FEMA Response and Recovery Climate Change Planning Guidance

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Handling Instructions

Questions pertaining to the distribution or transmission of this *FEMA Response and Recovery Climate Change Planning Guidance* document should be submitted to the Federal Emergency Management Agency (FEMA) the Planning and Exercise Division within the Office of Response and Recovery at fema-response-ped@fema.dhs.gov.

Intended Audience

The intended audience for this climate change guidance document includes all internal FEMA response and recovery planners.

Use of this Document

This guidance document provides background on climate change and how it impacts emergency management operations and also provides steps and considerations to incorporate into existing planning processes and products. General operational procedures and responsibilities are outlined in the *Response and Recovery Federal Interagency Operational Plan* (FIOP).

Record of Changes

Version	Date	Summary of Changes	Name

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INTRODUCTION

Purpose

Goal 2 of the *2022-2026 FEMA Strategic Plan* is to lead the whole of community in climate resilience by increasing climate literacy among the emergency management community, building a climate-resilient nation, and empowering risk-informed decision making. Climate change has resulted in verified impacts to populations, infrastructure, and the economy across the nation. The acceleration of climate change will increase the frequency and intensity of natural disasters and thereby increase the probability of climate-related threats. By anticipating increased response and recovery demands generated by more extreme and frequent disasters, emergency managers can devise ways to manage the impacts from changing climate patterns. This guidance is intended to provide FEMA national and regional planners with an overview of changes to the risk profiles of climate-related hazards for every region so that they may conduct appropriate response and recovery planning activities.

Adapting risk profiles for established hazards requires guidance on how to find and incorporate climate information. Most FEMA deliberate plans are developed for the national and regional levels. Typically, these plans are based on short-term assumptions about future conditions using observed data on meteorological conditions. While historical data are essential, they are no longer sufficient given the reality of climate change. Using a defined timeframe and operational area, emergency management planners can define climate-related risks and validate anticipated impacts by accessing authoritative climate resources.

Scope

This guidance is a standalone, internal FEMA document focused on high-level, practical, and actionable inputs. This guidance document is tailored to FEMA planning efforts aimed at response, stabilization, short-term recovery actions, long-term recovery considerations, and related readiness activities for climate-related incidents. Table 1 describes what this guidance document does and does not provide.

Table 1: Climate Change Guidance Scope

This Guidance Does Provide:	This Guidance Does Not Provide:
• An overview of climate change and general insights from climate assessments on observed climate-related impacts • Input regarding how FEMA should expand its threat/hazard profiles[1] based on climate change trends and predictions • Climate change planning considerations to inform FEMA's deliberate plans for federal emergency response and recovery operations	• Details on climate emissions scenarios • Actions to mitigate against long-term climate shifts • Other federal agencies' climate change responsibilities

[1] FEMA, National Risk and Capability Assessment, https://www.fema.gov/emergency-managers/risk-management/risk-capability-assessment.

Authorities

The required authorities to respond to an incident related to climate change will vary based on the specific incident and whether the incident results in a Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) declaration.

The primary agency for funding associated with non-Stafford Act incidents is dependent on the lead federal agency for the incident, which varies based on express and implied statutory authorities and the type and/or magnitude of the incident.[2]

FEMA is the primary funding agency for Stafford Act incidents. FEMA initiates mission assignments as a means to task and coordinate with other federal departments and agencies in providing immediate, short-term emergency response support. Types of mission assignments include Direct Federal Assistance (DFA) and Federal Operations Support (FOS). The availability of Stafford Act funding is generally triggered by a Presidential declaration of an emergency that is declared pursuant to Title V of the Stafford Act or a major disaster that is declared pursuant to Title IV of the Stafford Act.

FEMA considers environmental justice impacts as required by Executive Order 12898 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations), which directs each federal agency to avoid disproportionately high and adverse human health or environmental effects on low-income and minority populations. In accordance with Title VI of the Civil Rights Act of 1964, each federal agency shall ensure that all programs or activities receiving federal financial assistance that affect human health or the environment do not directly, or through contractual or other arrangements, use criteria, methods, or practices that discriminate on the basis of race, color, or national origin.[3]

See **Annex A: Executive/Statutory Authorities** for additional information on climate change authorities.

[2] Presidential Policy Directive 44: Enhancing Domestic Incident Response, https://www.hsdl.org/c/abstract/?docid=872547.

[3] Executive Order 12898 – Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, https://www.epa.gov/sites/default/files/2015-02/documents/clinton_memo_12898.pdf.

BACKGROUND

Climate Change Overview

Weather is what people experience when they step outside on any given day and is a result of the state of the atmosphere at a particular location over the short term. Weather is a function of atmospheric conditions that can change quickly from one moment to the next and over short distances.

Across the globe, observers and automated stations measure hourly or daily weather conditions at thousands of locations. Over time, these weather observations allow us to quantify long-term average conditions, which provide insight into an area's climate.

Climate can be described as the "average weather" for an area; it refers to the average of the meteorological conditions and weather patterns that occur over long time periods. The World Meteorological Organization (WMO) calculates climate conditions based on 30-year increments. It is common to see climate data reported by decade, season, or even for a given day of the year. In each of these cases, climatologists calculate average conditions based on many observations.

Climate encompasses the observable and long-term predictable trends and patterns for weather in regions constrained by geographic factors such as mountain ranges, coastlines, or interior plains. The expected conditions (climate) for a given location will differ from one week or month to the next as a function of global patterns, which include the relative angle of the sun's rays as seasons progress, ocean temperatures, and the behavior of large air masses.

Climate vs. Weather

Weather is the condition of the atmosphere over a short period of time that can change within minutes or hours.

Climate is how the atmosphere behaves over a long period of time, or the average regional weather patterns over decades.

Through geologic time, Earth's climate has varied, reflecting the complex interactions and dependencies of the solar, oceanic, terrestrial, atmospheric, and living components that make up Earth's systems. Earth experiences long cycles of warming and cooling that span tens of thousands to 100,000 years in length. The cycles are believed to be associated with regular changes in Earth's orbit that alter the intensity of the solar energy that the planet receives, absorbs, and reflects. Earth's climate has also been influenced on a very long timescale by changes in atmospheric chemistry and ocean circulation. Earth's climate has also changed due to sudden events, such as massive volcanic eruptions.

The rate of climate change in the 20th century stands out in the geological record as extremely rapid, especially relative to the last 10,000 years. Over the 21st century, climate scientists expect Earth's temperature will rise at an increasing rate, leading to more cumulative change than observed throughout the 20th century.[4] These changes have been occurring due to the influence of human emissions of greenhouse gases. Changes in land cover impact both weather and climate by altering the concentration of greenhouse gases and the exchange of energy between land and the atmosphere. For example, reforestation can provide localized cooling, but continued warming is expected in urban areas, which will exacerbate urban heat island effects.[5]

Greenhouse Gases (GHGs)

GHGs are gases that trap heat and solar radiation in Earth's atmosphere rather than allowing them to escape into space. This process of heating the atmosphere is known as the *greenhouse effect*. GHGs include carbon dioxide, methane, ozone, nitrous oxide, and industrial gases. Except for industrial gases, all are naturally occurring and are important for regulating Earth's temperature. Human activities have increased the amounts of carbon dioxide, methane, nitrous oxide, and industrial gases in the atmosphere, creating an imbalance in the complex system of feedback loops in Earth's warming atmosphere and leading to changes in the climate.

Weather and climate are often compared. Media reports often contextualize a given day or week's weather by comparing it to the observed climate record of average high, low, and mean values recorded in the 20th century. For instance, the highest temperature on an especially hot day might be compared to the historical average high temperature for that day in that location. Likewise, the lowest temperature in winter might be compared to the historical low temperature on that day in that location. Climate change refers to recent rapid shifts in those expected average values. What people 30 years ago considered "normal" or "average" is no longer an appropriate baseline for understanding a given day's weather.

Although FEMA responds to weather, climate projections indicate an increased frequency and intensity of weather-related incidents.

The National Oceanic and Atmospheric Administration (NOAA) monitors how global climate data changes through time in its annual assessment and reports results through several Climate Change Indicators on its Global Climate Dashboard. Below are some of the NOAA Climate Change Indicators tracked through NOAA's Global Climate Dashboard:

[4] NOAA, *Climate Literacy: The Essential Principles of Climate Sciences*, https://www.climate.gov/teaching/climate.

[5] *Fourth National Climate Assessment* (2018), U.S. Global Change Research Program (USGCRP), Chapter 5: Land Cover and Land-Use Change, https://nca2018.globalchange.gov/chapter/5/.

- **Annual Greenhouse Gas Index**: Tracks the combined warming influence of the long-lived trace gases in the atmosphere, including carbon dioxide, methane, nitrous dioxide, and several industrial chemicals. Carbon dioxide is the largest contributor to human-caused global warming.
    - According to the NOAA Global Monitoring Lab, the amount of carbon dioxide in the atmosphere has risen by 25 percent since 1958 and by about 40 percent since the Industrial Revolution.[6]
- **Arctic Sea Ice**: Tracks sea ice extent in the Arctic at the end of the summer melt season (each September) based on satellite observations.
    - The area covered by sea ice in the Arctic at the end of summer has shrunk by about 40 percent since 1979.[7]
- **Global Surface Temperature**: Tracks temperature measurements taken at locations around the globe, which are converted from absolute temperature readings to temperature anomalies.
    - Global temperatures rose about 1.8°F (1°C) from 1901 to 2020.[8]
- **Global Sea Level**: Tracks sea level estimates provided through tide gauges and satellite altimeters. Tide gauge stations worldwide measure daily high and low tides, which scientists use to calculate a global average. Sea level is also measured from space using radar altimeters.
    - Sea level rise has accelerated from a 1.7 mm/year increase throughout most of the 20th century to a 3.2 mm/year increase since 1993.[9]

Climate Equity

The goal of climate equity is to recognize and address unequal social and economic burdens imposed upon vulnerable populations from climate change and to ensure that all people share the benefits of climate protection efforts. Climate equity recognizes that specific populations are particularly vulnerable to climate change impacts, including socially vulnerable and underserved populations.[10]

Socially vulnerable populations consist of people at a disadvantage of recovering from disasters based on factors such as age, ethnicity, race, socioeconomic status, access to decision-making power, gender, employment, wealth, and other factors. Underserved

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[6] NOAA, Climate Change: Atmospheric Carbon Dioxide, https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide.

[7] NOAA, Climate Change: Arctic Sea Ice Summer Minimum, https://www.climate.gov/news-features/understanding-climate/climate-change-arctic-sea-ice-summer-minimum.

[8] NOAA, Climate Change: Global Temperature, https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature.

[9] NOAA, Climate Change: Global Sea Level, https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level.

[10] EPA, Climate Equity, https://www.epa.gov/climateimpacts/climate-equity#:~:text=Climate%20equity%20is%20the%20goal%20of%20recognizing%20and,people%20share%20the%20benefits%20of%20climate%20protection%20efforts.

communities[11] are groups that have limited or no access to resources or are otherwise disenfranchised.

Climate Equity Considerations

- Communities are differentially exposed to hazards and are disproportionately affected by climate-related health risks. Populations experiencing greater health risks include children, older adults, economically disadvantaged communities, and minority populations.
- The effects of extreme weather events are magnified in underserved communities located in risk-prone areas, which typically have poor quality or aging infrastructure and lack sufficient resources to invest in preparedness and resilience building.
- Approximately 40 percent of populations that live in coastal counties fall into an elevated risk category. This includes children, the elderly, households where English is not the primary language, and those living in poverty.[12]
- Black populations aged 65 and older have the most disproportionate risk, relative to their reference population, of residing in areas that have the highest projected increases in premature mortality from climate-driven changes.[13]
- Low-income households near floodplains are more exposed to water pollutants, particularly due to sea level rise, heavy rainfall, or extreme weather events. They may also have higher flood insurance costs and more difficulty getting insurance.[14]
- Various tools capture social vulnerability (including the Centers for Disease Control and Prevention's [CDC's] Social Vulnerability Index [SVI] and the Council on Environmental Quality's [CEQ's] Climate and Economic Justice Screening Tool [CEJST])[15] that can help planners better understand where the potential negative effects on communities from climate change may be exacerbated by disasters and then align planning efforts with FEMA grant program evaluation criteria.

[11] Executive Order 13985, Sec. 2, Definitions: For purposes of this order: (a) The term "equity" means the consistent and systematic fair, just, and impartial treatment of all individuals, including individuals who belong to underserved communities that have been denied such treatment, such as Black, Latino, and Indigenous and Native American persons, Asian Americans and Pacific Islanders and other persons of color; members of religious minorities; lesbian, gay, bisexual, transgender, and queer (LGBTQ+) persons; persons with disabilities; persons who live in rural areas; and persons otherwise adversely affected by persistent poverty or inequality.

(b) The term "underserved communities" refers to populations sharing a particular characteristic, as well as geographic communities, that have been systematically denied a full opportunity to participate in aspects of economic, social, and civic life, as exemplified by the list in the preceding definition of "equity."

