Assessing and Managing Risk to the National Critical Functions as a Result of Climate Change:

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RAND CORPORATION

This Study Sought to Help CISA Answer Three Questions

Which climate drivers pose the greatest risk to the 55 NCFs?

Which NCFs are at the most risk as a result of climate change?

How can stakeholders effectively mitigate risk to the NCFs from climate change?

The assessment focused on 27 high-priority NCFs

AGRICULTURE • Produce and Provide Agricultural Products and Services • Produce and Provide Human and Animal Food Products and Services	**GOVERNMENT AND PUBLIC SAFETY** • Provide Public Safety • Prepare for and Manage Emergencies • Provide Medical Care • Educate and Train • Enforce Law • Provide Housing • Support Community Health	**TRANSPORTATION** • Transport Cargo and Passengers by Air • Transport Cargo and Passengers by Vessel • Transport Passengers by Mass Transit • Transport Cargo and Passengers by Road • Transport Cargo and Passengers by Rail
ENERGY • Distribute Electricity • Transmit Electricity • Generate Electricity • Exploration and Extraction of Fuels	**INDUSTRY** • Maintain Supply Chains • Manufacture Equipment • Produce Chemicals • Provide Insurance Services	**WATER AND WASTE MANAGEMENT** • Supply Water • Manage Wastewater • Manage Hazardous Materials
	INFRASTRUCTURE • Develop and Maintain Public Works and Services • Provide and Maintain Infrastructure	

All 27 NCFs are at risk due to climate change

Nearly all NCFs could be affected by sea-level rise

As many as 3 out of 4 NCFs could be affected by flooding

2 out of 3 NCFs could be at risk from hurricanes

1 – No disruption: NCF operates normally

2 – Minimal disruption: NCF operates normally at national scale, but there may be local or regional impacts, such as infrastructure damage, minor NCF disruptions or slow provision of NCF services

3 – Moderate disruption: NCF operates normally for most of the nation, but major regions or key locations may be disrupted or in failure

4 – Major disruption: NCF is disrupted in most of the nation

5 – Critical: NCF is disrupted across the nation

Climate change could **increase the instability of agriculture** and **decrease the ability to reliably produce sufficient yields** by 2050, and **create dangerous outdoor working conditions.**

Public safety could be at risk in 2030 due to the **high volume of wildfires** straining firefighters and equipment.

Climate change could mean **temporary or permanent degradation** of the water supply in parts of the nation.

	2030	2050	2100
Agriculture			
Produce and Provide Agricultural Products and Services	2	2	3
Produce and Provide Human/Animal Food Products/Services	1	2	2
Energy			
Distribute Electricity	2	3	3
Transmit Electricity	2	3	3
Generate Electricity	2	2	3
Exploration and Extraction of Fuels	2	2	2
Government and Social Services			
Provide Public Safety	3	3	3
Prepare for and Manage Emergencies	2	3	3
Provide Medical Care	2	3	3
Educate and Train	2	2	3
Enforce Law	2	2	3
Provide Housing	2	2	3
Support Community Health	1	2	2
Industry			
Maintain Supply Chains	2	2	3
Manufacture Equipment	2	2	3
Produce Chemicals	2	2	3
Provide Insurance Services	2	2	2
Infrastructure			
Develop and Maintain Public Works and Services	2	3	3
Provide and Maintain Infrastructure	1	2	3
Transportation			
Transport Cargo and Passengers by Air	2	3	3
Transport Cargo and Passengers by Vessel	2	2	3
Transport Passengers by Mass Transit	2	2	2
Transport Cargo and Passengers by Road	2	2	2
Transport Cargo and Passengers by Rail	2	2	2
Water and Waste Management			
Supply Water	3	3	3
Manage Wastewater	2	3	3
Manage Hazardous Materials	2	3	3

Climate change could **increase the occurrence of longer, sustained power outages.**

By 2100, approximately 2.4 million residential properties, valued at over $1 trillion, could be at **risk of chronic flooding.**

Supply chains are at risk due to complicated logistic structures and reliance on coastal transportation, with the potential for **significant local to regional disruptions.**

