



State-Level Climate Change Projections for Site-Level Resilience Planning

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Achieving resilience through proactive planning

A site that is energy and water resilient has:

- Optimized systems and operations
- Identified risk, consequences, and cost
- Trained personnel and capabilities
- Actionable strategies to achieve diverse solutions

Incorporating climate change information into site-level resilience planning requires access to detailed, downscaled hazard and hazard projection information

**Particular focus on high impact, low frequency (HILF) hazards*



Risk analysis provides a robust, replicable framework for resilience analysis

What can go wrong?

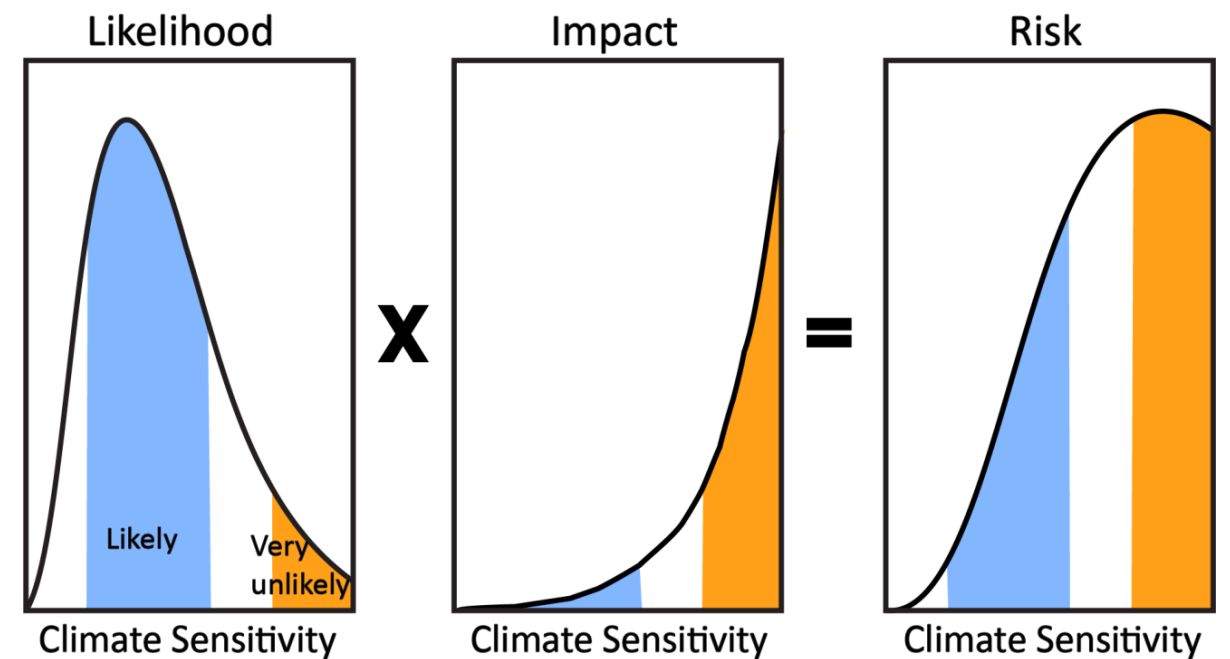
(A scenario)

How likely is it?

(A probability or frequency)

How bad would it be?

(A consequence severity)



Delgado, A., and Rabinowitz, H.S. *Considering Climate Change Scenarios in Site Resilience Planning*. 2021. doi:10.2172/1833511.
(After Spratt and Dunlop 2019)

First, identify the baseline hazard characteristics

Zip Code
 State ▼
 County ▼

Is the site in a location that has the potential to experience flooding? ▼

Highlight hazards that are likely to be impacted by climate change based on the National Climate Assessment
 Show hazards with zero frequency

Hazard Frequency

This table shows the anticipated annual frequencies of dual-impact hazards that could impact your site.