[12] NOAA, Economics and Demographics, https://coast.noaa.gov/states/fast-facts/economics-and-demographics.html.

[13] EPA (2021), *Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts*, https://www.epa.gov/system/files/documents/2021-09/climate-vulnerability_september-2021_508.pdf.

[14] EPA, Climate Change and the Health of Socially Vulnerable People, https://www.epa.gov/climateimpacts/climate-change-and-health-socially-vulnerable-people.

[15] Addendum to the Interim Implementation Guidance for the Justice40 Initiative, M-21-28, on using the Climate and Economic Justice Screening Tool (CEJST), https://www.whitehouse.gov/wp-content/uploads/2023/01/M-23-09_Signed_CEQ_CPO.pdf.

Environmental Justice

Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, culture, national origin, income, and educational levels with respect to the development, implementation, and enforcement of protective environmental laws, regulations, and policies. Environmental justice communities, also called overburdened communities, refer to minority, low-income, tribal, and indigenous populations or communities that experience disproportionate environmental harms and risks from exposure, or greater vulnerability, to the cumulative impacts from environmental hazards. This increased vulnerability may be attributable to an accumulation of negative, or lack of positive, environmental, health, economic, or social conditions within such populations.

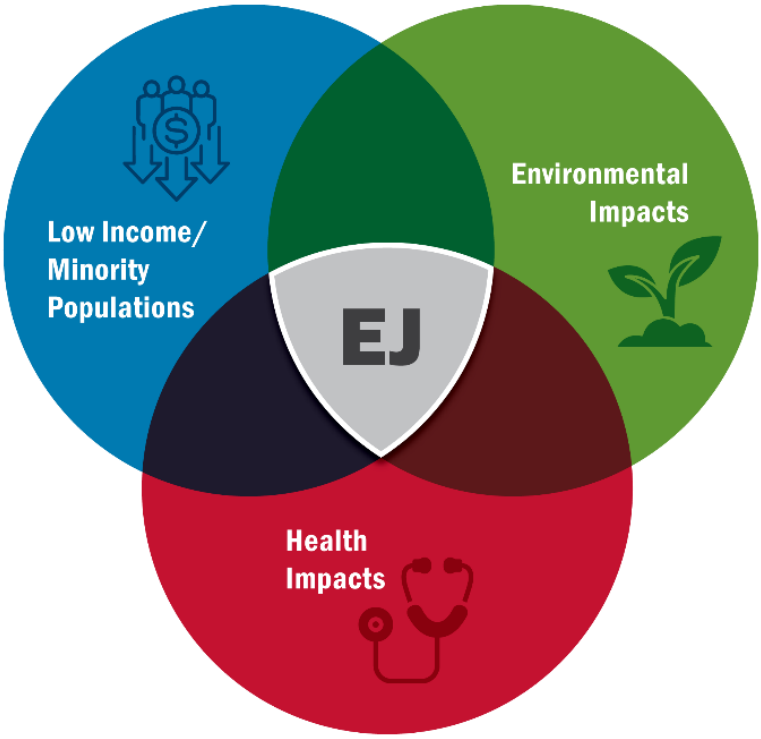

Figure 1: Environmental Justice Communities

For FEMA, environmental justice focuses on human health and environmental impacts on low-income and minority populations as required by Executive Order 12898. FEMA uses the U.S. Environmental Protection Agency's (EPA's) Environmental Justice Screening and Mapping Tool (EJScreen) to make environmental justice determinations. For FEMA to classify a community as low-income or minority, at least one of those populations must exceed the 50th percentile compared to the state average or exceed the 80th percentile based on one of the Environmental Justice (EJ) Indexes. EJ Indexes factor in the Demographic Index (average of Demographic Indicators) with each Environmental Indicator for every census block group. If the value is above the 80th percentile, the low-income and/or minority populations are overburdened by specific environmental stressors, such as particulate matter, traffic

proximity, hazardous waste proximity, etc. In those cases, the Demographic Indicators (*Low-Income* and *People of Color*) will not necessarily exceed the 50th percentile individually. The value could be lower than the 50th percentile, but those census block groups are particularly susceptible and sensitive to pollution. As such, FEMA also classifies communities exceeding the 80th percentile for any one of the EJ Indexes as low-income and/or minority communities.

FEMA uses the CEQ's definitions for the identification of populations disproportionately exposed to high and adverse environmental and human health effects.[16] Adverse health impacts may include bodily impairment, infirmity, illness, or death. Adverse environmental impacts may include ecological, cultural, human health, economic, or social impacts when those impacts are related to impacts on the natural or physical environment. The degree of impact to vulnerable populations and the resolution of those impacts may vary. There are guidelines for determining actions that are likely to have disproportionately high and adverse effects on human health and the environment.[17]

EPA's Office of Environmental Justice offers online tools and resources to support the integration of environmental justice considerations. Although their focus relates to EPA actions, the tools can serve as a starting point for incorporating environmental justice planning considerations into emergency management response and recovery operations.

Emerging Trends and Threats

Current and Anticipated Changes to Regional Hazards

Climate change is anticipated to affect emergency management response and recovery actions due to the impacts of climate change on meteorological and climate-related hazards. Changing weather patterns will make disasters more frequent and extreme and will affect a greater number of areas.

For example, the following list details hazards that are common in emergency management plans and provides examples of associated climate-related risk factors to consider. **Annex B: Climate Change Threat/Hazard Profiles** provides more detailed information on each of these hazards and how they are impacted by climate change.

- **Drought**: As temperatures climb, evaporation rates increase. In drought conditions, high evaporation rates will make droughts worse. Severe droughts can threaten drinking water supplies and disrupt agriculture.

[16] *Environmental Justice: Guidance Under the National Environmental Policy Act*, Council on Environmental Quality, December 10, 1997, p. 26, https://www.energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/G-CEQ-EJGuidance.pdf.

[17] *Promising Practices for EJ Methodologies in NEPA Reviews*, EPA, p. 29, https://www.epa.gov/sites/default/files/2016-05/documents/iwg_promising_practices_final_5-16-2016.pdf.

- **Extreme Heat**: The annual number of very hot days is increasing. Extreme heat is now affecting areas of the country that are unfamiliar with this hazard. Of all weather-related hazards, extreme heat causes the highest number of deaths each year.[18]
- **Coastal Flooding**: Rising sea levels are contributing to more frequent and intense coastal floods and storm surges. This can have significant impacts on coastal communities, including damage to homes and infrastructure, and disruptions to transportation and commerce.
- **Inland Flooding**: In many regions, more frequent and intense rains are leading to more severe flooding. Heavy rain can trigger flash flooding and make rivers overflow. Saturated soils also create ideal conditions for landslides and mudslides.
- **Hurricanes**: Warming ocean waters are fueling larger and stronger tropical storm systems and weather conditions and increasing the likelihood of rapid intensification. The Gulf Coast, Southeast, and Mid-Atlantic are seeing more destructive hurricanes.
- **Wildfires**: Warmer temperatures are now more common, and intense droughts are creating conditions conducive to larger wildfires. Wet growing seasons, paired with dry periods, can lead to high fuel loads; warmer winter temperatures have allowed pests to decimate forest health, leading to massive amounts of dead wood on forest lands. Wildfires threaten human health and safety through entrapment, poor air quality, and other risks.

This guidance does not address all possible climate-related concerns. Climate science is an evolving discipline. There will be unknown impacts and unresolved questions related to climate change.[19] For example, some climate research links extreme cold temperature events to Arctic warming due to its influence on the jet stream. However, this research is not yet well determined. Ongoing research will further explain the relationship between warmer Arctic temperature, a weakened polar jet, and cold air outbreak frequency and intensity. Such events have resulted in significant impacts to people and infrastructure and should be considered in emergency planning.

Regional Impacts

Changing hazards will impact communities and regions differently. The hazards that regions and communities have occasionally been exposed to will become more frequent and severe and new areas will be affected. Figure 2 illustrates the top climate-related hazards for each region in the United States. Not all climate-related hazards are listed.

[18] NWS/NOAA, Weather-related Fatality and Injury Statistics, https://www.weather.gov/hazstat/.

[19] *Fifth Assessment Report* (WGII AR5) (2014), *Technical Summary*, Intergovernmental Panel on Climate Change (IPCC), https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-TS_FINAL.pdf.

Figure 2: Regional Climate-related Hazards

For a comprehensive summary of the climate-related risks for each region, see the regional assessments in the *Fourth National Climate Assessment*, EPA's Climate Change Impacts by Region webpage, and the 2022 State Climate Summaries. The following sections detail some of the potential regional climate change impacts.

Shifting Hazards

Changing climate patterns are resulting in regions experiencing new hazards they were previously unfamiliar with. For example:

- **Tornadoes:** Changes in severe weather, such as tornadoes and thunderstorms, due to climate change is difficult to assess, but a recent peer-reviewed paper presents evidence that there is a shift in the historic record, as the number of tornado events in southeastern states have increased while those in Tornado Alley have decreased.[20]
- **Hurricanes:** Because the area of warming ocean waters is expanding, research suggest the zone where hurricanes can form is also growing. That could mean more storms forming and making landfall in higher latitudes than has been recorded historically.[21]
- **Wildfires:** Shortened land snow cover seasons and higher temperatures have made the Arctic more vulnerable to wildfires.[22] Larger wildfire burn areas are affecting air quality concerns in far distant areas unfamiliar with the hazard.

Northeast[23]

- The Northeast is experiencing warming temperatures and a large increase in the amount of rainfall measured during heavy precipitation events.
- Less distinct seasons, along with milder winters and earlier spring conditions, are already altering environments in ways that adversely impact tourism, farming, and forestry.
- More frequent heat waves in the Northeast are expected to increasingly threaten human health through more heat stress and air pollution.
- Sea level rise and more frequent heavy rains are expected to increase flooding and storm surges, threatening infrastructure.
- As temperatures rise, agriculture will likely face reduced yields, potentially damaging livelihoods and the regional economy.

Northwest[24]

- Climate change is projected to increase the risks from extreme events, including flooding, landslides, droughts, wildfires, and heat waves.

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[20] Gensini, V.A. and H.E. Brooks, 2018: Spatial trends in United States tornado frequency. npj Climate and 31 Atmospheric Science, 1 (1), 38. http://dx.doi.org/10.1038/s41612-018-0048-2.

[21] Garner et al, (2021), Evolving Tropical Cyclone Tracks in the North Atlantic in a Warming Climate, Advancing Earth and Space Science, https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2021EF002326.

[22] F*ourth National Climate Assessment* (2018), USGCRP, Chapter 8: Droughts, Floods, and Wildfire, https://science2017.globalchange.gov/chapter/8/.

[23] *Fourth National Climate Assessment* (2018), USGCRP, Chapter 18: Northeast, https://nca2018.globalchange.gov/chapter/18/.

[24] *Fourth National Climate Assessment* (2018), USGCRP, Chapter 24: Northwest, https://nca2018.globalchange.gov/chapter/24/.

- Climate change will likely result in continued reductions in snowpack and lower summer streamflows in the Northwest, worsening the existing competition for water resources. Larger numbers of rain-on-snow events will also lead to additional flooding.
- Higher temperatures, changing streamflows, and an increase in pests, disease, and wildfires will threaten forests, agriculture, and salmon populations.
- Sea level rise is projected to increase the erosion of most coastlines, escalating infrastructure and ecosystem risks.

Southeast[25]

- Coastal communities in the Southeast are already experiencing warmer temperatures as well as impacts from sea level rise, such as increased flooding.
- Higher temperatures and greater demands for water will strain water resources.
- Incidences of extreme weather, increased temperatures, and flooding will likely impact human health, infrastructure, and agriculture.
- Sea level rise is expected to contribute to increased storm surges and will increase the salinity of estuaries, coastal wetlands, tidal rivers, and swamps.

Southwest[26]

- The most rapid observations of warming temperatures and reduced snowpack have been observed in recent decades in the Southwest.
- Increasing temperatures and more frequent and severe droughts are expected to heighten competition for water for urban/residential use, agriculture, and energy production.
- Indigenous populations are expected to experience difficulties associated with access to fresh water, the sustaining of agricultural practices, and declines in cultural plant and animal populations.
- Drought, wildfire, invasive species, pests, and changes in species' geographic ranges will increase threats to native forests and ecosystems.

Midwest[27]

- Temperature increases in the Midwest have accelerated in recent decades, particularly increases in nighttime and winter temperatures.
- This region will likely experience warmer and wetter winters, springs with heavy precipitation, and hotter summers that have longer dry periods.

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[25] *Fourth National Climate Assessment* (2018), USGCRP, Chapter 19: Southeast, https://nca2018.globalchange.gov/chapter/19/.

[26] *Fourth National Climate Assessment* (2018), USGCRP, Chapter 25: Southwest, https://nca2018.globalchange.gov/chapter/25/.

