16 Climate Effects on U.S. International Interests

Federal Coordinating Lead Author

Meredith Muth
National Oceanic and Atmospheric Administration

Chapter Lead

Joel B. Smith
Abt Associates

Chapter Authors

Alice Alpert
U.S. Department of State

James L. Buizer
University of Arizona

Jonathan Cook
World Resources Institute (formerly U.S. Agency for International Development)

Apurva Dave
U.S. Global Change Research Program/ICF

John Furlow
International Research Institute for Climate and Society, Columbia University

Kurt Preston
U.S. Department of Defense

Peter Schultz
ICF

Lisa Vaughan
National Oceanic and Atmospheric Administration

Review Editor

Diana Liverman
University of Arizona

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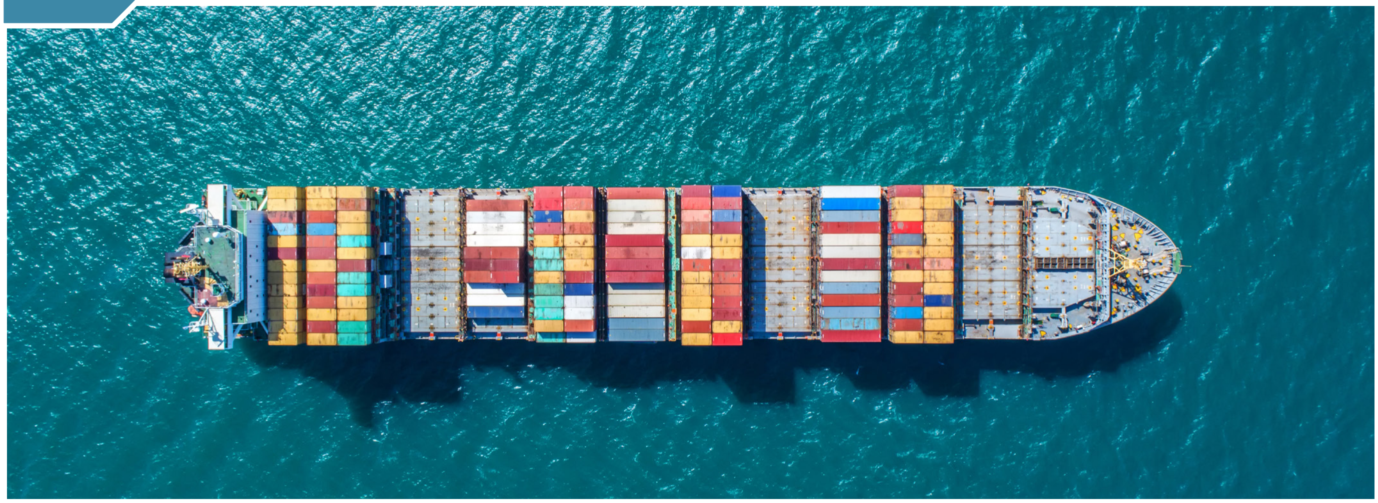
16 Climate Effects on U.S. International Interests



Container ship bringing goods to port

Key Message 1

Economics and Trade

The impacts of climate change, variability, and extreme events outside the United States are affecting and are virtually certain to increasingly affect U.S. trade and economy, including import and export prices and businesses with overseas operations and supply chains.

Key Message 2

International Development and Humanitarian Assistance

The impacts of climate change, variability, and extreme events can slow or reverse social and economic progress in developing countries, thus undermining international aid and investments made by the United States and increasing the need for humanitarian assistance and disaster relief. The United States provides technical and financial support to help developing countries better anticipate and address the impacts of climate change, variability, and extreme events.

Key Message 3

Climate and National Security

Climate change, variability, and extreme events, in conjunction with other factors, can exacerbate conflict, which has implications for U.S. national security. Climate impacts already affect U.S. military infrastructure, and the U.S. military is incorporating climate risks in its planning.

Key Message 4

Transboundary Resources

Shared resources along U.S. land and maritime borders provide direct benefits to Americans and are vulnerable to impacts from a changing climate, variability, and extremes. Multinational frameworks that manage shared resources are increasingly incorporating climate risk in their transboundary decision-making processes.

Executive Summary

U.S. international interests, such as economics and trade, international development and humanitarian assistance, national security, and transboundary resources, are affected by impacts from climate change, variability, and extreme events. Long-term changes in climate could lead to large-scale shifts in the global availability and prices of a wide array of agricultural, energy, and other goods, with corresponding impacts on the U.S. economy. Some U.S.-led businesses are already working to reduce their exposure to risks posed by a changing climate.

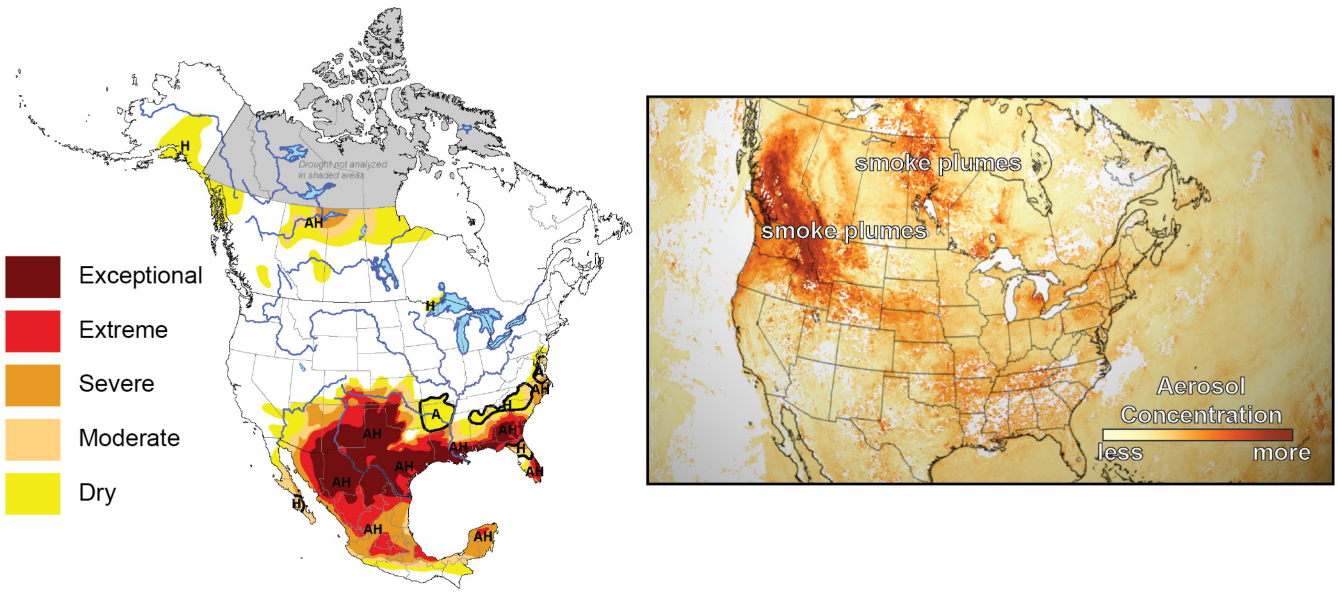
U.S. investments in international development are sensitive to climate-related impacts and will likely be undermined by more frequent and intense extreme events, such as droughts, floods, and tropical cyclones. These events can impede development efforts and result in greater demand for U.S. humanitarian assistance and disaster relief. In response, the U.S. government has funded adaptation programs that seek to reduce vulnerability to climate impacts in critical sectors.