Hazard	Annual Frequency	Frequency Category	
Drought			Read More
Earthquake	0.002	Extremely unlikely (1 in 1,000 years)	» Evaluate Hazard
Hail	0.2	Anticipated (1 in 10 years)	» Evaluate Hazard
Ice Storm	0.03	Anticipated (1 in 10 years)	» Evaluate Hazard
Strong Wind	0.2	Anticipated (1 in 10 years)	» Evaluate Hazard
Wildfire	0.002	Extremely unlikely (1 in 1,000 years)	» Evaluate Hazard
Winter Weather	1.6	Likely (once a year)	» Evaluate Hazard

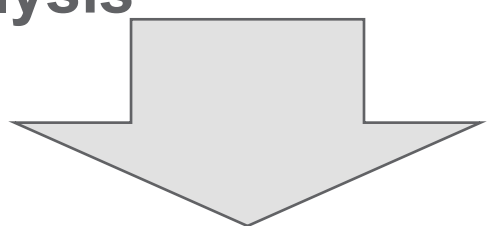


Technical Resilience Navigator (TRN) Identify Potential Hazards Tool

- Identifies potential range of hazards and how frequently they may impact a site
- Uses historic data from FEMA's National Risk Index (NRI), modified to display the likely annual frequency of a hazard at a site
- Highlights which hazards are likely to change as a result of climate change (per the National Climate Assessment (NCA))
- **Limitation:** Hazards are highlighted without state or regional-level context or information about anticipated changes in hazard frequency or severity

Available within TRN framework and outside TRN log-in at: <https://trn.pnnl.gov/potential-hazards>

Then, identify how climate change affects hazard characteristics

- Climate change may cause the frequency or severity of some hazards to change over time
 - Resources like NCA provide some context for how hazards might change, **but it is sometimes difficult to find detailed information at a regional or local scale applicable for site-level risk analysis**
- 
- Identify and compile state- and regional-level climate change projection resources through desk-based review, surveys, and semi-structured interviews



Delgado, A., and Rabinowitz, H.S. *Considering Climate Change Scenarios in Site Resilience Planning*. 2021. doi:10.2172/1833511. (After NCA 2018)

Identifying state-level climate change projection resources for site resilience planning

Which states have state-specific climate projection resources?

What hazards are considered?

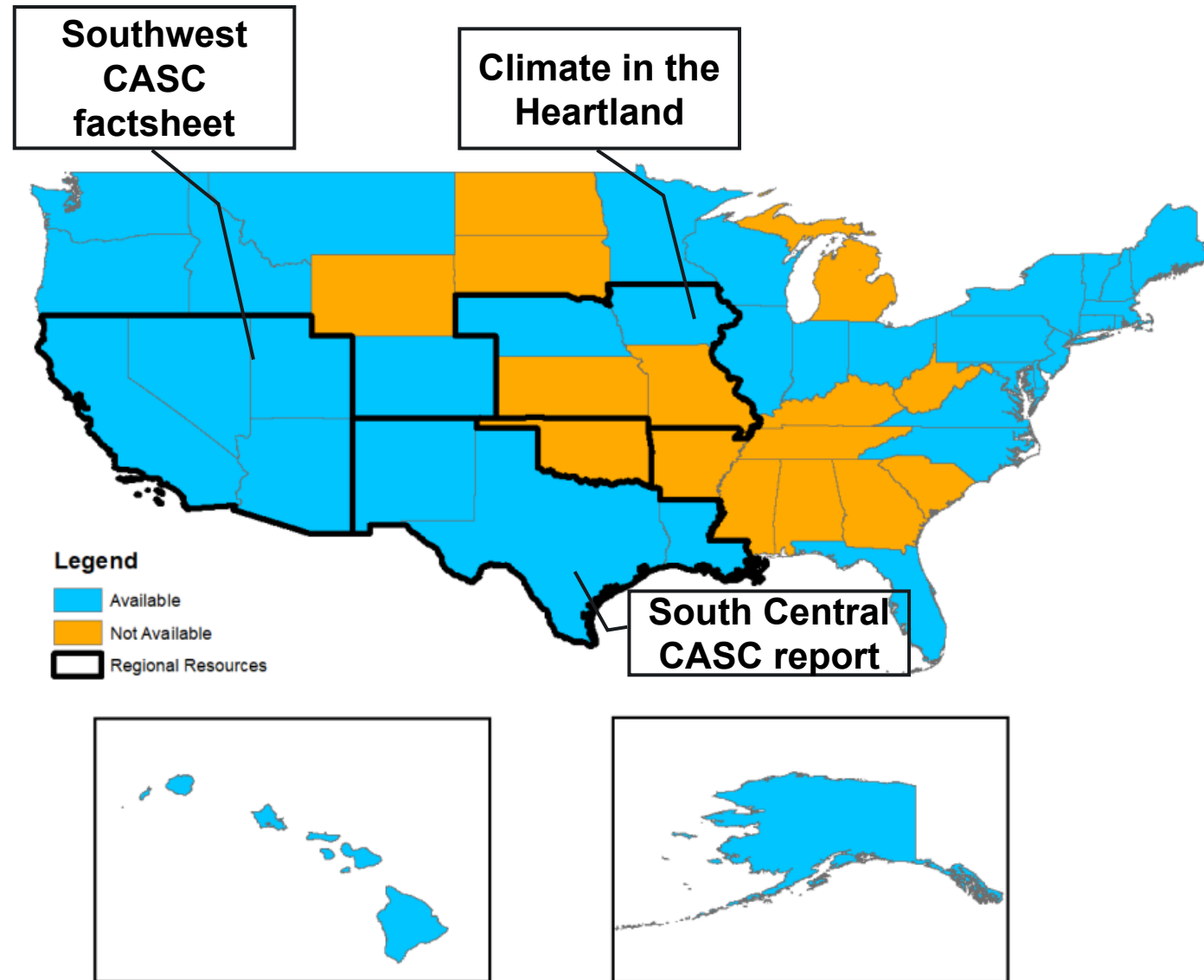
What are the drivers for the focus of each state's resources?