[27] *Fourth National Climate Assessment* (2018), USGCRP, Chapter 21: Midwest, https://nca2018.globalchange.gov/chapter/21/.

- Risks to human health are expected to rise as a result of warming temperatures, reduced air quality, and increased allergens.

Great Plains[28,29]

- Warmer winters are altering crop growth cycles and will require new agriculture and management practices.
- Projected increases in temperature and drought frequency will further stress the High Plains Aquifer, the primary water supply for the Great Plains.
- Changes in water availability are likely to present challenges to agricultural irrigation and threaten key wetland habitats.
- Older residents in rural areas and indigenous communities are especially vulnerable to the impacts of climate change.

Hawaii and Pacific Islands[30]

- Dependable and safe water supplies for Pacific Island communities and ecosystems are threatened by rising temperatures, changing rainfall patterns, sea level rise, and an increased risk of extreme droughts and flooding.
- Warmer and more acidic oceans are stressing coral reefs and fish habitats.
- Sea level rise is expected to threaten the water supplies, ecosystems, and infrastructure of U.S. tropical islands.
- Climate change is likely to affect the livelihoods of communities, as well as tourism and other important economic sectors, on tropical islands.

U.S. Caribbean[31]

- Salt water intrusion associated with sea level rise will reduce the quantity and quality of fresh water in coastal aquifers.
- Sea level rise, combined with stronger wave action and higher storm surges, will worsen coastal flooding and increase coastal erosion.
- Projected increases are expected in both average and extreme temperatures.

Alaska[32]

- Extensive permafrost thaw is expected by the end of the 21st century, increasing the risk of infrastructure damage.

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[28] *Fourth National Climate Assessment* (2018), USGCRP, Chapter 22: Northern Great Plains, https://nca2018.globalchange.gov/chapter/22/.

[29] *Fourth National Climate Assessment* (2018), USGCRP, Chapter 23: Southern Great Plains, https://nca2018.globalchange.gov/chapter/21/.

[30] *Fourth National Climate Assessment* (2018), USGCRP, Chapter 27: Hawai'i and U.S.-Affiliated Pacific Islands, https://nca2018.globalchange.gov/chapter/27/.

[31] *Fourth National Climate Assessment* (2018), USGCRP, Chapter 20: U.S. Caribbean, https://nca2018.globalchange.gov/chapter/20/.

[32] *Fourth National Climate Assessment* (2018), USGCRP, Chapter 26: Alaska, https://nca2018.globalchange.gov/chapter/26/.

- Alaska is among the fastest warming regions on Earth, with temperatures warming twice as fast as the global average since the middle of the 20th century.
- Arctic sea ice is projected to continue to decline, with nearly ice-free periods possible by mid-century.
- Native Alaskans are expected to experience declining availability of traditional foods and reduced access to sea ice hunting grounds.

INCORPORATING CLIMATE CHANGE INTO PLANNING PROCESSES AND PRODUCTS

Current historical data regarding extreme weather are necessary to understand risk but are not sufficient to plan for future risks associated with climate change. Consequently, climate change considerations should be incorporated into existing planning structures by:

- **Increasing climate literacy**: FEMA response and recovery planners should be climate literate, with a baseline understanding of climate change and its impacts on weather events and other hazards as well as emergency management operations.
- **Reviewing future conditions data and expanding hazard/threat profiles**: Threat profiles should be expanded to include potential climate change impacts, including at the national, regional, and state, local, tribal, and territorial (SLTT) levels.
    - Threat profiles can be expanded by reviewing anticipated trends from climate resources and/or by examining the weather events that adjacent states or regions routinely prepare for and evaluating how those events may impact or migrate to other regions and states. Planning for future climate scenarios is recommended.
    - By advancing threat profiles, SLTT governments will be more adept at assessing their readiness for shifting hazards, their increased intensities, and the resulting impacts to infrastructure and vulnerable populations.
- **Reviewing current planning products to identify opportunities to include climate change considerations and data**: Climate change may alter or intensify current hazards. Existing plans should be reviewed to incorporate data on climate change, climate change considerations, and potential vulnerabilities. Planners should regularly review the CDC's SVI data, floodplain and flood map (RiskMAP) information, and climate data to re-evaluate risks. See **Annex C: Climate Resources and Tools** for additional climate resources.
- **Developing additional planning products**: Climate change will impact each FEMA region's weather differently; not all regions will face the same challenges. Some regions and SLTT authorities may need to create additional planning products to address new threats/hazards that may emerge as a result of climate change.
- **Identifying the potential compounding effects of climate change threats**: Extreme weather associated with climate change may impact critical infrastructure, which can cause complex secondary impacts. Plans and actions that address readiness, response, and recovery should consider climate change in the broader emergency management resilience framework to ensure that maladaptive practices, such as actions that increase risk in another phase, are not incorporated.

- **Collaborating with other federal, regional, and state partners**: Regions and states that routinely respond to climate hazards may be able to offer valuable insights into expected response actions and anticipated resources. Other federal agencies can help to provide accurate climate data and identify potential cascading impacts.

The following sections outline climate change considerations that could be incorporated into existing or new plans. Additional hazard-specific critical considerations are detailed in **Annex B: Climate Change Threat/Hazard Profiles**.

Key Assumptions

Key assumptions include critical information accepted by planners as true in the absence of fact. Assumptions should be reviewed and validated during response and recovery operations for a climate-related incident. For the purposes of this guidance document, key assumptions include:

- Across the nation, meteorological hazards will continue to be more frequent and/or severe and will affect new locations due to climate change.
- An anticipated increase in the frequency and intensity of weather events will limit the availability and capacity of response resources.
- The extent of federal support will be based on the type and severity of the incident, existing statutory authorities, and the availability and applicability of resources.

Planning Considerations

Critical considerations for response operations, recovery planning, and related readiness activities include information on anticipated federal support requirements, the impacts from climate-related incidents, and collaboration considerations. Critical considerations for response and recovery planning are provided in the sections below.

Considerations related to climate impacts are categorized by familiar constructs used for planning in response and recovery. The FEMA Community Lifelines were used because they are a familiar construct used in a response to communicate incident impacts. The Recovery Support Functions (RSFs) provide a familiar coordinating structure for key functional areas of assistance in recovery.

FEMA Support Considerations

FEMA supports readiness and climate adaption activities through resilience grants and programs (see Table 4 in **Annex A: Executive/Statutory Authorities**). In response to a qualifying incident, a Stafford Act declaration provides additional authorities for FEMA to provide disaster assistance. If the incident does not result in a Presidential disaster declaration under the Stafford Act, FEMA may still provide assistance to the lead federal agency in an incident response upon request. (See the *Response and Recovery Federal Interagency Operational Plan* (FIOP) for more details about FEMA's operational structure and capabilities.)

- Some climate change-related hazards, such as extreme heat and drought, have impacts that do not align well with FEMA programs. FEMA will need to continue to work closely with other federal agencies to plan for all-of-government efforts.
- FEMA regions will support SLTT-led efforts to address life and safety needs resulting from weather events, with assistance and support from the private sector and other federal agencies.
- Anticipated increases in the frequency and intensity of weather events may limit the ability for SLTT jurisdictions to fulfill mutual aid agreements.
- Regions will require an array of federal resources to support states and tribes based on the types of extreme weather events they may face. FEMA-provided resources may include generators/fuel, debris removal assistance, communications assistance, commodity support, sheltering support, etc.
- Standard perceptions of risk that are based upon historical conditions or precedent are not sufficient for addressing all potential climate impacts; planners will have to adjust risk definitions to accommodate changing climate patterns.
- An anticipated increase in the frequency and intensity of weather events will pose a heightened risk to the protection of cultural heritage resources and will affect FEMA's engagement with environmental and historic preservation laws, regulations, and executive orders.
    - The Environmental Historic Preservation Advisor (EHPA) serves as the central point of coordination and communication for the Environmental Planning and Historic Preservation (EHP) function within the National Response Coordination Center (NRCC). The EHPA's primary incident support partners include an incident-specific FEMA Regional Environmental Officer, Emergency Support Function (ESF) #11 (Agriculture and Natural Resources) representatives, and the Heritage Emergency National Task Force (HENTF).[33]
    - FEMA's Office of Equal Rights (OER) Civil Rights Advisors provide guidance, technical assistance, compliance, and enforcement regarding environmental justice and civil rights issues.
- FEMA anticipates an increase in the frequency and intensity of weather events that may strain local, faith-based, and non-profit resource support for immediate and long-term recovery needs. SLTTs and FEMA will need to evaluate their recovery staffing plans to support integrated recovery coordination efforts for more and larger disasters.
- Regions will require federal interagency resources to support state and tribal recovery based on the types of extreme weather events they may face. Resources

[33] HENTF is a coalition of federal agencies and national service organizations and is co-sponsored by OEHP and the Smithsonian Cultural Rescue Initiative (SCRI). Its mission is to protect cultural heritage in our nation's states, tribes, territories, and local communities from the damaging effects of natural disasters and other emergencies. HENTF coordinates with the EHPA to assist in information sharing and the distribution of key messaging to stakeholders.

may include programmatic funding, technical assistance, housing and sheltering support, support for heating and cooling programs, etc.

- Regions will require additional long-term recovery experts to support integrated recovery coordination efforts.
- Emergency managers at all levels will need to leverage applications of recovery geospatial and decision-making tools to illustrate and consider climate risk and resilience for recovery grant projects.
- As disaster size and frequency increase, integrating mitigation and climate adaptation principles into pre-disaster recovery planning efforts will become critical for reducing the impacts of future disasters.

Differences Between Climate Mitigation, Climate Adaptation, and Hazard Mitigation

Climate Mitigation: Measures that reduce the amount and speed of future climate change by either reducing emissions of carbon dioxide, methane, and other heat-trapping gases or removing carbon dioxide from the atmosphere.

- *Example*: Strengthening emissions standards to reduce the amount of greenhouse gases in the atmosphere.

Adaptation: Adjustment in natural or human systems to a new or changing environment that takes advantage of beneficial opportunities or moderates negative effects.

- *Example:* Raising streets and upgrading stormwater infrastructure to address sea level rise.

Hazard Mitigation: Those capabilities necessary to reduce loss of life and property by lessening the impact of disasters.

- *Example:* Adopting and enforcing codes and standards to enable buildings to withstand earthquakes.

Climate Impact Considerations Aligned with FEMA Community Lifelines

Safety and Security

- An anticipated increase in climate-related events may strain SLTT response resources and capacities, resulting in increased requests for federal support.
- Decreased water volumes in remote streams and ponds may hamper firefighting capabilities.

Food, Hydration, Shelter

- Temperature and precipitation extremes may affect water quality and availability, agricultural productivity, and ecosystems and species.
- Thawing permafrost may lead to unsafe food storage and preservation.
- Sheltering needs may overwhelm SLTT capacities due to increases in climate-related events. Federal support may be required for the provision of additional sheltering and/or the relocation of impacted populations to unaffected areas.

- Wrap-around services may need to be provided for survivors waiting to access aid sites to ensure their health and well-being (e.g., moving water distribution to shaded areas in extreme heat scenarios). Pre-identified aid sites may need to be reevaluated to ensure protection for those awaiting access.

Health and Medical[34]

- More frequent and severe heat waves will lead to more heat-related illnesses and deaths.
- Changes in the timing and lengths of the seasons may cause shifts in the geographic areas where disease-carrying insects such as mosquitoes, ticks, and fleas typically transmit West Nile Virus, dengue fever, Lyme disease, malaria, and other diseases.
- Increasing temperatures may cause degradation of air quality, exacerbating health conditions such as heart disease.
- Increased plant growing seasons may increase pollen exposure and allergies, a greater number of severe storms will increase mold exposure, and increased temperatures and wildfire risk will lead to more air pollution, all of which can worsen lung disease and other health problems.
- Extreme weather events are associated with an increased risk of food- and water-borne illnesses, as sanitation services, hygiene measures, and safe food and water supplies are often compromised after such events.

Energy (Power & Fuel)

- Transmission line capacity will decline at higher temperatures, reducing power availability; extreme heat may also cause power lines to droop.[35]
- Extreme temperatures increase demand for cooling and heating capabilities, which may result in electricity shortfalls.
- Climate-related incidents, such as increases in extreme heat and wildfires, will increase the likelihood of public safety power shutoffs, limiting access to power.
- Extreme flooding or severe weather will threaten energy infrastructure.

Communications

- Extreme flooding or severe weather may impact communications infrastructure due to damage or loss of power.
- Buried fiber optic cables and nodes, which provide communications and internet services, are at risk of failure due to sea level rise and flooding. Communications

[34] HHS (2022), Climate Change and Health Equity, https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/index.html.