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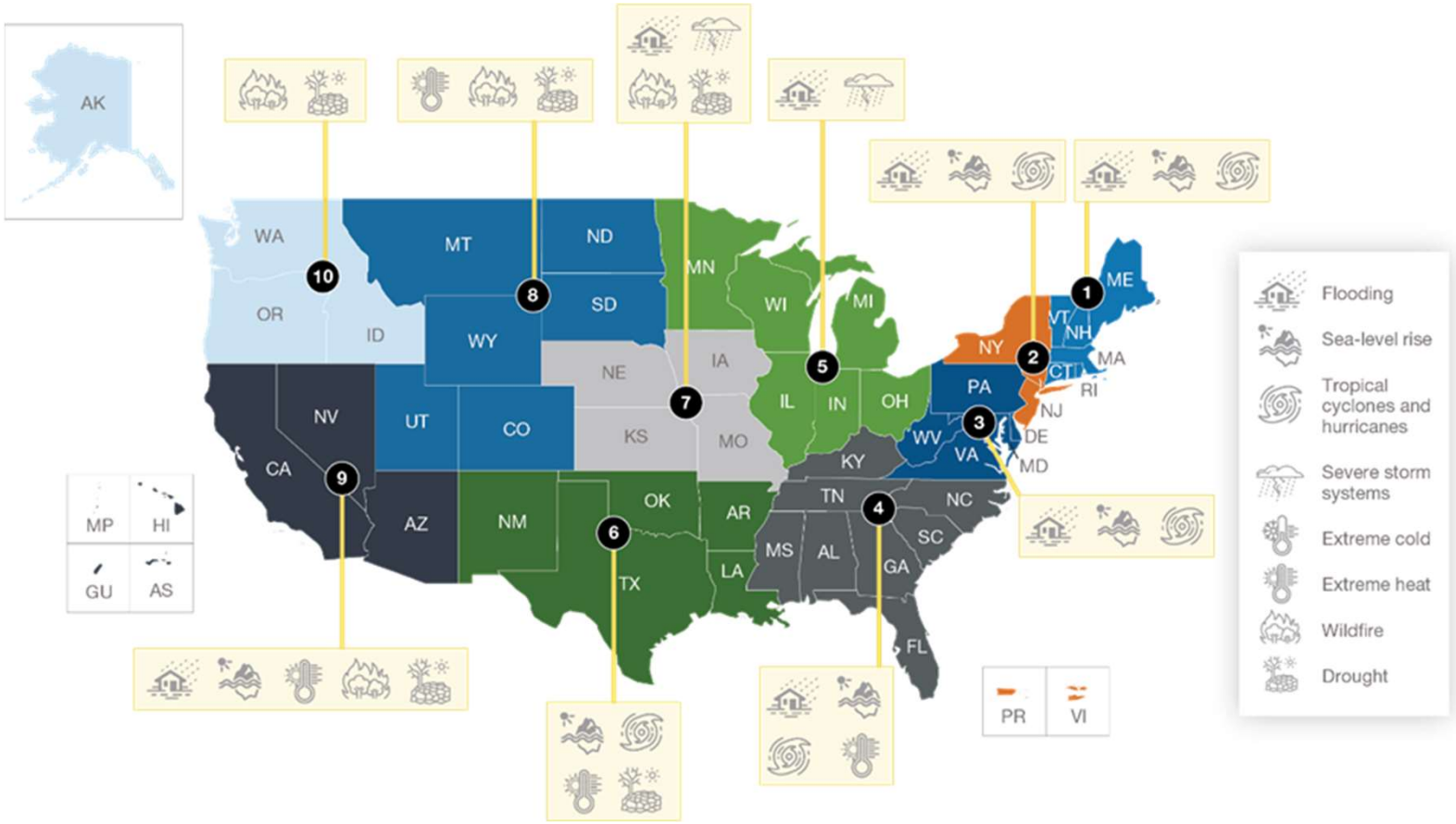
Risk from climate drivers will vary by region



Impact pathways help to shape risk and mitigation needs

PHYSICAL DAMAGE

Damage or disruption to physical infrastructure, such as from storms, heavy rain and snow, high winds, and wildfire