- Online review of state-level climate change resources
 - Georgetown Climate Center State Adaptation Progress Tracker
 - Additional web searches for each state that didn't have identified resources
- Survey
 - Sent to authors of identified climate change resources and state climatologists in states that had identified resources
 - Focused on whether the identified resource(s) incorporated state-specific downscaled models and which hazards were considered
- Semi-structured interviews
 - Requested interviews with state climatologists from states where no resources had been identified
 - Conducted additional interviews with respondents to the survey to follow up on additional questions

Metric	Number of state responses
Survey responses	16
Provided information via email	4
Participated in an interview	10
Total Responses ^a	26

^a For some states, multiple means of communication were used.

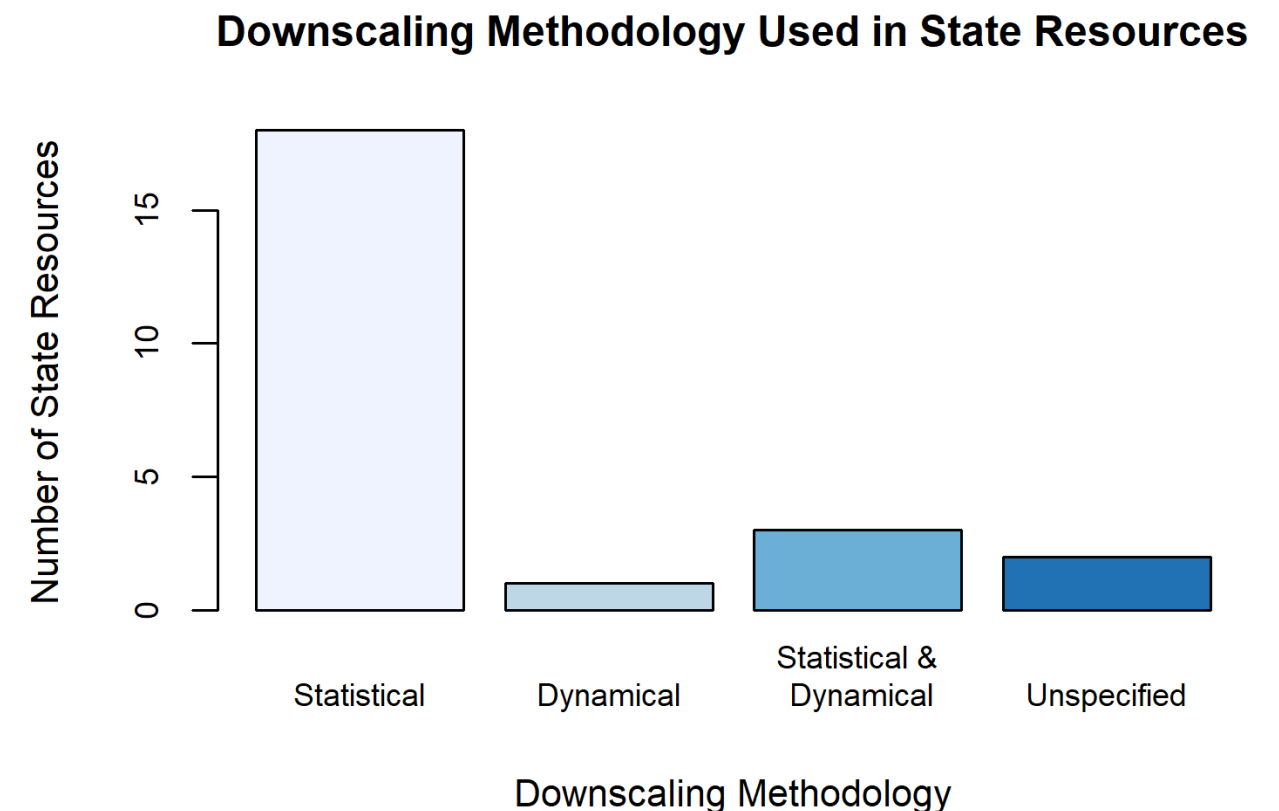
Availability of state-level resources



- 71% of states (35 states and DC, 36 in total) have state-level plans, assessments, analyses, tools or other resources
- An additional 3 states are included in regional assessments, for a total of 39 states (and DC) that have regional/state resources
- States that do not have state-level resources still have information available via the NCA and other national resources

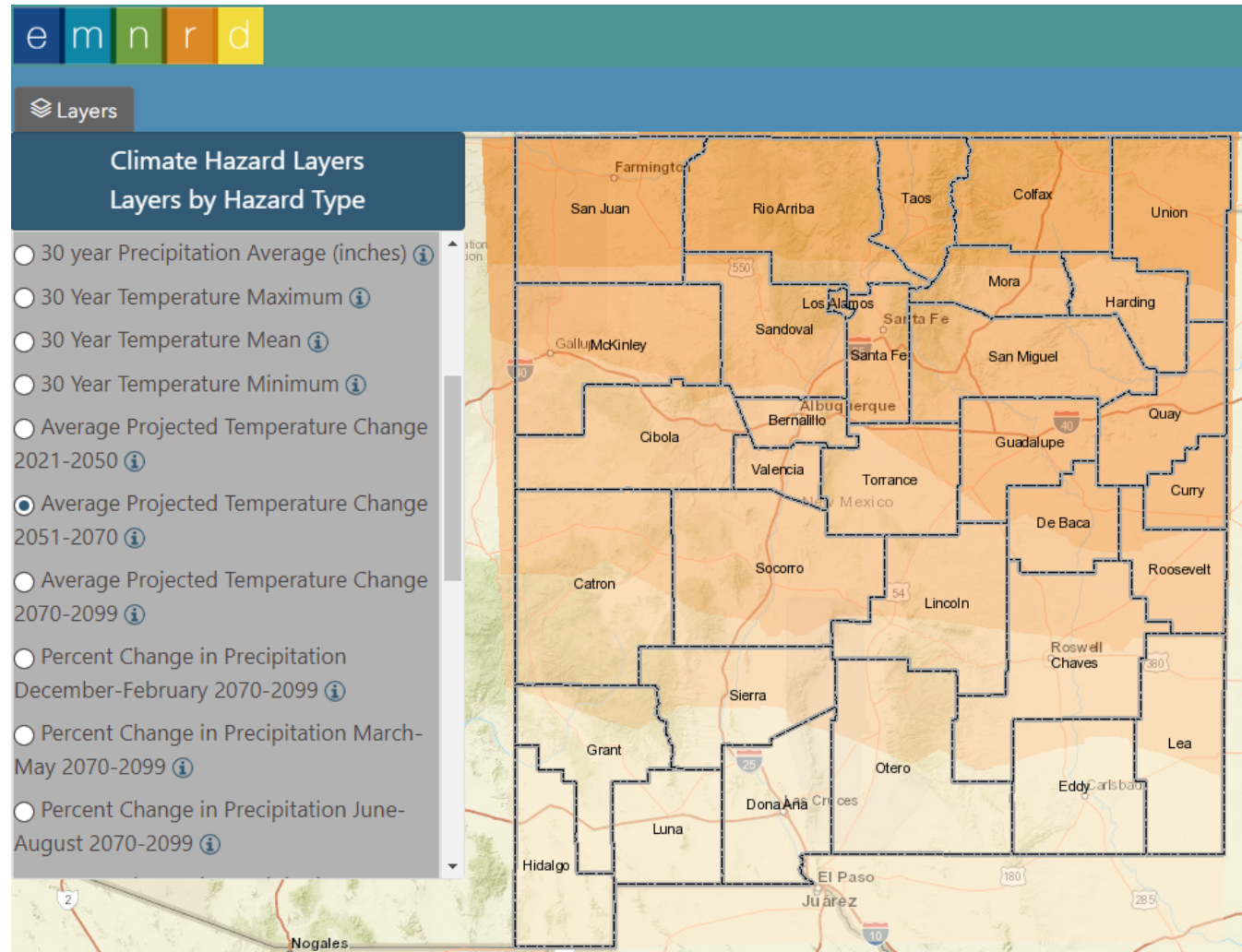
State-specific downscaled climate projections