[35] During the heat wave in the Pacific Northwest in 2021, the intense heat melted some power cables in Portland. NPR, https://www.npr.org/2021/06/29/1011269025/photos-the-pacific-northwest-heatwave-is-melting-power-cables-and-buckling-roads.

nodes are often clustered at low elevations around dense populations. Fiber buried on land is water- and weather-resistant but is not designed to be submerged.[36]

Transportation

- Extreme heat can warp railways and impact rail operations, cause paved surfaces to buckle and disrupt transit, and make it difficult for airplanes to take off.[37]
- An increase in flooding or weather events that result in the accumulation of debris will impact transportation routes.
- More than 60,000 miles of roads and bridges in coastal areas are at risk of flooding from climate change-related sea level rise.[38]
- Permafrost thaw may reduce the viability of roads made of ice and snow and damage transportation infrastructure due to ground sinking.[39]
- Compounding climate-related weather events that impact the transportation system could severely impact supply chains due to worker attrition, flooded routes, etc.
- Disruptions to supply chains will impact operations, logistics, and management activities for response and recovery.

Hazardous Materials

- Increased climate-related weather events may result in larger quantities of waste materials requiring processing. This may lead to increased greenhouse gas emissions from waste management activities as well as insufficient capacities for handling surges in the necessary recycling, treatment, and disposal processes for the waste generated.[40]

Water Systems

- Thawing permafrost may lead to the deterioration of reservoirs and impoundments that rely on the existence of permafrost for wastewater containment.
- The intersection of flooding and warmer weather may cause bacterial growth in local water sources, leading to health concerns (e.g., toxic algae blooms).

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[36] "Rising Seas Could Cause Problems For Internet Infrastructure," July 16, 2018, NPR, https://www.npr.org/2018/07/16/627254166/rising-seas-could-cause-problems-for-internet-infrastructure.

[37] Jacobs, J.M., et al. (2018). *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II*, USGCRP, Washington, D.C., https://nca2018.globalchange.gov/downloads/NCA4_Ch12_Transportation_Full.pdf.

[38] Ibid.

[39] *Fourth National Climate Assessment* (2018), UGCRP, Chapter 26: Alaska, https://nca2018.globalchange.gov/chapter/26/.

[40] EPA, Waste Management Planning to Mitigate the Impact of Climate Change, https://www.epa.gov/homeland-security-waste/waste-management-planning-mitigate-impact-climate-change.

Climate Impact Considerations Aligned with FEMA Recovery Support Functions (RSFs)

Economic

- Labor hours of weather-exposed workers may be lost due to high temperature days. This is also an equity consideration due to the demographics of weather-exposed workers, who are already at a greater risk for climate change impacts.
- The increasing frequency and intensity of climate-related hazards will cause increases in property damage and business income losses.
- The displacement of socially vulnerable and underserved populations often coincides with the displacement of essential, frontline workers, who are the foundation of a community's economy.

Health & Social Services

- Individuals residing in areas with high particulate air pollution are at greater risk of developing cancer as well as chronic illnesses such as asthma.[41]

Community Assistance

- Equity issues regarding illiteracy should be taken into consideration when conducting community engagement and training.
- Community assistance efforts and climate considerations should be incorporated into long-term recovery planning support strategies.
- FEMA should partner with the federal interagency, when possible, to leverage other agency authorities that support mitigation activities and build climate resilience.

Infrastructure Systems

- Projects should leverage resilience funding support[42] and adhere to consensus-based building codes and standards for low-carbon materials.
- Recovery-funded grant projects should emphasize mitigation measures (e.g., through the Hazard Mitigation Grant Program [HMGP] and 406 Mitigation funding) that support eligible risk reduction actions.
- Benefit-cost calculations should be streamlined for hazard mitigation solutions that are local, sustainable, and nature based, when possible, to enable better alignment with grant obligations and planning timelines.

[41] EPA (2021), *Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts*, https://www.epa.gov/system/files/documents/2021-09/climate-vulnerability_september-2021_508.pdf.

[42] FEMA, Recovery and Resilience Resource Library, https://www.fema.gov/emergency-managers/practitioners/recovery-resilience-resource-library.

Housing Recovery

- Sheltering and temporary housing will continue to be a prominent and challenging aspect of disaster recovery. FEMA may assist with state-led pre-disaster planning initiatives on housing to build greater resilience to climate-related disasters and encourage better planning and preparedness practices.

Natural & Cultural Resources

- FEMA Recovery programs support the widespread adoption of the Federal Flood Risk Management Strategy (FFRMS), and related policy updates, to ensure its implementation.
- Anticipated increases in the frequency and intensity of weather events will pose a heightened risk to the protection of cultural heritage resources, which in recovery operations are the shared responsibility of the FEMA EHP, HENTF, and the Natural and Cultural Resources RSF.

Collaboration Considerations

- Prior to a disaster, FEMA can work with and invest in communities to build resilience and mitigate impacts from anticipated climate-related hazards.
    - Through its Building Resilient Infrastructure and Communities (BRIC) grant program and Flood Mitigation Assistance (FMA) grant program, FEMA provides resources to help communities be better prepared for climate-related events.
    - FEMA grants can be invested in infrastructure, to include the funding of nature-based solutions and the adoption of hazard-resistant building codes, as well as response capabilities that will protect communities from anticipated climate-related events.
    - The National Exercise Program supports federal and SLTT partners in assessing and enhancing response capabilities and capacities and validating their plans, policies, and procedures regarding climate-related risk.
- FEMA will continue to work with internal and interagency partners to analyze and discuss the impacts of climate change.[43]
    - Participation in working groups allows FEMA to engage with climate experts and discuss events and interagency efforts to address climate impacts.
    - The FEMA Exercise Branch use the preparedness cycle to validate the agency's readiness, identify critical capability gaps across all mission areas, and ultimately provide FEMA and its partners with the tools needed to increase whole community outcomes in emergency management.
    - The FEMA National Preparedness Assessment Division advances preparedness efforts for all hazards by assessing progress, the effectiveness

[43] In the past, FEMA joined efforts, such as EPA's *Let's Talk about Heat Challenge*, which sought innovative, community-level solutions to the challenges of extreme heat events.

of preparedness programs and resources, and the communication of lessons learned for continual improvement.

- The FEMA Continuous Improvement Program (CIP) builds improvement through enhancements to preparedness and operational readiness initiatives by improving program operations, providing information for resource funding decisions, and tracking implementation of recommendations. FEMA's Continuous Improvement Technical Assistance Program (CITAP) includes tools to help guide users through these processes and methods.
- The National Integration Center provides guidance to SLTT partners and the federal interagency on incorporating resilience and climate change considerations into emergency management plans.

Other Planning Considerations

- Climate change is likely to compound weather-related events. For example, hurricane flooding may be worsened by storm surge, sea level rise, and heavy rainfall; extreme heat and droughts can create favorable conditions for wildfires.
- Compounding events will likely magnify impacts and decrease the availability of resources.
- Continuous impacts from climate change could lead to the mass migration of populations seeking to leave high-risk areas.
- Communities recovering from compounding climate-related weather events may see impacts on mental health, including an increased risk for post-traumatic stress disorder (PTSD) and depression for citizens in that community.
- Climate change disproportionately impacts socially vulnerable and underserved populations based on income and healthcare disparities, health risk,[44] educational level, race and ethnicity, and age.[41]
- Mitigation measures under the Individuals and Households Program may take a more prominent role in FEMA-provided assistance.

[44] NIH, *The Impact of Disasters on Populations with Health and Health Care Disparities*, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2875675/.

ANNEX A: EXECUTIVE/STATUTORY AUTHORITIES

Table 2. Climate Change Response-related Executive and Statutory Authorities

Authority	Agency	Description
Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act)	FEMA	The Stafford Act provides FEMA with the authority to coordinate disaster and emergency assistance to individuals, households, and businesses. It also outlines the disaster declaration process, which defines the relationship among federal, state, tribal, and voluntary agencies in disaster response efforts, determines the assistance that FEMA and states/tribes can provide, and defines the FEMA/state cost-sharing requirements for disaster funding.
Clean Air Act	EPA	EPA is granted authority by the Clean Air Act to regulate and waive standards for transportation fuels, emissions from generators, and emissions at fuel distribution terminals during disasters. Fuel waivers are contingent upon the fuel disruption being temporary, extreme, and unusual and applying to the smallest geographic area necessary. In emergency circumstances, EPA may issue No Action Assurances, temporarily stopping enforcement of specific requirements to facilitate the flow of power and fuel supplies to a region.
IRS Publication 510 – Excise Taxes	Internal Revenue Service (IRS)	The IRS collects federal taxes on all fuel used for highway motor vehicles. During emergency events, the IRS may grant waivers to people selling and using dyed fuel for highway use in disaster areas. The IRS waivers allow off-road dyed diesel fuel to be used in on-road vehicles without tax penalties.
49 U.S.C. § 60118 – Emergency Special Permits	Pipeline and Hazardous Materials Safety Administration (PHMSA)	PHMSA ensures the safe transportation of energy and other hazardous materials through pipelines. In emergency circumstances, PHMSA may grant special permits that temporarily modify compliance with federal pipeline regulations for owners and operators.
49 CFR § 390.23 – Relief from Regulations	Federal Motor Carrier Safety Administration (FMCSA)	Once the President, state governor(s), or FMCSA Field Administrator has declared an emergency, certain federal transportation safety regulations related to interstate commerce can be suspended, including the Hours of Service (HOS) requirements that limit the number of hours a driver may drive within a certain period. FMCSA waivers are commonly used to help relieve fuel shortages in a multi-state event.
Title VI of the Civil Rights Act of 1964 (42 U.S.C. § 2000d)	FEMA	Title VI prohibits programs and activities that receive federal financial assistance from discriminating on the basis of race, color, or national origin. Such programs and activities include those that affect human health or the environment.

Table 3. Climate Change Recovery-related Executive and Statutory Authorities

Authority	Agency	Description
Disaster Recovery Reform Act (DRRA) (Public Law 115-254)	FEMA	The DRRA made numerous legislative changes to the Stafford Act. Section 1204 of the DRRA amended Section 404 of the Stafford Act to allow FEMA to provide Hazard Mitigation Grant Program (HMGP) funds in any area that received a Fire Management Assistance Grant (FMAG) declaration, even if no major Presidential declaration was made. Section 404 authorizes FEMA to provide HMGP assistance for hazard mitigation measures that substantially reduce the risk of future damage, hardship, loss, or suffering in any area affected by a major disaster or any area affected by a fire for which assistance was provided under section 420.
Section 406 of the Stafford Act	FEMA	FEMA has the authority under Section 406 of the Stafford Act to provide Public Assistance (PA) program funding for cost-effective hazard mitigation measures for facilities damaged by an incident. SLTT governments can use this funding to protect facilities from the future disaster damage caused by large climate shifts and/or to develop mitigation projects that incorporate cost-effective, sustainable design principles.

Table 4. Hazard Mitigation-related Grant Programs

Authority	Agency	Description
Building Resilient Infrastructure and Communities (BRIC) Grant Program	FEMA	BRIC is a competitive grant program that provides funds annually in support of SLTT hazard mitigation projects. The program funds cost-effective projects designed to increase resilience, reduce injuries and loss of life, and reduce damage and destruction to property. Tribal nations, as eligible applicants, can use BRIC funding for property acquisition and relocation.
Hazard Mitigation Grant Program (HMGP)	FEMA	HMGP funds assist communities in rebuilding efforts aimed at increasing resilience to hazards. HMGP funds also support mitigation projects, including the acquisition of hazard-prone homes and businesses to enable owners to relocate to safer areas. HMGP grant funding is also available to tribal nations after a major disaster declaration.
Flood Mitigation Assistance (FMA) Grant Program	FEMA	The FMA program provides competitive grants to states, local communities, federally recognized tribes, and territories. Funds can be used for projects that reduce or eliminate the risk of repetitive flood damage to buildings insured by the National Flood Insurance Program.
Voluntary Community-driven Relocation Program	U.S. Department of the Interior (DOI)/ FEMA	The interagency subcommittee of this program is co-led by FEMA and DOI. It convenes federal agencies to explore key considerations, issues, and strategies for community partnerships to support the voluntary movement away from high-risk areas.

Table 5. Climate Change-related Executive Orders

Authority	Description
Executive Order (E.O.) 14030 – Climate-Related Financial Risk E.O. 13690 – Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input	The Federal Flood Risk Management Standard (FFRMS) expands federal floodplain management requirements established in E.O. 11988 (May 1977). The FFRMS aims to build a more resilient future through requiring federal agencies to consider and manage both current and future flood risk when the federal government funds projects involving new construction, substantial improvement, or repairs to substantial damage. FFRMS requires that federal agencies expand the floodplain and flood elevation of concern by adding freeboard to the base flood elevation, considering the 0.2% annual chance floodplain, or applying best-available actionable climate science. The standard was revoked but then reinstated through Executive Order 14030, Climate-Related Financial Risk, clarifying that the FFRMS should remain in effect.
E.O. 13985 – Advancing Racial Equity and Support for Underserved Communities through the Federal Government	E.O. 13985 directs federal agencies to: • Identify potential barriers that underserved communities and individuals may face in taking advantage of agency procurement and contracting opportunities; and • Assess whether new policies, regulations, or guidance documents may be necessary to advance equity in agency actions and programs.
E.O. 14008 – Tackling the Climate Crisis at Home and Abroad	E.O. 14008 requires all agencies to: • Use federal procurement and management of real property actions to support robust climate actions; • Submit a Climate Action Plan that identifies agency climate vulnerabilities as well as steps to bolster adaptation and increase climate resilience of facilities; and • Adhere to the requirements of the Made in America laws in making clean energy, energy efficiency, and clean energy procurement decisions.
E.O. 12898 – Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations	E.O. 12898 directs federal agencies to: • Identify and address the disproportionately high and adverse human health and/or environmental effects of their actions on minority and low-income populations to the greatest extent practicable; • Develop a strategy for implementing environmental justice; and • Promote nondiscrimination in federal programs that affect human health and the environment and provide minority and low-income communities access to public information and public participation.