Climate change, variability, and extreme events increase risks to national security through direct impacts on U.S. military infrastructure and, more broadly, through the relationship between climate-related stress on societies and conflict. Direct linkages between climate and conflict are unclear, but climate variability has been shown to affect conflict through intermediate processes, including resource competition, commodity price shocks, and food insecurity. The U.S. military is working to fully understand these threats and to incorporate projected climate changes into long-term planning.

The impacts of changing weather and climate patterns across U.S. international borders affect those living in the United States. The changes pose new challenges for the management of shared and transboundary resources. Many bilateral agreements and public–private partnerships are incorporating climate risk and adaptive management into their near- and long-term strategies.

U.S. cooperation with international and other national scientific organizations improves access to global information and strategic partnerships, which better positions the Nation to observe, understand, assess, and respond to the impacts associated with climate change, variability, and extremes on national interests both within and outside of U.S. borders.

Transboundary Climate-Related Impacts



Shown here are examples of climate-related impacts spanning U.S. national borders. (left) The North American Drought Monitor map for June 2011 shows drought conditions along the U.S.–Mexico border. Darker colors indicate greater intensity of drought (the letters A and H indicate agricultural and hydrological drought, respectively). (right) Smoke from Canadian wildfires in 2017 was detected by satellite sensors built to detect aerosols in the atmosphere. The darker orange areas indicate higher concentrations of smoke and hazy conditions moving south from British Columbia to the United States. *From Figure 16.4 (Sources: [left] adapted from NOAA 2018,[114] [right] adapted from NOAA 2018[115]).*

Introduction

The global impacts of climate (climate change, variability, and extreme events) are already having important implications for societies and ecosystems around the world and are projected to continue to do so into the future.[1,2,3] There are specific U.S. interests that can be affected by climate-related impacts outside of U.S. borders, such as climate variability (for example, El Niño/La Niña events), climate extremes (for example, floods resulting from extreme precipitation), and long-term changes (for example, sea level rise). These interests include economics and trade (Key Message 1), international development and humanitarian assistance (Key Message 2), national security (Key Message 3), and transboundary resources (Key Message 4). While these four topics are addressed separately, they can also affect each other. For example, climate-related disasters in developing countries not only have significant local and regional socioeconomic impacts, but they can also set back U.S. development investments, increase the need for U.S. humanitarian assistance, and affect U.S. trade and national security. U.S. citizens have long been concerned about the welfare of those living beyond U.S. borders and their vulnerability to the global impacts of climate.[4,5]

Key Message 1

Economics and Trade

The impacts of climate change, variability, and extreme events outside the United States are affecting and are virtually certain to increasingly affect U.S. trade and economy, including import and export prices and businesses with overseas operations and supply chains.

The impacts of climate change, variability, and extremes that occur outside the United States can directly affect the U.S. economy and trade through impacts on U.S.-owned, provided, or consumed services, infrastructure, and resources in other countries.[6,7,8,9] Additionally, impacts on foreign-owned infrastructure, services, and resources can have indirect impacts on U.S. trade and businesses that rely on those assets and services, such as impacts on overseas energy and water utilities in places where U.S. international businesses are located. These foreign impacts are in addition to the impacts that climate change, variability, and extreme events within U.S. borders have on the U.S. economy and trade,[10,11] as described elsewhere in the report (for example, Ch. 7: Ecosystems, KM 3).

In addition to local impacts on U.S.-owned assets abroad, climate change is expected to lead to large-scale shifts in the availability and prices of a wide array of agricultural,[12,13] energy,[14,15] and other goods, with corresponding impacts on the U.S. economy. These impacts occur on a wide range of timescales, ranging from months to multiple decades. For example, the prices of agricultural and mining commodities and manufactured goods are affected by year-to-year and decadal climate variations in the availability of irrigation water for agriculture or hydroelectric power.[16,17,18,19] International price changes affect U.S. businesses abroad, as well as U.S. exports and imports. An example is the damaging effect that a series of short-term climate extremes in 2010 and 2011 had on global wheat production. These extremes included drought in Russia, Ukraine, and the United States and damaging precipitation in Australia. A corresponding reduction in wheat production, in combination with high demand, low stocks, trade policies, and other factors, contributed to a spike in global wheat prices.[20] This benefitted U.S. wheat exports while increasing the cost of flour and bread in the United States.[21] This example highlights the complex interactions that often arise through major impacts of overseas climate change, variability, or extremes on U.S. interests (see Key Message 3 for a discussion

of some of the security implications from the 2010–2011 drought).[22] Where these impacts increase global market prices, U.S. purchasers and consumers tend to be harmed, whereas U.S. producers tend to benefit. The opposite is generally true for impacts that drive prices down.

Overseas climate variability, extremes, and change can disrupt U.S. economic interests through impacts to overseas supply chains via impacts to international manufacturing, storage, and transportation infrastructure (road, rail, shipping, and air; Figure 16.1).[23,24,25] At the same time, climate change is creating new transport opportunities, such as the potential summertime availability of trans-Arctic commercial shipping in the next few decades due to a reduction in ice cover caused by warmer temperatures,[26,27,28] though the infrastructure to support this transportation pathway and its safety has not yet been developed (Ch. 26: Alaska, KM 5).

Climate risks are being increasingly recognized and reported by businesses. The Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD 2017[29]) has encouraged businesses to report those risks, with hundreds of businesses currently enlisted as partners in the TCFD effort. Some U.S.-led businesses are working to reduce their climate risks abroad. One way they are doing this is through partnerships with environmental groups. For example, Starbucks and Conservation International[30] have partnered to strengthen the capacity of coffee farmers and supply chains to manage climate risks,[31] while Coca-Cola and the World Wildlife Fund are working together to protect foreign watersheds that Coca-Cola uses for water supply.[32] Coca-Cola increased its company-wide water efficiency from 2004 to 2012 by 21.4%, which avoided approximately $600 million in costs and tended to increase resilience in the face of water shortages.[33] As noted in the next section (Key Message 2), U.S. government actions are helping to promote climate resilience of infrastructure services[34,35] and other factors that have the potential to create more stable conditions for American businesses operating in developing countries, as well as promoting the welfare of those countries.

Global trade can promote resilience to climate change by shifting production of goods and services to areas with more favorable climates and away from those with less favorable climates.[36,37,38] However, these shifts will generally have associated costs and may have a harmful effect on communities where production is decreased.