- A state-level or finer-scale analysis can significantly improve the accuracy and relevancy of the assessment
- Quantitative projections typically focus on temperature and precipitation changes under different climate change scenarios, which can be used to provide context for changes in hazards
- Of the available state resources, 24 states included their own downscaled modeling for climate projections



Rabinowitz, H.S., S. Dahodwala, S. Baur, A. Delgado. *Availability of state-level climate change projection resources for use in site-level risk assessment.* (in prep)

Content of state-level resources



New Mexico Climate Risk Map (<https://nmclimaterisk.org/>), displaying Average Projected Temperature Change 2051-2070

- Reports/assessments, at the state level, generally discuss:
 - Anticipated changes in hazard frequency and severity (for hazards of concern to stakeholders)
 - The expected impacts of changing hazards (though generally not at the site-level)
 - Potential mitigation and adaptation strategies (usually at the regional or community-level)
- **Examples:**
 - New York state's *Responding to Climate Change in New York State (ClimAID)*
 - New Mexico web tools


Identify available national and state-level climate change projection resources


Enter your zip code or select your state from the drop-down menu to see resources relevant to your location.

Zip Code State


Below are resources with information about how climate change may impact the hazards experienced in Washington.


Washington Resources

 **Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers** - This report discusses regional and national climate projections and examines how the changing climate will impact the state of Washington. Most of the content of the report examines impacts on natural resources and ecosystems but there is a section that discusses impacts on built infrastructure, such as the effects of flooding and sea level rise on wastewater systems.

 **Washington Climate Change Impacts Assessment** - This report provides climate projections for the Pacific Northwest region and Washington state and discusses climate change impacts on multiple sectors, including energy and water resources. The climate projections produced in this assessment examine changes in future temperature and precipitation trends and resulting hydrological changes. Some changes in storm frequency and severity, as well as impacts of flooding on water infrastructure, are discussed.

National Resources

 **Climate Mapping for Resilience and Adaptation** - This web tool allows the user to enter a location and view projected changes in variables related to the site's exposure to climate hazards, including extreme heat, drought, wildfire, flooding, and coastal inundation, in different time periods (from historical 1976 to late century) and under low and high emission scenarios. This information is communicated through charts, tables, and maps.

 **Climate Toolbox** - This resource provides a variety of tools for visualizing historical and projected climate trends. Some of the variables examined include temperature, precipitation, wildfire, and drought, and changes in these variables are communicated visually via dashboards, maps, bar graphs, scatter plots, and other figures.