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ANNEX B: CLIMATE CHANGE THREAT/HAZARD PROFILES

Drought

Climate change is expected to change the frequency and intensity of drought patterns. As Earth's average temperature rises, evaporation rates will increase, leading to more precipitation in some areas and less precipitation in others. Climate projections for the Southwest indicate that the region may experience chronic precipitation deficits, which will increase meteorological drought risk, as defined below. Significant precipitation declines are not confidently projected outside of the Southwest; however, higher temperatures may increase the frequency and magnitude of agricultural droughts across the country in the future.[45]

Recent droughts and associated heat waves have reached record intensities in some regions. However, the 1930s "Dust Bowl" remains the most significant drought in the historical record.[46] Climate change impacts on U.S. drought conditions are complicated. Little evidence is found for a human influence on observed precipitation deficits, but significant evidence is found for a human influence on surface soil moisture deficits due to evapotranspiration caused by higher temperatures.[47]

Drought increases can occur during all seasons of the year and are directly tied to changes in precipitation (seasonality, frequency, and intensity). When winter droughts occur, they happen when precipitation is already typically lower than other times of the year and don't generate negative impacts as readily as when droughts occur during the growing season. Unlike other incidents, droughts can affect most U.S. regions and territories and can be hard to recognize before it is too late to mitigate impacts. The United States has spent an estimated $249 billion on 26 major droughts in the last 30 years that have affected two-thirds of the continental United States.[48]

There are five different classes of drought, each with differing impacts, as defined by the National Integrated Drought Information System (NIDIS):[49]

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[45] National Integrated Drought Information System, Historical Drought, https://www.drought.gov/what-is-drought/historical-drought.

[46] *Climate Science Special Report* (2017), *Fourth National Climate Assessment, Volume I*, USGCRP, https://science2017.globalchange.gov/downloads/CSSR2017_FullReport.pdf.

[47] *Climate Science Special Report* (2017), *Fourth National Climate Assessment, Volume I*, USCGRP, https://science2017.globalchange.gov/downloads/CSSR2017_FullReport.pdf.

[48] CISA (2021), *Drought and Infrastructure: A Planning Guide*, https://www.cisa.gov/sites/default/files/publications/Drought_and_Infrastructure_A_Planning_Guide_508c.pdf.

[49] National Integrated Drought Information System, Drought Basics, https://www.drought.gov/what-is-drought/drought-basics.

- **Meteorological drought** describes conditions when dry weather patterns dominate an area.
- **Agricultural drought** describes conditions when crops become affected by drought.
- **Hydrological drought** describes conditions when a low water supply becomes evident in a water system.
- **Socioeconomic drought** describes conditions when the supply and demand of various commodities are affected by drought.
- **Ecological drought** describes conditions when natural ecosystems are affected by drought.

Impacts

All vital infrastructure systems, both human-made and natural, face drought-related risks. Drought can affect agriculture, critical infrastructure, and various public services and create competition for water resources between urban, rural, and industrial needs, impacting all facets of society.

The consequences of drought include the disruption of economic, health, and critical infrastructure systems through both direct and secondary hazards. Direct hazards include lack of raw water availability and water degradation. Secondary hazards include exacerbation of land subsidence and increases in wildfires, flooding, and dust storms. Additionally, dry soils, combined with frigid winter temperatures, can lead to deeper frost line depths and cause infrastructure issues such as water main breaks and frozen pipelines.

Agricultural production, critical ecosystem functions, and soil nutrient uptake rates are dependent upon water availability. Drought can alter the balance of ecosystems, affecting fish, game, wildlife, and plant species. Ecosystems, which are vital to human communities, are interdependent and the vulnerability of one can lead to cascading impacts on another.

Response Considerations

FEMA Community Lifeline Considerations

- **Safety and Security**
    - Responders may be at risk for decreased access to water resources during response operations.
    - Animal migration (driven by reduced access to food and water in their natural ranges) into areas more densely populated by humans or into areas where responders are managing drought impacts may become problematic.
    - Low flow or lack of water in remote streams and ponds will hamper wildland fire responses.
    - Toxic dust may prompt additional personal protective equipment (PPE) needs in response and recovery operations.

- **Food, Hydration, Shelter**
    - Drought impacts to aquaculture, agriculture, and pasture lands may result in losses that lead to decreased food availability, less food sovereignty, as well as increased food costs.
- **Health and Medical**
    - Drought affects air quality, especially when drier soils combine with windy conditions. Toxins in the soil can become airborne and cause lung irritation and adverse health effects in certain populations.[50]
    - Particulate matter from dried lakebeds can increase rates of chronic and acute diseases associated with air pollution, including reproductive dysfunction, developmental defects, cognitive impairment, cardiovascular damage, and cancer.[51] Toxic pollutants have been detected in the sediment of the Great Salt Lake, for example.[52]
- **Energy**
    - Hydroelectric power losses may cause strain on power grids and increase the need for generator support.
    - Drought will likely threaten fuel production, enhanced oil recovery, oil refining, and thermoelectric power generation due to its reliance on surface water for cooling.[53]
- **Transportation**
    - During drought conditions that result in low water levels in rivers and other waterways, port and water-based transportation operations may be limited due to a reduction in available routes.
- **Water Systems**
    - Projected increases in temperature and drought frequency would further stress the High Plains Aquifer, the primary water supply for the Great Plains.[54]
    - Drought impacts to estuary environments (where salt water and fresh water meet) may impact drinking water quality as well as species conservation efforts and make certain agricultural areas unfarmable due to land salinity.

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[50] CDC (2020), Health Implications of Drought, https://www.cdc.gov/nceh/drought/implications.htm.

[51] Abbott et al. (2023), *Emergency measures needed to rescue Great Salt Lake from ongoing collapse*, https://pws.byu.edu/GSL%20report%202023.

[52] Sediments include arsenic, cadmium, mercury, nickel, chromium, lead, copper, selenium, organic contaminants, and cyanotoxins.

[53] *Fourth National Climate Assessment* (2018), UGCRP, Chapter 4: Energy Supply, Delivery, and Demand, https://nca2018.globalchange.gov/chapter/4/.

[54] EPA, Climate Impacts in the Great Plains, https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-great-plains_.html.

Equity Considerations

- Droughts significantly impact rural communities and local agriculture, which can drive farmers out of business. This can lead to inequitable cascading impacts on the cost of food for low-income communities.

Extreme Heat

Changes in the number of heat waves, or extreme heat events, are a notable impact of climate change. Over the past 60 years, heat waves have increased in duration, frequency, and intensity and research shows that the trend toward longer and more intense heat waves will continue.[55] In addition, the average "season" for heat waves has increased by 47 days across 50 major U.S. cities since the 1960s.[56] These urban areas are also susceptible to the heat island effect, in which temperatures within cities are higher than in outlying areas due to factors such as loss of vegetation and the prevalence of pavement, buildings, and concentrated human activity.[57] Research also points to the existence of intra-urban heat islands, a phenomenon in which certain neighborhoods or areas within a city experience higher temperatures than others.

Historically, underserved and marginalized communities may experience more severe impacts from extreme heat than other populations, both in terms of infrastructure impacts and health impacts. Research also shows correlations between income level, race, and intra-urban heat islands.[58]

Impacts

Extreme heat events present numerous dangers to infrastructure, the public, and responders. Extreme heat can impact transportation systems by damaging essential infrastructure. For example, the paved surfaces of roads and runways (typically made of asphalt or concrete) are both sensitive to extreme heat and can become unsafe for use during periods of excessively high temperatures. Similarly, train tracks may warp and buckle in extreme heat. Besides disrupting public transit, extreme heat events can affect response operations by limiting or even disabling certain modes of transportation to or from disaster sites. Heat waves can also have severe impacts on power grids, either by damaging physical infrastructure or by stressing electrical systems through increased demands for air conditioning and other power needs, or both.[59]

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[55] EPA, Climate Change Indicators: Heat Waves, https://www.epa.gov/climate-indicators/climate-change-indicators-heat-waves.

[56] USGCRP, Heat Waves, https://www.globalchange.gov/browse/indicator-details/3983.

[57] EPA, Learn About Heat Islands, https://www.epa.gov/heatislands/learn-about-heat-islands.

[58] EPA, Heat Islands and Equity, https://www.epa.gov/heatislands/heat-islands-and-equity.

[59] MIT Climate Portal, Extreme Heat, https://climate.mit.edu/explainers/extreme-heat.

As the leading weather-related cause of death in the United States, heat waves pose a significant threat to human health.[60] As heat waves become more severe and more common, this threat will increase, both in areas already prone to extreme heat and in areas that may soon face such events and are potentially less prepared (e.g., areas without widespread air conditioning).

Response Considerations

FEMA Community Lifeline Considerations

- Safety and Security
  - Responders and survivors may be at risk for heat-related illnesses during response operations.
  - Response personnel should consider elements like available shade and ground cover materials (e.g., pavement vs. grass) in extreme heat scenarios.
- Food, Hydration, Shelter
  - Extreme heat may increase the need for temporary shelters, cooling centers, and water distribution missions.
  - The demand for water may outstrip supply chain and individual water distribution resources, resulting in a need for water generation and purification solutions (atmospheric, desalination) and household containers.
- Health and Medical
  - Extreme heat often results in the highest annual number of deaths among all weather-related disasters.
  - Heat may exacerbate existing illnesses, such as asthma and cardiovascular disease.
  - Hospitals may need to prepare for providing heat illness treatments (e.g., ice baths).
  - If extreme heat causes power outages, access to specific treatments, such as dialysis, may be limited.
- Energy
  - Responders should be prepared for overloaded power grids and increased demands on generators.
- Transportation
  - When possible, emergency responders should identify multiple modes of transportation and routes when traveling to and from response locations and staging areas due to potential inaccessibility from warped rail tracks, overheated/damaged concrete or asphalt, etc.

[60] EPA, Climate Change Indicators: Heat-related Deaths, https://www.epa.gov/climate-indicators/climate-change-indicators-heat-related-deaths.

Equity Considerations

- Socially vulnerable populations, including individuals with medical conditions and those with disabilities as well as children, older adults, unhoused persons, agricultural and other outdoor workers, marginalized racial groups, lower-income persons, incarcerated persons, and persons without air conditioning, may be at a higher risk for heat-related illness or death.[61]

Coastal Flooding

Coastal flooding occurs when high or rising tides or storm surges result in water inundation on normally dry coastal land.[62] Coastal flooding is expected to worsen significantly in the next 30 years due to sea level rise. Sea levels are estimated to rise between 10 to 12 inches by 2050, resulting in a 10-fold increase in damaging coastal floods when compared to today's flooding frequency.[63] Local impacts will be highly variable due to regional differences in sea level rise rates. Coastal flood events associated with high tides may occur weekly or monthly, as compared to historical rates of just a few events per year.[64] In the United States, 7 of the 10 most expensive disasters were caused by coastal storms.[65]

Impacts

Given that coastal areas contain 40 percent of the U.S. population, the coastal flooding risk to coastal residents as well as property and structures is significant. Impacts from recurring coastal floods include frequent road closures, less stormwater drainage capacity, weakened infrastructure from frequent inundation or salt water exposure, and increased exposure to pathogens as drinking water and wastewater facilities fail.[66]

Hawaii and the Pacific Islands

Coastal flooding and erosion will increase due to sea level rise.[67] Long-term migration of populations currently inhabiting low-lying Pacific Islands is of particular concern, and efforts to relocate coastal residents is ongoing.[68]

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[61] EPA (2021), *Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts*, https://www.epa.gov/cira/social-vulnerability-report.https://www.epa.gov/system/files/documents/2021-09/climate-vulnerability_september-2021_508.pdf.

[62] FEMA, National Risk Index: Coastal Flooding, https://miptest.msc.fema.gov/nri/coastal-flooding#:~:text=Coastal%20Flooding%20is%20when%20water%20inundates%20or%20covers,compared%20to%20the%20rest%20of%20the%20United%20States.

[63] Paddock, M., Climate Change 101, NOAA and NWS PowerPoint presentation (April 27, 2022).

[64] NOAA, Understanding Stormwater Inundation, https://coast.noaa.gov/stormwater-floods/understand/.