Few studies exist that quantify the impact of climate change on U.S. corporations and the effectiveness of adaptation actions to reduce those impacts.[39]

Impact of 2011 Thailand Flooding on U.S. Business Interests

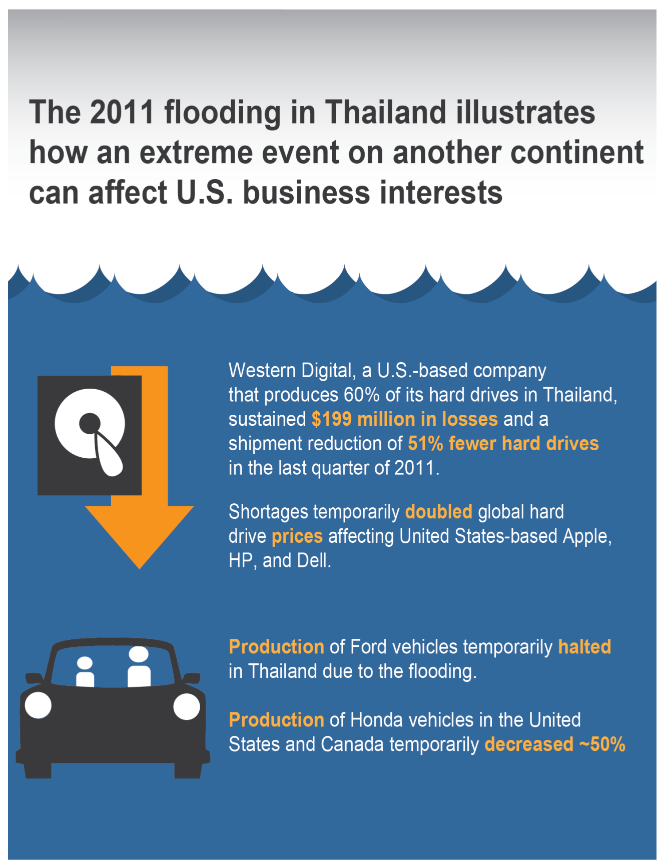


Figure 16.1: Severe flooding in Thailand in 2011 created significant disruptions of local business operations and global supply chains, resulting in a range of impacts to U.S. business interests. Source: ICF.

Key Message 2

International Development and Humanitarian Assistance

The impacts of climate change, variability, and extreme events can slow or reverse social and economic progress in developing countries, thus undermining international aid and investments made by the United States and increasing the need for humanitarian assistance and disaster relief. The United States provides technical and financial support to help developing countries better anticipate and address the impacts of climate change, variability, and extreme events.

U.S. development assistance helps save lives, reduce poverty, and strengthen democratic governance; it also helps societies emerge from humanitarian crises.[40,41] Given their structures and levels of development, the economies and societies of developing countries are generally at greater relative risk from the impacts of climate variability, change, and extremes than are those of developed countries.[1] In addition to causing suffering in developing countries, these impacts threaten to undermine U.S. investments in development and may necessitate additional humanitarian assistance (and possibly military assistance or intervention; see Key Message 3) in response to more frequent and severe natural disasters (such as flooding).

U.S. international development assistance programs, implemented either directly by U.S. government agencies (such as the U.S. Agency for International Development [USAID] and the Millennium Challenge Corporation [MCC]) or indirectly through multilateral institutions (such as the World Bank and United Nations agencies), invest in critical sectors such as agriculture, water and sanitation, health, and infrastructure. These sectors, and the U.S. investments in them, are sensitive to natural variations in climate and extremes and are vulnerable to adverse impacts of climate change.[1,34,42]

The U.S. government systematically identifies climate risks and seeks to reduce the vulnerability of its international development investments. For example, the MCC amended its Environmental Guidelines in June 2012 to formally adopt the International Finance Corporation's Performance Standards on Environmental and Social Sustainability, which includes provisions on climate risk management.[43,44] In addition, USAID has its own climate risk management guidelines.[45] For more than a decade, the U.S. government has also funded adaptation programs that seek to reduce vulnerability to climate impacts in these critical sectors.

Developing countries are often highly vulnerable to climate extremes, which can set back development and increase the need for disaster response and recovery assistance. For example, in 1998, Hurricane Mitch devastated Honduras and Nicaragua, killing thousands of people and causing widespread damage to property and infrastructure.[46] USAID and the U.S. Department of Defense (DoD) jointly responded with an immediate relief effort. USAID also reoriented many of its programs to focus on longer-term recovery.[47] Climate change is likely to increase the demand for U.S. humanitarian assistance of this kind, given the expected increase in the severity of extreme events like tropical cyclones and droughts.[1,48,49]

Many developing countries depend heavily on agriculture as a major source of jobs and a large percentage of their gross domestic product (GDP). Drought can have impacts on food production and security at multiple scales. At the national level, the loss of food and income and the need to help farmers through bad

years can set back development. At the household level, drought can wipe out crops and financial assets and leave families vulnerable to starvation.

The United States works at several levels to help countries anticipate drought and to provide farmers with tools to manage risks to their crops and finances. For example, the United States invests in early warning systems in developing countries such as the Famine Early Warning Systems Network (FEWS NET), a joint effort by multiple U.S. agencies created after a devastating drought in Ethiopia in 1984. Currently, FEWS NET works with governments and international partners in 34 countries (Figure 16.2).[50] In 2015, FEWS NET warned that Ethiopia was facing its worst drought in 60 years and projected that as many as 15 million people would face acute food insecurity. Before the drought and food crisis materialized, USAID mobilized an emergency aid program and provided 680,000 metric tons of food to more than 4 million people.[51]

U.S. investments in making Ethiopian agriculture more climate resilient also helped individual farmers cope with the 2015 drought. A financial risk management program enables farmers to buy “weather index” insurance, which links payouts to certain indicators of extreme weather, such as drought. The insurance program uses information from FEWS NET and coordinates with Ethiopian partners as well as global reinsurance companies. More than 25,000 Ethiopian farmers who purchased this type of insurance received payouts during the drought, helping them to pay off debts, feed their families, and care for livestock.[52,53] Similar index insurance products are being developed through public–private partnerships across Africa, Asia, and Latin America.

Investments by the United States towards enhancing national capacity to produce and use climate information in decision-making, also known as climate services, help countries manage their own risks and build resilience. For instance, the United States collaborated with Jamaica’s meteorological service and agriculture ministry to develop a seasonal drought forecast tailored to the needs of Jamaican farmers. Jamaican agriculture was severely affected by drought in 2014.[54] Crop production losses were 57% nationally and close to 75% among farmers identifying climate risks as a major concern. However, farmers who used the drought forecast fully were able to cut their losses nearly in half that year compared to farmers who did not use or did not have access to the forecast.[55]

Climate-resilience investments are being made to assist other key economic sectors in developing countries, including some that are expected to have benefits over longer time frames. For instance, in the Philippines, the United States has supported six cities and provinces to consider climate impacts in the provision of water supply and wastewater treatment services. The project is improving the design, management, and maintenance of long-lived infrastructure, as well as local planning and governance.[56] It assisted one water-scarce city, Zamboanga City, in developing the country’s first-ever urban water demand management plan.[57]