← Tool identifies relevant climate change resources (assessments, reports, and web tools) for a zip code or state entry

← **State resources** are provided, as available, for state-level information on how climate change may affect specific hazards. National tools may not account for state-level heterogeneity in hazards.

← **National resources** are provided for every state, including those lacking state-level resources, and include the NCA state summaries, climate and sea level-rise mapping tools, and other resources.

Drivers for developing climate change resources

- Several states have established councils, task forces and/or working groups to coordinate climate planning across the state
- Many climate programs and offices are housed within universities, and sometimes the universities provide the analysis and resources without support from the state government
- Stakeholder demand can drive development and focus of climate change resources
- In cases where climate trends can provide additional insight, 29 states have mesonets with mapping functionality and with available historical data for download. Weather data can be found for all states at the University of Utah's MesoWest website

Characteristic of Resource	Count
Resource development driven by policy	18
Resource sponsored by state	17
Climate program housed at a university	7
State has access to resource at another level (e.g., municipality, county, regional)	8

Summary

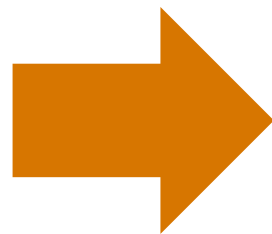
- To incorporate climate change information into site-level risk assessment, sites must include information about how hazards are expected to change due to climate change. However, this information is often difficult to find at a local scale relevant to site-level analyses.
- Majority of states have resources available with information about how climate change may impact locations within the state
- However, many focus on temperature and precipitation rather than providing insight into projected changes in HILF hazards. The focus of resources is largely driven by the key stakeholders involved in the process.
- Some national-level resources provide detailed projection information at a relatively local scale (e.g., county or zip code) such as NOAA's Coastal Flood Exposure Mapper
- A look-up tool for national and state-level climate change resources is available at <https://trn.pnnl.gov/toolkit/climate-change-resources>

Thank you

TRN: Applying information from climate resources for sensitivity analysis

- Information on projected changes in hazards obtained from state-level (and national) resources can be used to build sensitivity cases in the TRN that represent different potential climate futures
- For example, you may have found that your state will be subject to more frequent and severe hurricanes and ice storms under a climate change scenario. This could impact future energy and water outage durations and frequencies, which you can model using the TRN's sensitivity analysis feature.

- Change annual frequency
- Change outage duration



Dual-Impact Hazard		Base Case	Increased Hurricane Freq/Sev	Increased Ice Storm Freq/Sev
Earthquake, mag. 6.0+ - Electricity	Outage Duration (hrs)	1 week	1 week	1 week
	Frequency (hrs)	Unlikely (1 in 100 years)	Unlikely (1 in 100 years)	Unlikely (1 in 100 years)
Earthquake, mag. 6.0+ - Water	Outage Duration (hrs)	1 week	1 week	1 week
	Frequency (hrs)	Unlikely (1 in 100 years)	Unlikely (1 in 100 years)	Unlikely (1 in 100 years)
Hurricane - Electricity	Outage Duration (hrs)	1 day	1 week	1 day
	Frequency (hrs)	Anticipated (1 in 10 years)	Likely (once a year)	Anticipated (1 in 10 years)
Hurricane - Water	Outage Duration (hrs)	1 week	1 week	1 week
	Frequency (hrs)	Unlikely (1 in 100 years)	Anticipated (1 in 10 years)	Unlikely (1 in 100 years)
Ice Storm - Electricity	Outage Duration (hrs)	1 day	1 day	1 week
	Frequency (hrs)	Likely (once a year)	Likely (once a year)	Almost certain (3 times/year)

TRN: Use sensitivity analysis to explore potential climate scenarios

Sensitivity Cases: Risk Ranking - Hazard



Sensitivity cases can explore potential impact from changes to hazards impacting the site and how that impacts which hazards are driving risk and should be addressed via resilience solutions. In this example, for a climate change scenario where ice storms increase in frequency/severity, it becomes a significantly higher risk driver.

