the immediacy and subtlety of the heat effect on irritability, hostile perception biases, and aggression, it is doubtful that such an educational intervention will have a large impact.

On the other hand, the other two ways global warming increases human violence appear to be good candidates for intervention. If governments began preparing now to feed, shelter, educate, and move at-risk populations to regions in which they can maintain their livelihoods and their cultures, we could dramatically reduce both the development of violence-prone individuals and the civil unrest, emigration, and war problems. This will cost huge amounts of money and will require more international cooperation than our planet has ever seen. Failure to do so will result in additional disasters for millions of people.

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