Famine Early Warning Systems Network

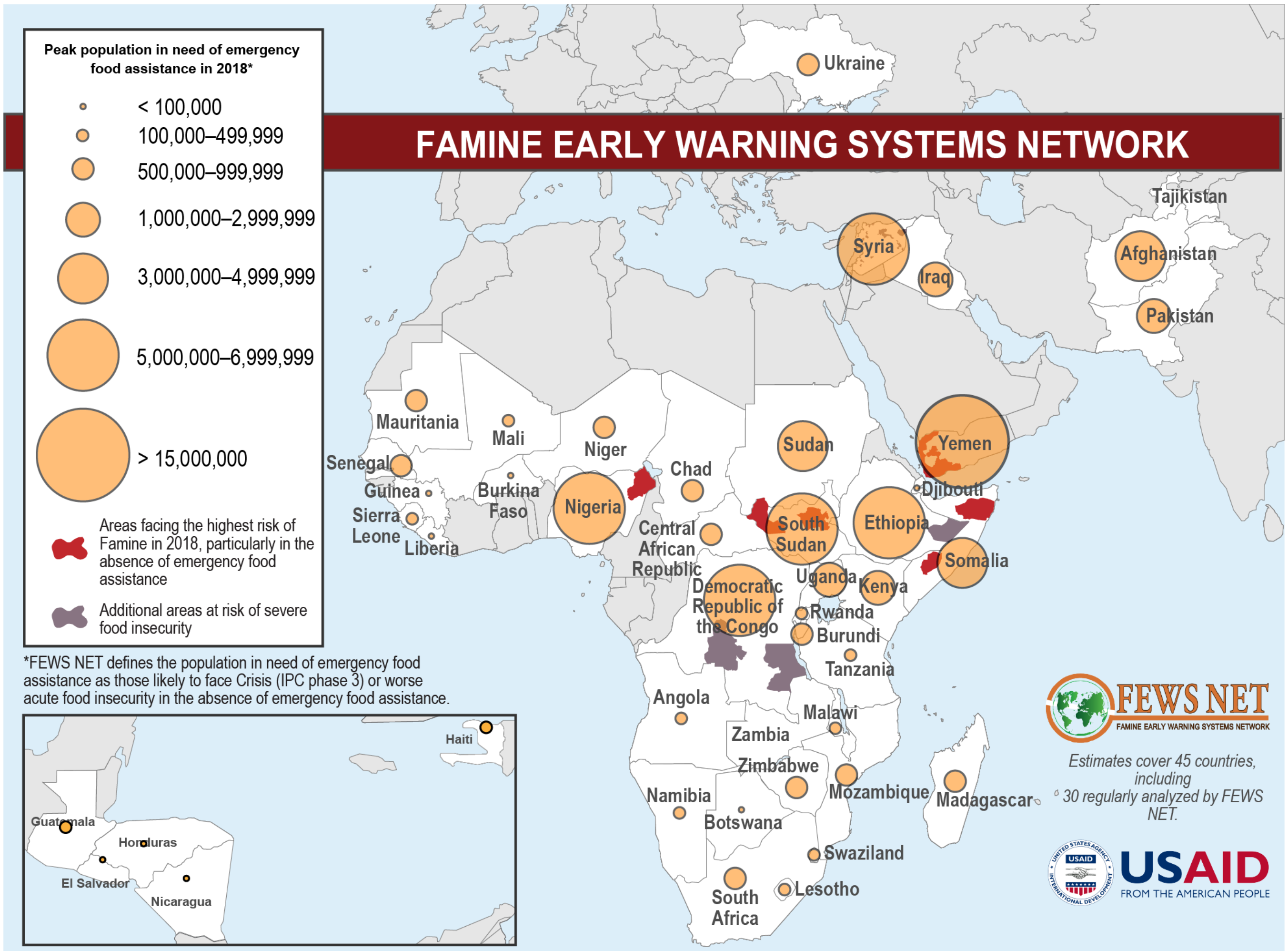


Figure 16.2: The Famine Early Warning Systems Network involves a collaboration between U.S. government agencies, other national government ministries, and international partners to collect data and produce analyses of conditions in food-insecure regions and countries. The analyses integrate information on climate, agricultural production, prices, trade, nutrition, and other societal factors to develop scenarios of food security around the world 6 to 12 months in advance. This map shows projections of peak populations in need of emergency food assistance in 2018. Source: adapted from USAID 2018.[58]

Key Message 3

Climate and National Security

Climate change, variability, and extreme events, in conjunction with other factors, can exacerbate conflict, which has implications for U.S. national security. Climate impacts already affect U.S. military infrastructure, and the U.S. military is incorporating climate risks in its planning.

Climate change and extremes increase risks to national security through direct impacts on U.S. military infrastructure and by affecting factors, including food and water availability, that can exacerbate conflict outside U.S. borders.[59,60] Droughts, floods, storm surges, wildfires, and other extreme events stress nations and people through loss of life, displacement of populations, and impacts on livelihoods.[61,62] Increases in the frequency and severity of such events, as well as other aspects of climate change, may require a larger military mission

focus on climate-sensitive areas such as coasts, drought-prone areas, and the Arctic.[60]

Climate change is already affecting U.S. Department of Defense (DoD) assets by, among other impacts, damaging roads, runways, and waterfront infrastructure.[63] DoD is working to both fully understand these threats and incorporate projected climate changes into long-term planning to reduce risks and minimize impacts. There are many examples of DoD's planning and action for risks to its assets from climate change. DoD has performed a comprehensive scenario-driven examination of climate risks from sea level rise to all of its coastal military sites,[64] including atolls in the Pacific Ocean.[65] In the Arctic, the U.S. Coast Guard and Navy are pursuing strategies to respond to the changing geopolitical significance resulting from the projected absence of summer sea ice in the next few decades (Ch. 2: Climate, KM 7).[66,67,68,69]

The risks climate change may hold for national security more broadly are connected to the relationships between climate-related stresses on societies and conflict. Direct linkages between climate-related stress and conflict are unclear,[70] but climate variability has been shown to affect conflict through intermediate processes, including resource competition, commodity price shocks, and food insecurity.[71,72] The potential for conflict increases where there is a history of civil violence, conflict elsewhere in the region, low GDP or economic growth, economic shocks, weak governance, and lack of access to basic needs.[61] For example, droughts around the world in 2010 contributed to a doubling of global wheat prices in 2011 and a tripling of bread prices in Egypt.[73] This and other factors, including national trade policy and poverty, contributed to the civil unrest that ultimately resulted in the 2011 Egyptian revolution.[73] While the 2010 droughts were not the sole cause of the revolution, they contributed to destabilization of an already unstable region. Likewise, drought in Somalia has forced herders to sell livestock they could not provide for, reducing their incomes and leading some to join armed groups.[74] Water scarcity and climate-related variations in water availability can increase tensions and conflict between countries.[75] In these and other instances, conflict was related to stress from climate-related events, but non-climatic factors also had an important role.[76,77,78,79,80,81,82,83] However, in some cases, water scarcity and variability can result in cooperation rather than conflict.[61,84]

Human migration is another potential national security issue. Extreme weather events can in some cases result in population displacement. For example, in 1999 the United States granted Temporary Protected Status to 57,000 Honduran and 2,550 Nicaraguan nationals in response to Hurricane Mitch.[85] In 2013, more than 4 million people were internally displaced by Typhoon Haiyan in the Philippines,[86] and the United States committed 13,400 military personnel to the relief effort (Figure 16.3).[87] Six months after Typhoon Haiyan, more than 200,000 people remained without adequate shelter.[88] While neither Hurricane Mitch nor Typhoon Haiyan was solely attributable to climate change,[89] tropical cyclones are projected to increase in intensity, which would increase the risk of forced migration.[2,49] Slower changes, including sea level rise and reduced agricultural productivity related to changes in temperature and precipitation patterns, could also affect migration patterns.[61] However, whether migration in response to climate change will generally cause or exacerbate violent conflict is still uncertain (Ch. 27: Hawai'i & Pacific Islands, KM 6).[90,91]

U.S. Military Relief Efforts in Response to Typhoon Haiyan

Figure 16.3: The U.S. military conducted humanitarian and disaster relief efforts in the aftermath of Typhoon Haiyan in the Philippines in 2013. (upper left) An officer aboard an MH-60R Seahawk helicopter prepares to drop off humanitarian supplies. (upper right) A sailor assists a Philippine nurse in treating a patient's head wound at the Immaculate Conception School refugee camp. (lower left) Residents displaced by the storm fill the cargo hold of a C-17 Globemaster aircraft. (lower right) Sailors aboard the aircraft carrier USS *George Washington* move a pallet of drinking water across the flight deck. Photo credit: U.S. Department of Defense.