VARP: Incorporating climate projections for DOE resilience planning

Identify Current and Projected Hazards and Their Likelihoods								
Hazard #	Regional Hazards Impacting DOE Site <i>(Choose at least 2)</i>	Hazard Description <i>(Provide if "Other" specified as hazard)</i>	Current Annual Frequency at the Site <i>(Historical average # of events per year, e.g. 1 hail storm in 10 years = 0.1, 2 hurricanes in 1 year = 2)</i>	Current Hazard Likelihood <i>(Calculated)</i>	Projected Effect of Climate Change <i>(Describe how the hazard's frequency is expected to change due to climate change)</i>	Confidence in Projection, and Source of Information <i>(Record this information for future reference)</i>	Projected Annual Frequency at the Site with Climate Change <i>(Average # of events/year) (Calculated)</i>	Projected Hazard Likelihood with Climate Change <i>(Calculated)</i>
1	Coastal Flooding		1.5	Likely	Increase		3	Almost Certain
2	Earthquake		0.009	Unlikely	No Change		0.01	Unlikely
3	Winter Weather	snow storm	2.3	Almost Certain	Decrease		1	Likely
4	Wildfire	smoke exposure, unlikely to actually burn	1	Likely	Increase		3	Almost Certain
5								
6								
7								
8								
9								
10								

Hazard Likelihood: What is the likelihood that the hazard will occur in any given year (i.e., average annual frequency)?		Category Breakpoint <i>(Geometric mean-based)</i>
Almost Certain	3	1000
Likely	1	1.7
Anticipated	0.1	0.32
Unlikely	0.01	0.032
Extremely Unlikely	0.001	0.0032

DOE Vulnerability Assessment and Resilience Plan (VARP) requires consideration of climate projections in reported risk results using a more qualitative risk matrix approach. Climate projections used to automatically shift hazard frequency estimates for risk calculations

Achieving climate resilience at federal sites

E.O. 14008

- Climate Action Plans and Data & Information Products to improve adaptation and increase resilience

E.O. 14057

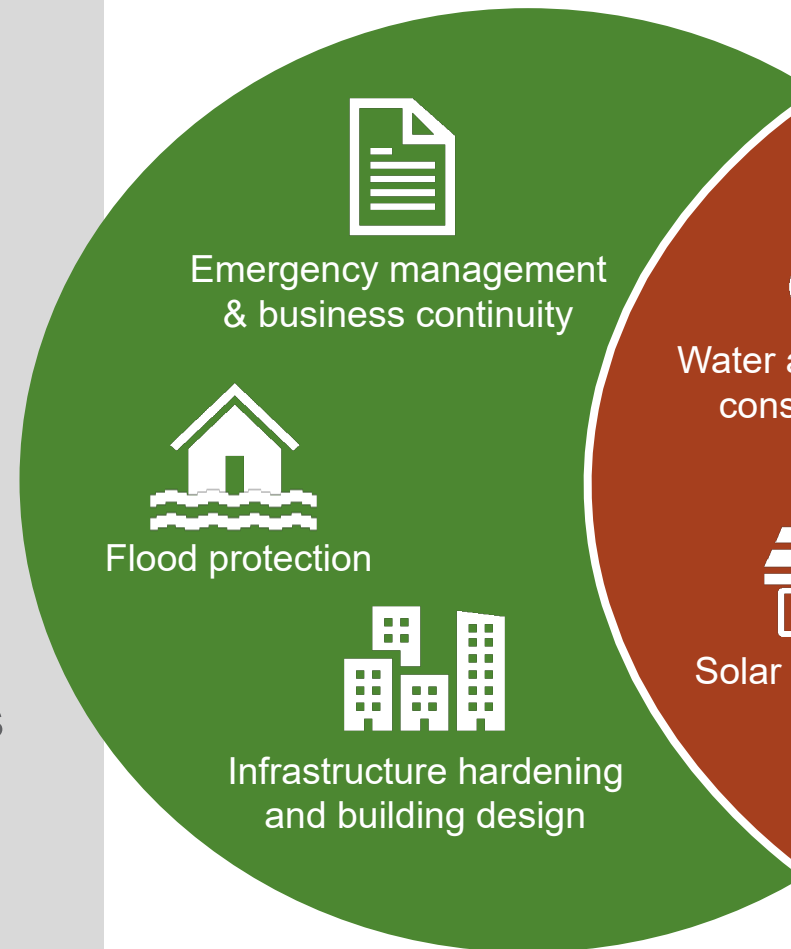
- Climate resilient infrastructure and operations
- Climate- and sustainability-focused Federal workforce