[65] FEMA, Thinking Beyond Flood Maps (arcgis.com), https://storymaps.arcgis.com/stories/da2b7cb4ad53424980be99e9ffeeb374.

[66] *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*, Chapter 6, USGCRP, https://health2016.globalchange.gov/.

[67] Paddock. M, Climate Change 101, NOAA and NWS PowerPoint presentation (April 27, 2022).

[68] USGS, Coastal Climate Impacts, https://www.usgs.gov/centers/pcmsc/science/coastal-climate-impacts.

Western U.S. and Alaska

Coastal flooding poses major threats to coastal communities, particularly to local infrastructure.[69] For instance, in California, half a million people and $100 billion worth of coastal property are at risk over the next 100 years. The more uncertain impacts of coastal flooding on the West Coast are how wave runup and coastal erosion will affect future base flood elevations (BFEs) and velocity zones. Research shows that there is a non-linear response of BFE along bluffed or hardened shorelines from incremental sea level rise. Local studies are needed to determine local BFE responses to sea level rise, making it difficult to map future BFEs consistently on the West Coast.

Longer sea ice-free seasons, higher ground temperatures, and relative sea level rise are expected to worsen flooding and accelerate erosion in many areas, leading to the loss of terrestrial habitat and cultural resources and requiring the relocation of entire communities, such as the Kivalina in northwestern Alaska.[70]

Eastern U.S and Gulf Coast

The East Coast has seen the greatest increase in the number of coastal flood days and also experiences the most frequent coastal flooding.[71] Compared to high-tide flooding frequencies that were typical in 2000, 2020 saw the number of flood days increase 100 to 150 percent along the Northeast Atlantic and Eastern Gulf coastlines. Even higher percentage increases (more than 400 percent) occurred along the Southeast Atlantic. Percentage increases compared to 2000 were greatest in the Western Gulf (more than 1,100 percent, or 22 days) in Bay Waveland, Mississippi.[72]

Great Lakes

Water levels and water temperatures are two important and interrelated indicators of climate change in the Great Lakes. The lakes support a variety of ecosystems, provide drinking water and recreational opportunities, and play a vital role in the economies of the eight states adjacent to the Great Lakes through major commercial activity such as shipping, fisheries enterprises, and more.

The amount of water in the Great Lakes goes up and down based on the season, rainfall amounts, and a variety of other factors. Low water levels create dredging and infrastructure issues, while high levels cause flooding and erosion problems. Although there is natural fluctuation in lake water levels, they have declined slightly for most of the Great Lakes over

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[69] Paddock, M., Climate Change 101, NOAA and NWS PowerPoint presentation (April 27, 2022).

[70] *Fourth National Climate Assessment* (2018), UGCRP, Chapter 26: Alaska, https://nca2018.globalchange.gov/chapter/26/.

[71] EPA, Climate Change Indicators: Coastal Flooding, https://www.epa.gov/climate-indicators/climate-change-indicators-coastal-flooding.

[72] NOAA, High Tide Flooding, https://coast.noaa.gov/states/fast-facts/recurrent-tidal-flooding.html.

the last few decades. In the past few years, however, lake water levels have seen notable increases and are now toward the top of their historical ranges.[73]

Response Considerations

FEMA Community Lifeline Considerations

- Energy
  - Coastal flooding, including wave action and storm surges, may affect gas and electric asset performance, cause asset damage and failure, and disrupt energy generation, transmission, and distribution.[74]
  - A sea level rise of just 3.3 feet could expose dozens of power plants to a greater risk of experiencing a 100-year flood scenario.[75]
- Communications
  - Buried fiber optic cables and nodes, which provide internet and communication services, are at risk due to anticipated sea level rise. These nodes are often clustered at low elevations around dense populations. Fiber buried on land is water- and weather-resistant but is not designed to be submerged.[76]
- Transportation
  - Flooded roadways may limit the ability for response resources to be transported to impacted locations.
- Hazardous Materials
  - High lake levels and strong storms could impact several industrial facilities, contaminated sites, and communities along Lake Michigan.[77]
- Water Systems
  - As sea levels continue to rise, salt water infiltration into groundwater resources may reduce the availability of fresh water.

Equity Considerations

- Approximately 40 percent of the populations living in coastal counties fall into an elevated risk category. This includes children, the elderly, households where English is not the primary language, and those living in poverty.[78]

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[73] EPA, Climate Change Indicators: Great Lakes Water Levels and Temperatures, https://www.epa.gov/climate-indicators/great-lakes.

[74] *Fourth National Climate Assessment* (2018), USGCRP, Chapter 4: Energy Supply, Delivery, and Demand, https://nca2018.globalchange.gov/chapter/4/.

[75] *Fourth National Climate Assessment* (2018), USGCRP, Chapter 4: Energy Supply, Delivery, and Demand, https://nca2018.globalchange.gov/chapter/4/.

[76] "Rising Seas Could Cause Problems For Internet Infrastructure," NPR (2018), https://www.npr.org/2018/07/16/627254166/rising-seas-could-cause-problems-for-internet-infrastructure.

[77] *Rising Waters: Climate Change Impacts and Toxic Risks to Lake Michigan's Shoreline Communities* (2022), https://elpc.org/resources/rising-waters-climate-change-impacts-and-toxic-risks-to-lake-michigans-shoreline-communities.

[78] NOAA, Economics and Demographics, https://coast.noaa.gov/states/fast-facts/economics-and-demographics.html.

- Traffic delays from high-tide flooding are projected to disproportionately affect populations that are low income, are of minority status, and/or have no high school diploma.[79]

Inland Flooding

Rivers and streams experience flooding from rainstorms and spring snowmelt, or a combination of the two. Although the risk for flooding varies across the United States, most low-lying areas are susceptible to floods. The probability of flooding depends on several factors, such as topography, regional/local climate, and human-made changes to river systems (landscape changes, river modifications, etc.). Flood events are classified according to their "annual exceedance probability" (e.g., 10% annual chance, 1% annual chance, 0.2% annual chance, 0.1% annual chance).

Impacts

Climate scientists have predicted that periods of heavy rain will become more common as Earth heats up. The amount of rain falling in the heaviest rainstorms has increased across the country between 1958 and 2016.[80] Floods have generally become larger in rivers and streams across large parts of the Northeast and Midwest, while flood frequencies have decreased in other parts of the country, especially the Southwest and the Rockies.[81] Floodplain inundation is expected to increase by approximately 45 percent by the end of the century.[82]

A warmer atmosphere holds and subsequently releases more water. Since 1901, the climate has become about 4 percent wetter, and, in the Northeast, the most extreme storms are generating approximately 27 percent more moisture than they did a century ago.[83] A study by NOAA examining the record-breaking rainfall in Louisiana in 2016 determined that the rains there were at least 40 percent more likely to have occurred and were 10 percent more intense as a result of climate change.[84,85]

In regions where seasonal snowmelt plays a significant role in annual runoff, hotter temperatures can trigger more rain-on-snow events, with warm rains inducing faster and

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[79] EPA (2021), Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts, https://www.epa.gov/system/files/documents/2021-09/climate-vulnerability_september-2021_508.pdf.

[80] *Fourth National Climate Assessment* (2018), Chapter 2: Our Changing Climate, https://nca2018.globalchange.gov/chapter/2/.

[81] Hersher, R. (2022), "How Climate Change Drives Inland Floods," NPR, https://www.npr.org/2022/08/03/1115384628/how-climate-change-drives-inland-floods.

[82] AECOM, FEMA Climate Change Report, https://aecom.com/fema-climate-change-report/.

[83] *Fourth National Climate Assessment, Volume I: Climate Science Special Report*, USGCRP, Chapter 7 – Precipitation Change in the United States, https://science2017.globalchange.gov/chapter/7/.

[84] NRDC, Flooding and Climate Change: Everything You Need to Know, https://www.nrdc.org/stories/flooding-and-climate-change-everything-you-need-know.

[85] NOAA (2016), "Climate Change Increased Chances of Record Rains in Louisiana by at Least 40 Percent," https://www.noaa.gov/media-release/climate-change-increased-chances-of-record-rains-in-louisiana-by-at-least-40-percent.

earlier melting. The combination of rain and melting snow can exacerbate spring flooding, as winter and spring soils are typically high in moisture and often still frozen and therefore less able to absorb runoff. Regions with higher numbers of rain-on-snow events, such as the Northwest, are expected to see higher flooding risks.

2022 Flash Floods in Kentucky and West Virginia

During July 25-30, 2022, several thunderstorms brought heavy rain, flash flooding, and river flooding to eastern Kentucky and central Appalachia. These thunderstorms caused rainfall rates in excess of 4 inches per hour across complex terrain that led to widespread impacts. While it did not rain continuously during this 4-day stretch, the overwhelming amounts of rain and flooding led to 39 deaths and widespread damage. Entire homes and parts of some communities were swept away by flood waters, leading to heavy infrastructure damage.[86]

The rainfall totals observed between these dates across eastern Kentucky were over 600 percent of normal. While most of the region was drier than normal going into July, the amount of rain during that short period overwhelmed the area. The estimated peak rainfall totals of 14-16 inches from July 26 to July 29 had been unheard of historically. There is less than a 1 in 1,000 chance of that amount of rain falling in any given year over a 4-day period.[87]

FEMA provided assistance in Kentucky that included Individual and Households Programs (IHP) support, Public Assistance (PA) grants, and Hazard Mitigation Grant Program (HMGP) funding. FEMA provided federal disaster assistance in West Virginia to supplement local recovery efforts in areas affected by severe storms, flooding, landslides, and mudslides from the July 2022 flooding event. Federal funding was provided on a cost-sharing basis for emergency work, repair or replacement of facilities, and hazard mitigation measures.

In West Virginia, flooding caused by extreme precipitation over the state's rugged topography is considered the state's costliest and most severe natural hazard. West Virginia's annual precipitation rates over this century are projected to increase, with the largest increases occurring during the winter and spring months. The number and intensity of extreme precipitation events are also projected to increase.[88]

[86] National Weather Service, https://www.weather.gov/jkl/July2022Flooding.

[87] National Weather Service, https://www.weather.gov/jkl/July2022Flooding.

[88] NOAA National Centers for Environmental Information, *State Climate Summaries 2022: West Virginia*, https://statesummaries.ncics.org/chapter/wv/.

Response Considerations

FEMA Community Lifeline Considerations

- Safety and Security
  - Flood-related injuries and fatalities are often caused by vehicle use during flood events.[89]
  - If SLTT capabilities are overwhelmed, SLTT entities may request Urban Search & Rescue (US&R) task force support to assist with water rescues.
- Food, Hydration, Shelter
  - Flood damage to homes may prompt the need for FEMA IHP support.
- Health and Medical
  - Floodwaters may be contaminated with harmful chemicals, waste, or debris.
  - Floodwaters may contain sewage, which can cause diarrheal disease through exposure to E. coli or Salmonella if anything contaminated with such floodwaters is consumed.[90]
- Energy
  - Extreme rainfall may lead to flash floods that undermine power line foundations and pipeline crossings and inundate riverbank energy facilities, such as power plants, substations, transformers, and refineries.[91]
- Transportation
  - Flooded roadways may limit the ability for response resources to be transported to impacted locations.

Equity Considerations

- Vulnerable populations are the least likely to have flood insurance, access to transportation during evacuations, cash on hand, or the ability to relocate.[92]

Other Considerations

- Mudslides develop when water rapidly accumulates in the ground and results in a surge of water-saturated rock and debris. Areas where wildfires or human modification of the land have destroyed vegetation on slopes are particularly vulnerable to landslides during and after heavy rains.[93]

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[89] FEMA Preparedness Community, Flood | Vehicle (Do Not Drive in Floodwaters; "Turn Around, Don't Drown!"), https://community.fema.gov/ProtectiveActions/s/article/Flood-Vehicle-Do-Not-Drive-in-Floodwaters-Turn-Around-Don-t-Drown.

[90] CDC, Floodwater After a Disaster or Emergency, https://www.cdc.gov/disasters/floods/floodsafety.html.

[91] *Fourth National Climate Assessment* (2018), USGCRP, Chapter 4: Energy Supply, Delivery, and Demand, https://nca2018.globalchange.gov/chapter/4/.

[92] NRDC, Flood Insurance Subsidies Must Include Options to Lower Risk, https://www.nrdc.org/bio/joel-scata/flood-insurance-subsidies-must-include-options-lower-risk.

[93] CDC, Landslides and Mudslides, https://www.cdc.gov/disasters/landslides.html.

Hurricanes/Tropical Cyclones/Typhoons

The number and strength of tropical storms varies significantly from year to year, making it difficult to detect trends in the frequency and intensity of hurricanes over time. As the climate continues to warm, however, it is predicted that the average intensity of hurricanes will rise while the overall number of hurricanes will remain unchanged. The expected increase in hurricane intensity is a result of rising sea levels, increased rainfall, and increased wind intensities.