Key Message 4

Transboundary Resources

Shared resources along U.S. land and maritime borders provide direct benefits to Americans and are vulnerable to impacts from a changing climate, variability, and extremes. Multinational frameworks that manage shared resources are increasingly incorporating climate risk in their transboundary decision-making processes.

The shared borders of the United States are extensive. Land borders with Canada (13 states) and Mexico (4 states) include shared rivers and lakes. Maritime borders are shared with 21 countries by Hawai'i and other island areas, including the U.S. Caribbean, the U.S.-Affiliated Pacific Islands, and the Arctic region.[92,93]

Climate variability and change, as well as related extreme events across shared U.S. borders, can have direct and indirect impacts on those living in the United States. For example, increased temperatures coupled with decreased precipitation in northern Mexico can lead to an increase in the intensity of dust storms and wildfires, which can cross

the border into the United States.[94,95,96,97,98,99] Similarly, transport of smoke from wildfires across the Canadian borders can lead to air quality and health concerns in the United States (Figure 16.4) (see also Ch. 24: Northwest, Box 24.7). Movement of fish species is affected by changes in water temperature (Ch. 9: Oceans, KM 2; Ch. 20: U.S. Caribbean, KM 2) as illustrated by the migration of Pacific hake, an economically important fish species that migrated northward from the United States to Canadian waters due to warmer ocean temperatures during the 2015 El Niño.[100] Additionally, climate impacts are likely to exacerbate cross-border issues related to water, wildlife, trade, transportation, health (Box 16.1) (see also Ch. 14: Human Health), infrastructure, energy, natural resources (such as biodiversity and forests), food security, human migration, and cultural resources. Shared water resources such as rivers and lakes are particularly sensitive to changes in precipitation (Figure 16.4). In the U.S.–Mexico drylands region, large areas are projected to become drier (Ch. 23: S. Great Plains),[101,102] which is expected to present increasing demands for water resources on top of existing stresses associated with population growth.[103,104] Along the U.S.–Canada border, changing weather patterns along the Columbia River, which originates in Canada, affect the amount of water available for irrigation, drinking water supplies, and hydroelectric power generation.[105]

Transboundary Climate-Related Impacts

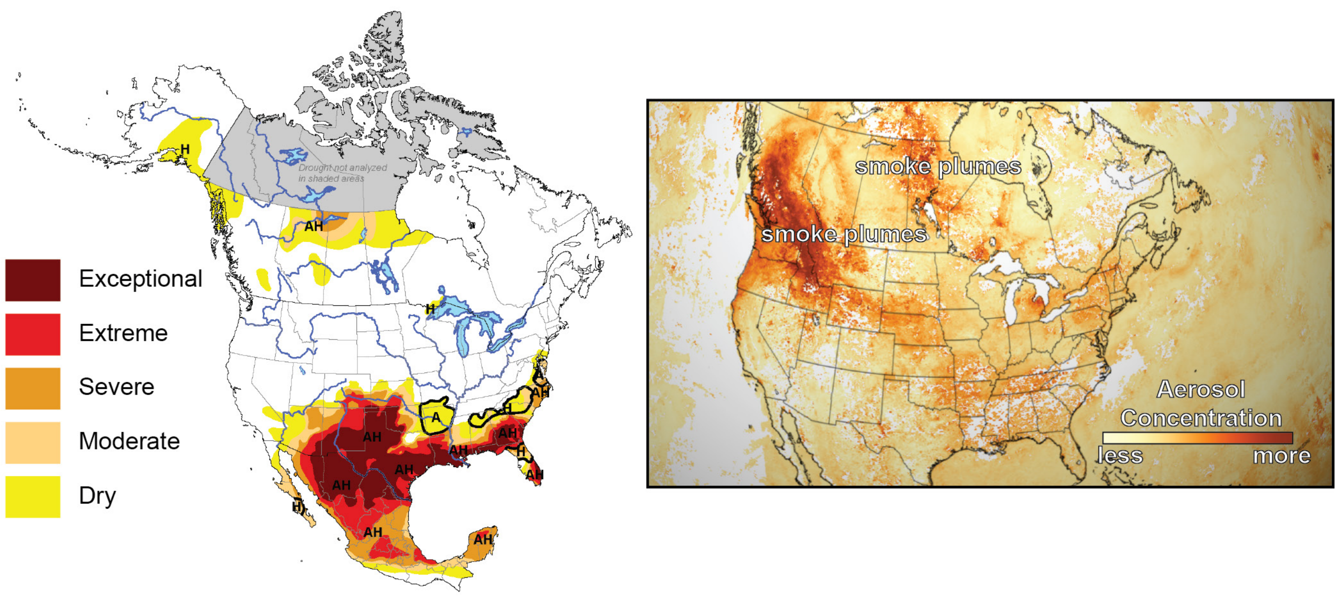


Figure 16.4: Shown here are examples of climate-related impacts spanning U.S. national borders. (left) The North American Drought Monitor map for June 2011 shows drought conditions along the US–Mexico border. Darker colors indicate greater intensity of drought (the letters A and H indicate agricultural and hydrological drought, respectively). (right) Smoke from Canadian wildfires in 2017 was detected by satellite sensors built to detect aerosols in the atmosphere. The darker orange areas indicate higher concentrations of smoke and hazy conditions moving south from British Columbia to the United States. Sources: (left) adapted from NOAA 2018,[114] (right) adapted from NOAA 2018.[115]

Box 16.1: Implications of Global Health Risks for the United States

Climate effects outside the United States can impact human health within the Nation as well as U.S. interests abroad, such as deployed military personnel.[116,117] For example, the past two decades have seen the introduction or reintroduction into the United States of several vector-borne diseases, including West Nile virus, dengue, chikungunya, and, most recently, Zika (Ch. 14: Human Health, Box 14.2).[118,119,120] While climate is only one factor influencing the spread of these diseases, warmer conditions and precipitation changes projected to occur outside and inside the United States could influence disease transmission across and within U.S. borders as well as habitat suitability for disease-carrying insects and pests.[121,122,123] Warmer temperatures provide the opportunity for mosquitoes and other disease-carrying pests to increase their geographic range. These changes, in combination with international travel patterns, could facilitate establishment of these diseases, especially in South Florida, the Texas–Mexico border area, and the U.S. Caribbean Territories.[124,125]

The management process of shared water resources is increasingly incorporating climate information into the decision-making process. Several agreements between countries have recently been restructured to consider changing weather patterns and related management challenges to include climate risk and adaptive management into their near- and long-term strategies. Along the Mexican border, the International Boundary and Water Commission, which implements water treaties between the United States and Mexico, is exploring an array of adaptive water management strategies (Ch. 25: Southwest, Box 25.1)[106] and utilizes an adaptive approach that can help with managing climate-related impacts on Colorado River water.[107] An example of this adaptive management approach is the design of flexible surface water and groundwater storage facilities, coupled with governance mechanisms that continuously account for changing climate conditions and water demand.