E.O. 14072

- Strengthen the nation's forests by pursuing sustainable and science-based land management

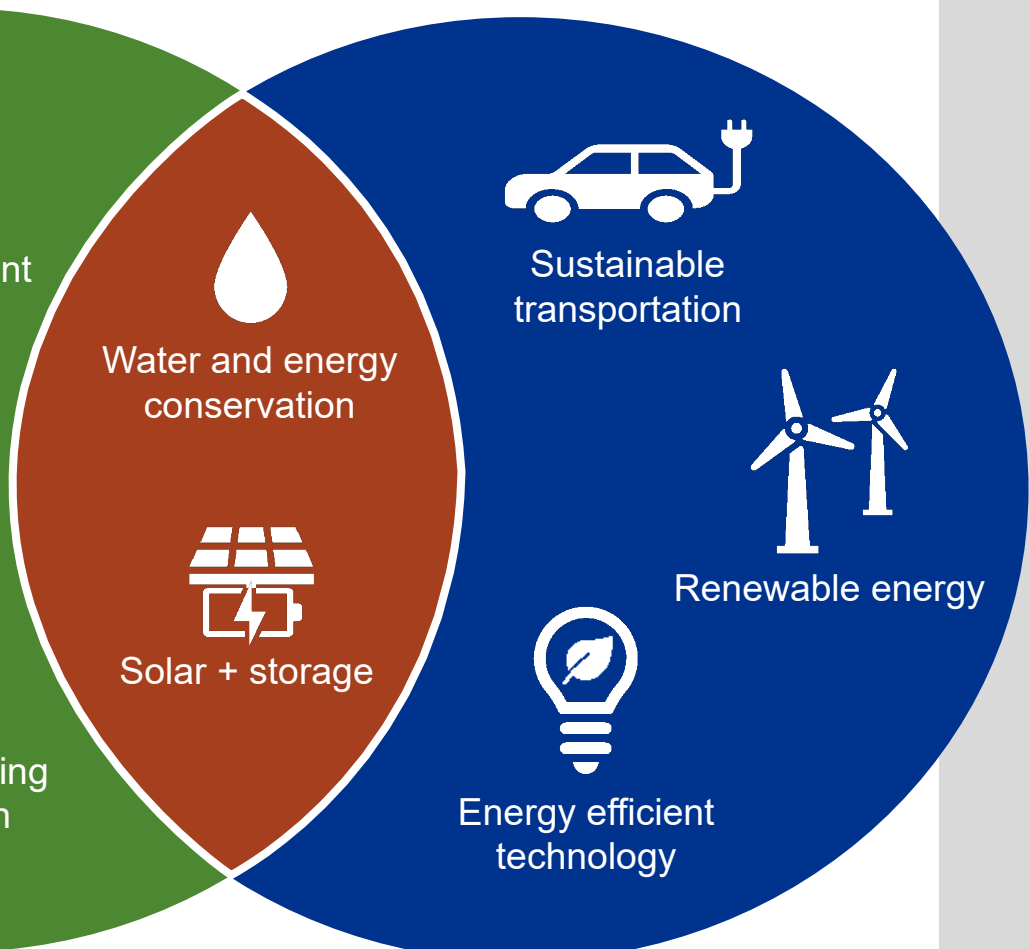
ADAPTATION

Action to manage the risks of climate change impacts



MITIGATION

Action to reduce emissions that cause climate change



E.O. 14057

- 100% carbon pollution-free electricity on net annual basis by 2030
- 100% zero-emission vehicle acquisitions by 2035
- Net-zero emissions building portfolio by 2045
- 65% reduction in scope 1 and 2 GHG emissions by 2030 from 2008 levels
- Net-zero emissions from Federal procurement