Impacts

Sea levels are rising as oceans warm and expand. This expansion, combined with the melting of land-based ice, has caused the global average sea level to rise by roughly 7 to 8 inches since 1900—a trend that is expected to accelerate over the coming decades.[94] Higher sea levels give coastal storm surges a higher starting point when a major hurricane approaches. The resulting storm surges are therefore able to reach higher levels and penetrate further inland in low-lying areas. The risk is even greater if storms make landfall during periods of high tide.

A hurricane's ability to produce rain is affected by the temperatures of both the air and ocean. Warm air can hold more moisture and more moisture often leads to more rain. Since the 1970s, rising air temperatures have caused the water vapor content in the atmosphere to rise. Hurricane rainfall rates are projected to increase in the future due to a warming climate and the accompanying increase in atmospheric moisture content. Modeling studies project an increase on the order of 10-15 percent for rainfall rates, averaged within about 100 km of a storm, in a 2-degree Celsius global warming scenario.[95]

Warming of ocean surface temperatures due to climate change is likely fueling more powerful tropical cyclones.[96] Sea surface temperatures have increased during the 20th century and continue to rise. From 1901 through 2020, temperatures rose at an average rate of 0.14°F per decade.[97] During this century, the temperature of the sea surface is projected to warm even faster, which will fuel stronger hurricanes in the tropics. Research suggests that rising temperature will increase the likelihood of rapid intensification, defined as an increase in hurricane wind speeds of 35 mph within 24 hours.[98]

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[94] *Climate Science Special Report* (2017), *Fourth National Climate Assessment, Volume I*, USGCRP, Executive Summary, https://science2017.globalchange.gov/chapter/executive-summary/.

[95] NOAA, Global Warming and Hurricanes, Geophysical Fluid Dynamics Laboratory, https://www.gfdl.noaa.gov/global-warming-and-hurricanes/.

[96] NOAA, Climate change is Probably Increasing the Intensity of Tropical Cyclones, https://www.climate.gov/news-features/understanding-climate/climate-change-probably-increasing-intensity-tropical-cyclones.

[97] EPA, Climate Change Indicators: Sea Surface Temperature, https://www.epa.gov/climate-indicators/climate-change-indicators-sea-surface-temperature.

[98] NOAA, Geophysical Fluid Dynamics Laboratory, Global Warming and Hurricanes, https://www.gfdl.noaa.gov/global-warming-and-hurricanes/.

Additionally, as ocean temperatures rise, there is less cold, subsurface ocean water to serve as a braking mechanism for hurricanes. When strong storm winds churn up cold subsurface water, the cooler waters typically weaken storm strength. If deeper waters become too warm, however, this natural braking mechanism weakens.

As of 2020, records show that, since 1995, there have been 17 above-normal Atlantic hurricane seasons—the largest stretch of above-normal seasons on record—as measured by NOAA's Accumulated Cyclone Energy (ACE) Index. (ACE calculates the intensity of a hurricane season by combining the total number of hurricanes along with the observed wind speeds). Some models predict that although there may not be more storms toward the end of the century, more of them will be classified as Category 4 and Category 5 hurricanes.[99]

Response Considerations

FEMA Community Lifeline Considerations

- Safety and Security
  - Higher storm surges and increased rainfall will lead to greater flooding in hurricane events. Flooding is the most significant contributor to deaths in hurricanes.[100]
  - If SLTT capabilities are overwhelmed, SLTT entities may request US&R task force support to assist with water rescues.
- Food, Hydration, Shelter
  - Flood damage to homes may prompt the need for FEMA IHP support.
- Health and Medical
  - Floodwaters may be contaminated with harmful chemicals, waste, or debris.
  - Floodwaters may contain sewage, which can cause diarrheal disease through exposure to E. coli or Salmonella if anything contaminated with such floodwaters is consumed.[101]
- Energy
  - In the Southeast, power plants and oil refineries are especially vulnerable to flooding. The span and duration of impacts to facilities will likely depend on the category of the hurricane. The number of electricity generation facilities in the Southeast potentially exposed to hurricane storm surge is estimated at 69 for a Category 1 storm and 291 for a Category 5 storm.[102]

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[99] NASA, How Climate Change May Be Impacting Storms Over Earth's Tropical Oceans – Climate Change: Vital Signs of the Planet, https://climate.nasa.gov/ask-nasa-climate/2956/how-climate-change-may-be-impacting-storms-over-earths-tropical-oceans/.

[100] The Weather Channel, "This Is Actually the Biggest Killer During Hurricanes and Tropical Storms," https://weather.com/safety/hurricane/news/us-deaths-hurricanes-tropical-storms-nhc-study.

[101] CDC, Floodwater After a Disaster or Emergency, https://www.cdc.gov/disasters/floods/floodsafety.html.

[102] *Fourth National Climate Assessment* (2018), USGCRP, Chapter 4: Energy Supply, Delivery, and Demand, https://nca2018.globalchange.gov/chapter/4/.

- Communications
    - The flooding and winds associated with hurricanes have the capacity to damage critical communications systems.
- Transportation
    - Flooded roadways may limit the ability for response resources to be transported to impacted locations.

Equity Considerations

- Approximately 40 percent of the populations living in coastal counties fall into an elevated risk category. This includes children, the elderly, households where English is not the primary language, and those living in poverty.[103]

Other Considerations

- The increasing strength of hurricanes is causing greater damage, and increased development in coastal areas is leading to growing property risk. From 1970 to 2010, the total population of coastal counties increased by approximately 40 percent.[104]
- Because the area of warming ocean waters is expanding, the zone where hurricanes can form is also growing. That could mean more storms forming and making landfall in higher latitudes than has been recorded historically.

Wildfires

Climate change is already causing an increase in the scale and total burn area of wildfires across the United States. The frequency of large wildfires is influenced by a combination of natural and human factors, such as temperature, soil moisture, relative humidity, wind speed, and vegetation (fuel density).[105] Widespread increases in surface air vapor pressure deficit (VPD) levels, which are a measure of the atmosphere's thirst, are a primary driver of growing wildfire activity.[106] Climate change has elevated surface temperatures, resulting in higher VPD levels and a doubling of cumulative forest fire burn areas.[107] Historic forest management practices have also led to higher fuel densities in most U.S. forests. This increased fuel load and warming temperatures are making larger wildfires in the western United States more frequent.[108] The wildfire season has also lengthened in many areas due

[103] NOAA, Economics and Demographics, https://coast.noaa.gov/states/fast-facts/economics-and-demographics.html.

[104] NOAA, Economics and Demographics, https://coast.noaa.gov/states/fast-facts/economics-and-demographics.html.

[105] *Climate Science Special Report* (2017), *Fourth National Climate Assessment, Volume I*, USCGRP, https://science2017.globalchange.gov/downloads/CSSR2017_FullReport.pdf.

[106] CISA, National and International Climatology Study Extreme Weather Events and Impacts.

[107] Abatzoglou and Williams, *Impact of anthropogenic climate change on wildfire across western US forests*, https://www.pnas.org/doi/full/10.1073/pnas.1607171113.

[108] *Climate Science Special Report* (2017), *Fourth National Climate Assessment, Volume I*, USGCRP, Droughts, Floods, and Wildfire, https://science2017.globalchange.gov/chapter/8/.

to such factors as warmer spring temperatures, longer summer dry seasons, and drier soils and vegetation.[109]

The relationship between climate change and wildfires is complex. Wildfire activity and the environmental conditions caused by climate change together create a feedback loop in which the burning of organic matter releases greenhouse gases into the atmosphere that then further contribute to climate change and compound wildfire risk.

The impact of climate change on wildfire frequency and severity varies across the United States. Oregon's historic 2020 fire season included fires that were consistent with similar past fire events in the region, but extreme drought likely contributed to increased fire severity in the state.[110] In California, wildfire exclusion practices have played a sizable role in the accumulation of wildland vegetation, which has helped to fuel its recent wildfires. Future conditions created by climate change may lead to abnormal wildfire events occurring in regions across the country.[111]

Impacts

Wildfires threaten human health and safety. Direct human fatalities are the result of entrapment, when people or firefighters are unable to escape a fire. Additionally, smoke exposure may impact communities far beyond a wildfire burn area, causing or exacerbating health problems.[112] Water supplies can be adversely affected during a wildfire and for years afterward due, in part, to contaminants associated with ash settling on streams, lakes, and water reservoirs.[113] Wildfires can also impact the short- and long-term migration of displaced residents, including short-term emergency evacuations and long-term displacements when homes are destroyed.

Wildfires are increasingly destructive and costly. Between 1980 and 2021, the United States experienced 20 wildfire events that caused more than $1 billion in damage; 16 of those 20 wildfires occurred since 2000.[114]

Western U.S. and Alaska

Wildfires have increased in size and intensity and are projected to continue increasing in the western United States. Modeling of future temperature and VPD level increases that are

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[109] *Climate Science Special Report* (2017), *Fourth National Climate Assessment, Volume I*, USGCRP, https://science2017.globalchange.gov/downloads/CSSR2017_FullReport.pdf.

[110] Reilly et al (2022), *Cascadia Burning: The historic, but not historically unprecedented, 2020 wildfires in the Pacific Northwest, USA*, https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/ecs2.4070.

[111] McKenzie et al. (2008), *Chapter 15: Global Warming and Stress Complexes in Forests of Western North America*, ScienceDirect, https://www.sciencedirect.com/science/article/abs/pii/S1474817708000156?via%3Dihub.

[112] EPA, Why Wildfire Smoke is a Health Concern, https://www.epa.gov/wildfire-smoke-course/why-wildfire-smoke-health-concern.

[113] EPA, Wildfires: How Do They Affect Our Water Supplies?, https://www.epa.gov/sciencematters/wildfires-how-do-they-affect-our-water-supplies#:~:text=Water%20supplies%20can%20be%20adversely%20affected%20during%20the,in%20place%20and%20retains%20water%20is%20burned%20away.

[114] NOAA, Billion-Dollar Weather and Climate Disasters, https://www.ncei.noaa.gov/access/billions/.

expected to occur due to climate change point to increases in the aridity of forest fuels during the fire season and a subsequent increase in forest fire activity. Increases in these climatic drivers were found to be responsible for over half the already observed increase in western U.S. forest fuel aridity from 1979 to 2015 and for the doubling of forest fire burn areas between 1984 and 2015.[115]

Historically, wildfires have been less frequent and smaller in Alaska compared to wildfires elsewhere. Wildfires along Alaska's tundra and in its forests will likely increase substantially under the projected warmer and drier conditions caused by climate change. The total area burned in the state is projected to increase between 25 and 53 percent by the end of the century.[116]

2017 California Wildfires

The 2017 California wildfire season, with its 9,270 separate wildfires, was one of the most destructive in history, burning over 1.5 million acres, destroying 10,868 structures, and causing 47 deaths. California's wildfire season typically runs from early summer through late autumn. Historically, by the end of October, California enters its rainy season and its wildfire season ends.

In October 2017, Southern California received very little rain and had just experienced the second hottest summer on record, to date. These factors along with the area's typical fall Santa Ana winds and an increase in dry vegetation (fuel load) provided the perfect conditions for a major wildfire.[117]

In December, a series of 29 wildfires occurred. The Thomas Fire was the largest and most destructive, burning more than 272,000 acres, forcing the evacuation of over 230,000 people, and destroying more than 1,000 structures. A month later, severe rainstorms led to mudslides, a common secondary disaster seen in areas affected by wildfires. The mudslides in Montecito, California, destroyed 500 additional structures and resulted in 20 fatalities.[118] The Thomas Fire resulted in a Fire Management Assistance Declaration and a major disaster declaration.[119]

Eastern U.S.

Although the total area burned by wildfire is greatest in the western United States, the Southeast has the largest area burned by prescribed fires and the highest number of wildfires. In the future, rising temperatures and increases in the duration and intensity of

[115] *Climate Science Special Report* (2017), *Fourth National Climate Assessment, Volume I*, USCGRP, https://science2017.globalchange.gov/downloads/CSSR2017_FullReport.pdf.

[116] *Climate Science Special Report* (2017), *Fourth National Climate Assessment, Volume I*, USCGRP, https://science2017.globalchange.gov/downloads/CSSR2017_FullReport.pdf.

[117] NOAA, December wildfires scorch southern California in 2017, https://www.climate.gov/news-features/event-tracker/december-wildfires-scorch-southern-california-2017.

[118] Thomas Fire and CA Storm, U.S. Congressman Salud Carbajal, https://carbajal.house.gov/district/thomas-fire.htm.