The International Joint Commission is also using adaptive management to address climate risks to U.S.–Canadian waters.[108] At the subnational level, the U.S.–Canada Great Lakes Water Quality Agreement incorporated a new annex in 2012 to identify, quantify, understand, and predict the impacts of climate change on Great Lakes water quality,[109] which has helped foster the binational development of new climate products for the Great Lakes (Ch. 21: Midwest, KM 3). Researchers are incorporating climate information into computer models of streamflow and reservoirs along the U.S.–Canada border to help decision-makers understand the long-term potential impacts to flood risk management, hydropower generation, and water availability in the Columbia River Basin.[110] This work is led by U.S. and Canadian agencies in partnerships with academic institutions and regional entities and can be utilized to inform management over long periods of time. These examples of including climate risk into the management of shared river and lake resources can be a model for improving resilience of other shared resources, such as fisheries.

In addition to government-to-government management of transboundary resources, public–private partnerships are increasingly helping to manage climate risks associated with these resources. For example, numerous efforts exist of transboundary collaboration in the Rio Grande–Rio Bravo Basin (Ch. 23: S. Great Plains, Case Study "Rio Grande Valley and Transboundary Issues"), including a bilateral public–private partnership that has implemented collaborative science, restoration, and monitoring actions to restore the river, with climate adaptation as one of the objectives. The partnership consists of businesses, nongovernmental conservation organizations, federal and

state agencies, academic institutions, private foundations, and the public from both Mexico and the United States.[104,111,112,113] The U.S. Caribbean (Ch. 20: U.S. Caribbean, KM 6) and Hawai‘i and the Pacific Islands (Ch. 27: Hawai‘i & Pacific Islands) are actively engaged with international partners to build adaptive capacity and reduce risks associated with climate change uncertainty at the regional level. Such international engagement may be more in demand in the future to address increasing vulnerabilities of transboundary resources.

Box 16.2: Benefits of International Scientific Cooperation on Climate Research

Cooperation with international science efforts significantly enhances understanding of the impacts of climate variability and climate change here in the United States. As described in the Executive Summary of the recently published *Climate Science Special Report: Fourth National Climate Assessment, Volume I*, changes in the Earth's atmosphere, oceans, land surface, and ice sheets can have major effects on U.S. climate and interests.[3] For example, projected sea level changes in the United States are driven in part by changes that occur outside of our borders in ice sheets, glaciers, and water temperatures.[64,126,127] While localized phenomena, such as coastal subsidence (sinking of land) and regional variance in sea levels, contribute to global sea level rise, understanding the contribution of global-scale changes is critical. Rainfall and temperature patterns in parts of the United States are affected by the El Niño–Southern Oscillation (ENSO), a climatic phenomenon that occurs in the tropical Pacific Ocean. Understanding such global-scale phenomena exceeds the capabilities of any one country alone.[3,128] Furthermore, international collaboration can enhance institutional adaptive capacity as noted in the U.S. Caribbean chapter (Ch. 20) of this report. Through the Global Change Research Act of 1990, Congress recognizes and mandates the importance of U.S. engagement and leadership in international scientific research.[129] Cooperation with other international and national scientific organizations enables the United States to better observe, understand, assess, and manage the impacts of climate processes on U.S. interests within and outside of national borders. Examples of benefits to the United States of international scientific cooperation include

- *access to observations, data, and knowledge* that can shed light on how distant processes affect U.S. climate;[130,131,132]
- *opportunities to leverage funding and equipment* in the development and maintenance of climate observing systems, spreading the cost among countries that participate, including the United States;[133,134,135,136]
- *knowledge of climate impacts in regions and sectors of interest to the United States*, which can be used to inform decisions about humanitarian and development assistance, national security, and transboundary resource management;[51,137]
- *the ability to shape the priorities of an increasingly global and interdisciplinary research community*, which can help focus attention and resources on issues relevant to the United States through participation in joint research efforts[138,139] and assessments;[140,141,142] and
- *mechanisms to share technical expertise and experiences with other countries, regions, and communities with respect to climate services, adaptation, resilience building, and sustainable development* in order to apply lessons learned in other regions to U.S. risk management challenges.[143,144,145,146]

Box 16.3: How Well Are Climate Risks to U.S. International Interests Understood and Addressed?

There is high confidence that climate change, variability, and extreme events can result in profound consequences for U.S. international interests relating to economy and trade (Key Message 1), development and humanitarian assistance (Key Message 2), national security (Key Message 3), and managing shared resources across our borders (Key Message 4). Projections of climate change indicate that these impacts will continue throughout the century and will likely accelerate in the future.[3]

Despite this level of confidence, the mechanisms by which climate impacts beyond American borders can affect U.S. interests are not uniformly well understood. Some of this uncertainty arises because these impacts are part of complex systems, and understanding how climate change, variability, and extremes affect such systems can be challenging (Ch. 17: Complex Systems). For example, as noted in Key Message 3, the connections between climate and national security are complex because national security can be affected through intermediate processes such as resource competition. Such processes are challenging to model and forecast because they can be affected by such difficult-to-predict factors as policy decisions, human behavior, and climate surprises.[147]

In addition, the literature on climate impacts on U.S. international interests is at an early stage of development. For example, while there is a relatively well-developed literature on the potential global economic impacts of climate change (e.g., IPCC 2014, Mani et al. 2018[1,148]), there is a much more limited literature on the implications of such impacts for U.S. businesses, their supply lines, economics, and trade (see Key Message 1). Research on the potential consequences of international climate change on U.S. economics and trade, coupled with analyses of the impacts of climate change within U.S. borders, could provide key insights to better understand impacts and inform actions that promote the well-being of the U.S. economy.

Efforts are underway to adapt to climate change, variability, and extreme events in all four of the Key Message topics addressed in this chapter. However, our understanding about the effectiveness of these particular adaptations and their potential to offset adverse impacts (or take advantage of positive impacts) is quite limited (Ch. 28: Adaptation, Figure 28.1). One explanation is that many of these international-related adaptations have not been in place long (such as the incorporation of climate change projections into transboundary water management efforts; Key Message 4), and there have been relatively few attempts to assess and evaluate their effectiveness. In addition, multiple stakeholders (such as other development organizations, host country governments, nongovernmental organizations, and the private sector) and other factors (such as condition of infrastructure, governance) may have a role in adaptation beyond our borders, thus making it challenging to assess the efficacy of international adaptation actions. Nonetheless, it appears to be highly unlikely that the measures implemented so far will fully avoid or offset the adverse impacts of climate change, variability, and extremes on U.S. international interests.

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USGCRP Coordinator
Apurva Dave
International Coordinator and Senior Analyst

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Traceable Accounts

Process Description

The Fourth National Climate Assessment (NCA4) is the first U.S. National Climate Assessment (NCA) to include a chapter that addresses the impacts of climate change beyond the borders of the United States. This chapter was included in NCA4 in response to comments received during public review of the Third National Climate Assessment (NCA3) that proposed that future NCAs include an analysis of international impacts of climate change as they relate to U.S. interests.

This chapter focuses on the implications of international impacts of climate change on U.S. interests. It does not address or summarize all international impacts of climate change; that very broad topic is covered by Working Group II of the Intergovernmental Panel on Climate Change (IPCC; e.g., IPCC 2014[1]). The U.S. government supports and participates in the IPCC process. The more focused topic of how U.S. interests can be affected by climate impacts outside of the United States is not specifically addressed by the IPCC.

The topics in the chapter—economics and trade, international development and humanitarian assistance, national security, and transboundary resources—were selected because they illustrate ways in which U.S. interests can be affected by international climate impacts. These topics cut across the world, so the chapter does not focus on impacts in specific regions.

The transboundary section was added to address climate-related impacts across U.S. borders. While the regional chapters address local and regional transboundary impacts, they do not address impacts that exist in multiple regions or agreements between the United States and its neighbors that create mechanisms for addressing such impacts.

The science section is part of the chapter because of the importance of international scientific cooperation to our understanding of climate science. That topic is not treated as a separate section because it is not a risk-based issue and therefore not an appropriate candidate to have as a Key Message.

The U.S. Global Change Research Program (USGCRP) put out a call for authors for the International chapter both inside and outside the Federal Government. The USGCRP asked for nominations of and by individuals with experience and knowledge on international climate change impacts and implications for the United States as well as experience in assessments such as the NCA.

All of the authors selected for the chapter have extensive experience in international climate change, and several had been authors on past NCAs. Section lead assignments were made based on the expertise of the individuals and, for those authors who are current federal employees, based on the expertise of the agencies. The author team of ten individuals is evenly divided between federal and non-federal personnel.

The coordinating lead author (CLA) and USGCRP organized two public outreach meetings. The first meeting was held at the Wilson Center in Washington, DC, on September 15, 2016, as part of the U.S. Agency for International Development's (USAID) Adaptation Community Meetings and solicited input on the outline of the chapter and asked for volunteers to become chapter authors or otherwise contribute to the chapter. A public review meeting regarding the International

chapter was held on April 6, 2017, at Chemonics in Washington, DC, also as part of USAID's Adaptation Community Meetings series. The USGCRP and chapter authors shared information about the progress to date of the International chapter and sought input from stakeholders to help inform further development of the chapter, as well as to raise general awareness of the process and timeline for NCA4.

The chapter was revised in response to comments from the public and from the National Academy of Sciences. The comments were reviewed and discussed by the entire author team and the review editor, Dr. Diana Liverman of the University of Arizona. Individual authors drafted responses to comments on their sections, while the CLA and the chapter lead (CL) drafted responses to comments that pertained to the entire chapter. All comments were reviewed by the CLA and CL. The review editor reviewed responses to comments and revisions to the chapter to ensure that all comments had been considered by the authors.

Key Message 1

Economics and Trade

The impacts of climate change, variability, and extreme events outside the United States are affecting and are virtually certain to increasingly affect U.S. trade and economy, including import and export prices and businesses with overseas operations and supply chains (*very likely, medium confidence*).

Description of evidence base

Major U.S. firms are concerned about potential climate change impacts to their business (e.g., Peace et al. 2013, Peace and Maher 2015[10,11] and illustrative examples of SEC filings describing climate risks to U.S. companies operating abroad[6,7,8,9]). Examples include the 2011 food price spike[20,21] and the 2011 Bangkok flooding; corresponding prolonged and cascading impacts to transportation and supply chains are documented in the citations related to those issues.[23,24,25] Future changes in precipitation, temperature, and sea level (among other factors) are very likely, as described in USGCRP,[3] and are very likely to exacerbate impacts on the U.S. economy and trade, relative to past impacts.

Major uncertainties

The literature base on the impacts of climate change outside U.S. borders to the U.S. economy and trade is significantly smaller than that on climate change impacts within U.S. borders. In particular, few studies have attempted to quantify the magnitude of the past impacts of climate variability and change that occur outside the United States on U.S. economics and trade. Since there is limited literature, it is unclear how climate-driven regional shifts in economic activity will affect U.S. economics and trade. Nonetheless, the general nature of the main types of impacts described in this section are relatively well known.

Description of confidence and likelihood

The portion of the main message pertaining to the future is *very likely* due to the likelihood of future climate change[3] and persistence of the sensitivity of the U.S. economy and its trade to climate conditions. There is *medium confidence* that climate change and extremes outside the

United States are impacting and will increasingly impact our trade and economy because there is insufficient empirical analysis on the causal relationships between past international climate variations outside the United States and U.S. economics and trade to provide higher confidence at this time. No attempt was made in this chapter to define the net impact of international climate change on the U.S. economy and trade; such a statement would have had very low confidence due to the current paucity of quantitative analyses.

Key Message 2

International Development and Humanitarian Assistance

The impacts of climate change, variability, and extreme events can slow or reverse social and economic progress in developing countries, thus undermining international aid and investments made by the United States and increasing the need for humanitarian assistance and disaster relief (*likely, high confidence*). The United States provides technical and financial support to help developing countries better anticipate and address the impacts of climate change, variability, and extreme events.

Description of evidence base

The link between climate variability, natural disasters, and socioeconomic development is fairly well established (e.g., UNISDR 2015, Hallegatte et al. 2017[149,150]), though some uncertainties about this relationship remain.[151] Humanitarian disasters driven by climate impacts have led to specific changes in U.S. development assistance. For instance, the Famine Early Warning Systems Network (FEWS NET) was created after the droughts that contributed to mass starvation in Ethiopia in the mid-1980s. More recent crises in the Horn of Africa prompted major investments in resilience at the USAID.[152]

The relationship between climate change and socioeconomic development has been assessed extensively by the Intergovernmental Panel on Climate Change through its assessment reports (e.g., IPCC 2014[1]). There is some research on the economic costs and benefits from climate change (e.g., Nordhaus 1994, Stern et al. 2006, Estrada et al. 2017, Tol 2018[153,154,155,156]). However, it can be difficult to separate climate impacts on a sector from the role of other impacts, such as weak governance (Ch. 17: Complex Systems).

The United States has long invested in socioeconomic development in poorer countries with the intention of reducing poverty and encouraging stability. Additionally, stable and prosperous countries make for potential trading partners and a reduced risk of conflict. These ideas are presented in numerous U.S. development, diplomacy, and security strategies (e.g., U.S. Department of State and USAID 2018, 2015[40,41]). There is ample evidence that the United States has invested in measures to reduce climate risks and build resilience in developing countries (e.g., USAID 2016[157]). However, this chapter does not assess the efficacy of these efforts.

Major uncertainties

Climate change adaptation is an emerging field, and most adaptation work is being carried out by governments, local communities, and development practitioners through support from development agencies and multilateral institutions. Evaluations of the effectiveness of adaptation

interventions are generally conducted at the project level for its funder, and results may not be publicized. Some research is emerging on the economic benefits of adaptation interventions (e.g., Hallegatte et al. 2016, Chambwera et al. 2014[158,159]). Over time, it is likely that more activities will be implemented, more evaluations will be conducted, and the evidence base will grow.

Description of confidence and likelihood

There is *high confidence* in the Key Message. There is ample evidence that the impacts of climate variability and change negatively affect the economies and societies of developing countries and set back development efforts. There is also evidence of these impacts leading to additional U.S. interventions, whether through humanitarian or other means, in some places.