[119] FEMA, FEMA Fire Management Assistance Granted for Thomas Fire, https://www.fema.gov/press-release/20210318/fema-fire-management-assistance-granted-thomas-fire.

droughts are expected to increase wildfire occurrence and reduce the effectiveness of prescribed fires.[120]

Response Considerations

FEMA Community Lifeline Considerations

- Safety and Security
  - The nature of wildland firefighting has shifted in recent years. Conditions related to changing weather and fuel have prevented the direct attack of fires by ground personnel and have contributed to larger wildfires that are more difficult to extinguish.
  - Increasingly, difficult wildfire conditions may result in increased responder injuries and fatalities as well as impacts to their mental health.
- Food, Hydration Shelter
  - As wildfires increase in frequency and scale, additional resources and awareness will be needed to address short-term sheltering, long-term housing, safe drinking water, and sustained food supplies.
  - Fire damage may result in greater losses of crops, a decrease in crop quality, or changes in harvesting methods that harm productivity.[121]
  - Livestock will likely suffer more direct losses due to wildfire and smoke exposure, including burns, burn-related deaths, and pneumonia. Additionally, larger and more intense wildfires may lead to greater indirect losses, such as reduced conception rates, lower birth weights, and reductions in animal milk production.[122]
- Health and Medical
  - An increased rate of mental health disorders post-wildfire has been found in both adults and children and may grow with increasing wildfire activity.[123]
  - Wildfires will continue to affect air pollution and regional air quality. The effects of wildfire smoke range from eye and respiratory tract irritation to more serious disorders, including reduced lung function, bronchitis, exacerbation of asthma and heart failure, and premature death.[124]

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[120] *Fourth National Climate Assessment* (2018), UGCRP, Chapter 19: Southeast, https://nca2018.globalchange.gov/chapter/19/.

[121] AEI (2021), How Does Wildfire Affect U.S. Agriculture?, https://aei.ag/2021/09/13/wildfire-smoke-impact-agriculture/.

[122] O'Hara et al. (2021), Impacts from Wildfires on Livestock Health and Production: Producer Perspectives, PubMed, https://pubmed.ncbi.nlm.nih.gov/34827962.

[123] To et al. (2021), The Impact of Wildfires on Mental Health: A Scoping Review, PubMed, https://pubmed.ncbi.nlm.nih.gov/34562964/.

[124] EPA, Wildland Fire Research: Health Effects Research, https://www.epa.gov/air-research/wildland-fire-research-health-effects-research#:~:text=Wildfires%20increase%20air%20pollution%20in%20surrounding%20areas%20and,of%20asthma%20and%20heart%20failure%2C%20and%20premature%20death.

- Energy
    - Wildfires may cause disruptions to energy systems, particularly in regions experiencing preventive power shutoffs.
- Transportation
    - The transportation of water requires secure routes; wildfire-damaged areas may affect transportation capabilities.
- Hazardous Materials
    - Hazardous materials facilities may be threatened by an increase in the number and extent of wildfires.
- Water Systems
    - Increasing numbers of wildfires will create more damage to watersheds, harming both water quality and water supplies. Soot and ash introduce pollutants to lakes and streams, with detrimental downstream effects on wildlife and human health.[125]

[125] USGS, Wildfire and Climate Change, https://www.usgs.gov/science-explorer/climate/wildfire.

ANNEX C: CLIMATE RESOURCES AND TOOLS

Table 6 provides a list of climate resources and tools, noting whether they provide information on social vulnerability, future conditions, and/or natural hazards such as wildfire, flood, and hurricanes. The list was compiled by FEMA's Climate Team. Questions/comments can be submitted to the Climate Team at FEMA-ClimateAdaptation@fema.dhs.gov.

Table 6. Climate Change Resource Capability Inventory

Dataset / Application / Tool	Difficulty of Use (Operational Level)	Social Vulnerability	Future Conditions	Wildfire	Flood	Hurricane
Climate and Economic Justice Screening Tool (CEJST) – White House	Low	Yes	Yes	No	Yes	No
Coastal Flood Exposure Mapper – NOAA	Low	Yes	Yes	No	Yes	Yes
Community Resilience Estimates (CRE) – U.S. Census Bureau	Low	Yes	No	No	No	No
Low-Income Energy Affordability Data (LEAD) Tool – DOE/EERE	Low	Yes	No	No	No	No
Wildfire Risk to Communities – USDA/USFS	Low	Yes	No	Yes	No	No
Climate Mapping for Resilience and Adaptation (CMRA) – White House/NOAA	Medium	Yes	Yes	Yes	Yes	No
Environmental Justice Screening & Mapping Tool (EJScreen) – EPA	Medium	Yes	Yes	Yes	Yes	No
National Risk Index (NRI) – FEMA	Medium	Yes	No	Yes	Yes	Yes
Neighborhoods at Risk – Headwaters Economics	Medium	Yes	Yes	No	Yes	No
Resilience Analysis & Planning Tool (RAPT) – FEMA	Medium	Yes	Yes	Yes	Yes	Yes
Sea Level Rise Viewer – NOAA	Medium	No	Yes	No	Yes	No
Social Vulnerability Index (SVI) – CDC	Medium	Yes	No	No	No	No
Climate Risk and Resilience Portal (ClimRR) – Argonne National Laboratory/AT&T/FEMA	High	Yes	Yes	Yes	Yes	Yes
Hazus – FEMA	High	No	No	No	Yes	Yes

*This list is not all-inclusive and represents the most commonly available and used tools for emergency management.

**Tools listed are often updated without notice. Capabilities identified are as of March 2023.

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ANNEX D: GLOSSARY

- **Adaptation:** Adjustment in natural or human systems to a new or changing environment that takes advantage of beneficial opportunities or moderates negative effects. (USGCRP 2022-2031 Strategic Plan)
- **Cascading impacts:** Cascading impacts from extreme weather/climate events occur when an extreme hazard generates a sequence of secondary events in natural and human systems that result in physical, natural, social, or economic disruption, whereby the resulting impact is significantly larger than the initial impact. Cascading impacts are complex and multi-dimensional and are associated more with the magnitude of vulnerability than with that of the hazard. (IPCC 2022 Annex-II)
- **Climate:** Climate is determined by the long-term pattern of temperature and precipitation averages and extremes at a location. (Climate.gov)
- **Climate change:** A change in the state of the climate that can be identified by changes in the mean and/or variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent human-driven changes in the composition of the atmosphere or in land use. (USGCRP 2022-2031 Strategic Plan)
- **Climate equity:** The goal of recognizing and addressing the unequal burdens made worse by climate change, while ensuring that all people share the benefits of climate protection efforts. Achieving equity means that all people—regardless of their race, color, gender, age, sexuality, national origin, ability, or income—live in safe, healthy, fair communities. (EPA Climate Equity)
- **Climate extreme (extreme weather or climate event):** The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classified as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., high temperature, drought, or heavy rainfall over a season). For simplicity, both extreme weather events and extreme climate events are referred to collectively as climate extremes. (IPCC 2022 Annex-II)
- **Climate mitigation (also greenhouse gas mitigation):** Measures that reduce the amount and speed of future climate change by either reducing emissions of carbon dioxide, methane, and other heat-trapping gases or by removing carbon dioxide from the atmosphere. (USGCRP 2022-2031 Strategic Plan)
- **Coastal erosion:** When a net loss of sediment or bedrock from the shoreline results in landward movement of the high-tide mark. (IPCC 2022 Annex-II)

- **Compound weather/climate events:** The terms 'compound events,' 'compound extremes,' and 'compound extreme events' refer to the combination of multiple drivers and/or hazards that contributes to societal and/or environmental risk. (IPCC 2022 Annex-II)
- **Disproportionate effects:** Situations of concern where there exists significantly higher and more adverse health and environmental effects on minority populations, low-income populations, or indigenous peoples. (EPA EJ 2020 Glossary)
- **Drought:** An exceptional period of water shortage for existing ecosystems and the human population (due to low rainfall, high temperature, and/or wind). (IPCC 2022 Annex-II)
- **Environmental justice**: The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. (EPA EJ 2020 Glossary)
- **Frontline community:** Communities or populations that have experienced systemic socioeconomic disparities, environmental injustice, or another form of injustice and are highly vulnerable to and will experience disproportionately high adverse impacts from environmental and climate injustice and inequitable climate actions. (USGCRP 2022-2031 Strategic Plan)
- **Global warming**: Long-term increase in global average temperature as a result of human activity (Climate.gov). Climate change encompasses global warming, but refers to the broader range of changes that are happening to our planet. (NASA Global Climate Change Frequently Asked Questions)
- **Hazard Mitigation:** Those capabilities necessary to reduce loss of life and property by lessening the impact of disasters. (FEMA Resources for Climate Resilience)
- **Heat wave:** A period of abnormally hot weather, often defined with reference to a relative temperature threshold, lasting from two days to months. Heat waves and warm spells have various and, in some cases, overlapping definitions. (IPCC 2022 Annex-II)
- **Land cover:** The physical characteristics of the land surface, such as crops, trees, or concrete. (USGCRP 2022-2031 Strategic Plan)
- **Land use:** Activities taking place on land, such as growing food, cutting trees, or building cities. (USGCRP 2022-2031 Strategic Plan)
- **Overburdened community:** Minority, low-income, tribal, or indigenous populations or geographic locations in the United States that potentially experience disproportionate environmental harms and risks. This disproportionality can be as a result of greater vulnerability to environmental hazards, lack of opportunity for public participation, or other factors. Increased vulnerability may be attributable to an accumulation of negative, or lack of positive, environmental, health, economic, or social conditions within these populations or places. The term describes situations where multiple

factors, including both environmental and socio-economic stressors, may act cumulatively to affect health and the environment and contribute to persistent environmental health disparities. (EPA EJ 2020 Glossary)

- **Resilience:** The ability to prepare for anticipated hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions due to emergencies. (Presidential Policy Directive 8: National Preparedness)
- **Salt water intrusion/encroachment**: Displacement of fresh surface water or groundwater by the advance of salt water due to its greater density. This usually occurs in coastal and estuarine areas due to decreasing land-based influence (e.g., from reduced runoff or groundwater recharge or from excessive water withdrawals from aquifers) or increasing marine influence (e.g., relative sea level rise). (IPCC 2022 Annex-II)
- **Storm surge:** The temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions (low atmospheric pressure and/or strong winds). The storm surge is defined as the excess above the level expected from the tidal variation alone at that time and place. (IPCC 2022 Annex-II)
- **Underserved communities/populations**: Groups that have limited or no access to resources or that are otherwise disenfranchised. These groups may include people who are socioeconomically disadvantaged; people with limited English proficiency; geographically isolated or educationally disenfranchised people; people of color as well as those of ethnic and national origin minorities; women and children; individuals with disabilities and others with access and functional needs; and seniors. (FEMA Glossary)
- **Urban heat island:** The increased air temperatures in urban areas in contrast to cooler surrounding rural areas. (IPCC 2022 Annex-II)
- **Vulnerability:** The degree to which physical, biological, and socioeconomic systems are susceptible to and unable to cope with adverse impacts of climate change. (USGCRP 2022-2031 Strategic Plan)
- **Weather:** The state of the atmosphere with respect to wind, temperature, cloudiness, moisture, pressure, etc. Weather refers to these conditions at a given point in time. (NOAA's National Weather Service Glossary)

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ANNEX E: ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Definition
ACE	Accumulated Cyclone Energy
BFE	base flood elevation
BRIC	Building Resilient Infrastructure and Communities
CDC	Centers for Disease Control and Prevention
CEJST	Climate and Economic Justice Screening Tool
CEQ	Council on Environmental Quality
CISA	Cybersecurity & Infrastructure Security Agency
ClimRR	Climate Risk and Resilience Portal
CMRA	Climate Mapping for Resilience and Adaptation
CRE	Community Resilience Estimate
DFA	Direct Federal Assistance
DOI	U.S. Department of the Interior
DRRA	Disaster Recovery Reform Act
E.O.	Executive Order
EHP	Environmental Planning and Historic Preservation
EHPA	Environmental Historic Preservation Advisor
EPA	Environmental Protection Agency
ESF	Emergency Support Function
FEMA	Federal Emergency Management Agency
FFRMS	Federal Flood Risk Management Strategy
FIOP	Federal Interagency Operational Plan
FMCSA	Federal Motor Carrier Safety Administration
FOS	Federal Operations Support
GHG	greenhouse gas
HENTF	Heritage Emergency National Task Force
HMGP	Hazard Mitigation Grant Program
HOS	Hours of Service
IHP	Individual and Households Program
IPCC	Intergovernmental Panel on Climate Change
IRS	Internal Revenue Service

Acronym/Abbreviation	Definition
LEAD	Low-Income Energy Affordability Data
NIDIS	National Integrated Drought Information System
NOAA	National Oceanic and Atmospheric Administration
NRCC	National Response Coordination Center
NRI	National Risk Index
NWS	National Weather Service
PA	Public Assistance
PHMSA	Pipeline and Hazardous Materials Safety Administration
PPE	personal protective equipment
PTSD	post-traumatic stress disorder
RAPT	Resilience Analysis & Planning Tool
RSF	Recovery Support Function
SCRI	Smithsonian Cultural Rescue Initiative
SLTT	state, local, tribal, and territorial
SVI	Social Vulnerability Index
UCG	unified coordination group
US&R	Urban Search & Rescue
USGCRP	U.S. Global Change Research Program
USGS	U.S. Geological Survey
WMO	World Meteorological Organization