Key Message 3

Climate and National Security

Climate change, variability, and extreme events, in conjunction with other factors, can exacerbate conflict, which has implications for U.S. national security (*medium confidence*). Climate impacts already affect U.S. military infrastructure, and the U.S. military is incorporating climate risks in its planning (*high confidence*).

Description of evidence base

Based on an assessment of a wide range of scientific literature on climate and security, multiple national security reports have framed climate change as a stressor on national security.[59,60,62,160,161,162,163] A large body of research has examined how stress due to adverse climatic conditions may affect human and national security in relation to conflict. While a few studies clearly link climatic stress to insecurity conflict,[164,165] more often studies do not find a measurable direct response.[70,77,82,166,167,168,169,170] Instead, the relationship between climate and conflict is often framed as climate stress affecting conflict through intermediate processes, including commodity price shocks and food and water security, which are themselves documented stressors on conflict.[61,71,72] Many studies focus on Africa, but evidence exists throughout the world.[76,77,78,80,81,82,83] Additional complexity arises from evidence of a range of societal responses to resource scarcity such as that brought on by climate change and natural variability.[61]

The U.S. military is observing climate change impacts to its infrastructure and is taking a scenario-driven, risk-based approach to address resultant challenges. Exceedance probability plots of the type used to support engineering siting and design analysis were used but modified to include responses to time-specific tidal phases and historical trends to create an estimate of the "present day" exceedance probability. The hindcast projections kept pace with an Intermediate-Low sea level rise scenario of approximately 5 mm/year (about 0.2 inches/year).[171] The focus for Department of Defense (DoD) infrastructure management, however, is the resultant increased trend for exceedances that would challenge infrastructure functional integrity (such as negative impacts to critical roadways and airfields).[171] In an effort to understand risks to the integrity of coastal facilities more broadly, the DoD uses a scenario-driven risk management approach to support decision-making regarding its coastal installations and facilities. The scenario approaches provide a framework for the inherent uncertainties of future events while providing decision support. Scenarios are not simply predictions about the future but rather plausible futures bounded by

observations and the constraints of physics. Using scenarios, decision-makers can then examine risks through the lens of event impacts, costs of additional analysis, and the results of inaction. In this way, inaction is recognized as an important decision in its own right.[64]

Major uncertainties

The impact and risk of conflict related to climate change is difficult to separate from other drivers of environmental vulnerability, including economic activity, education, health, and food security.[61,70] There is currently a lack of robust theories that fully explain causality and associations between climate change and conflict.

Datasets on climate change, conflict, and security are often limited in length and pose statistical difficulties.[70] However, recent advances in statistical analysis have begun to allow the quantification of indirect effects of multiple variables connecting climatic pressures and violence.[172] These results are preliminary, mostly due to a lack of necessary data and the difficulty of quantifying relevant social variables, such as identity politics or grievances. There is a widespread pattern of examining instances of conflict for drivers, precluding the possibility of finding that climate-related stressors did not result in conflict. There is a need to analyze situations where no conflict occurred despite existing climate risks. Intercomparison of quantitative studies of the link between conflict and adverse climate conditions is complicated because the wide range of climatic and social indicators differ in spatial and temporal coverage, often due to a lack of data availability. Prehistoric and premodern evidence of the impact of climate change on conflict is not necessarily relevant to modern societies,[167] and some of the climate shifts currently being faced are unprecedented over centuries to millennia.[170] Therefore, the possible existence of a relationship is better understood than its particulars and is best expressed in the formulation that climate extremes and change *can* exacerbate conflict.

The ongoing Syrian conflict is often framed in terms of climate change. However, it is not possible to draw conclusions on the role of climate in the outcome of an ongoing conflict. Moreover, the role of climate variability (such as drought), the contribution of climate change to such variability, and the contribution of climate variability to the subsequent conflict is a matter of active debate in the assessed literature.[173,174,175,176]

The documented impacts of climate on national security largely occur through processes associated with natural climate variability, such as drought, El Niño, and tropical storms. While observed and projected increases in extreme weather and climate events have been attributed to climate change, uncertainty remains.[48,177,178,179]

Similarly, additional studies are underway to determine the potential impacts of climate change on DoD resources and mission capabilities. Many of these efforts seek to assess the vulnerability of infrastructure to climate change across a wide variety of ecosystems.[180,181,182]

Description of confidence and likelihood

There is consensus on framing climate as a stressor on other factors contributing to national security. Given the knowledge of factors that increase the risk of civil wars, and evidence that some of these factors are sensitive to climate change, the IPCC found justifiable concern that “climate change or changes in climate variability [could] increase the risk of armed conflict in

certain circumstances."[61] However, the literature examining specific causality does not result in a high confidence conclusion to link climate and conflict, which is reflected in the Key Message *medium confidence* assignment. Multiple schools of thought exist on the mechanisms and degree of linkages, and models are incomplete. Data are improving and evidence continues to emerge, but the inconsistent evidence limits our ability to assign a probability to this Key Message.

Nonetheless, with regard to climate impacts on physical infrastructure, the DoD observes changes in the infrastructure at its installations that are consistent with climate change. In keeping with sound stewardship and prudence, it uses scenario-driven approaches to identify areas of risk while continuing to research and provide resilient responses to the observed changes.

Key Message 4

Transboundary Resources

Shared resources along U.S. land and maritime borders provide direct benefits to Americans and are vulnerable to impacts from a changing climate, variability, and extremes (*very likely, high confidence*). Multinational frameworks that manage shared resources are increasingly incorporating climate risk in their transboundary decision-making processes.

Description of evidence base

In the U.S.–Mexico drylands region, large areas are projected to become drier,[102] which will present increasing demands for water resources on top of existing stresses related to population growth.[103,104] There is *high confidence* that resources critical to livelihoods at borders between the United States and neighboring nations are becoming increasingly vulnerable to impacts of climate change and that the multinational frameworks that manage these resources are increasingly incorporating research-based understanding of the climate risks that these resources face. The literature supporting the Key Message is substantial, increasing in quantity and robustness.[96,97,98,99,100,105] The current impacts are well documented, and the projections of future impacts are aligned with the robust projections of future climate variability.[94,95] The literature also provides examples of bilateral agreements and management frameworks in place to manage these resources. Examples of the impacts include the migration northward into Canadian waters of Pacific hake, a migratory species sensitive to water temperature, during periods of warmer water temperature.[100] One example of a bilateral management framework is the inclusion in 2012 of a climate change impacts annex to the U.S.–Canada Great Lakes Water Quality Agreement to identify, quantify, understand, and predict climate change impacts on the water quality of the Great Lakes.[109]

Major uncertainties

Impacts on shared resources along U.S. international borders are already being experienced. Uncertainties about the impacts are aligned with the uncertainties associated with projections of future climate variability. As elaborated upon in multiple regional chapters of this report (Ch. 18: Northeast; Ch. 20: U.S. Caribbean; Ch. 21: Midwest; Ch. 24: Northwest; Ch. 25: Southwest; Ch. 26: Alaska; Ch. 27: Hawai'i & Pacific Islands), weather patterns in these border regions are projected to continue to change with varying degrees of likelihood and confidence.

Description of confidence and likelihood

There is *high confidence* in the main message. There is sufficient empirical analysis on the relationships between past climate variations along U.S. international borders. The statement about the likelihood that impacts on shared resources will affect the bilateral frameworks established to manage these resources is based on expert understanding of the integration of climate risk into existing and future frameworks.

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