LACK OF RESOURCES

Interruption in the supply of inputs, such as water shortages from drought

WORKFORCE SHORTAGES

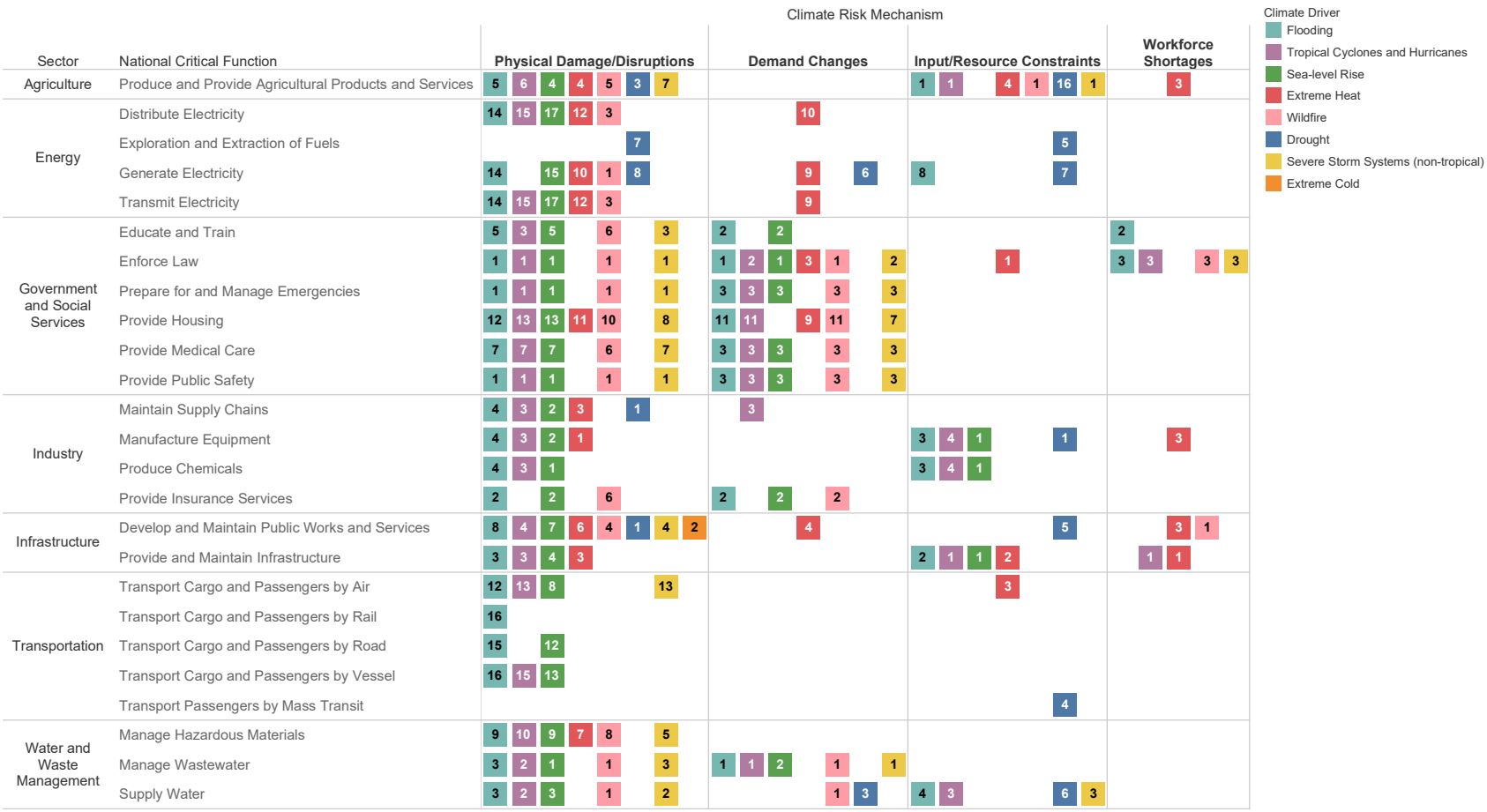
Shortage in workers, such as when normal functions curtailed because workers unable to work in extreme heat

DEMAND CHANGES

Changes in the demand for an NCF, such as the strained ability to respond to emergencies, because so many happen at once

Current work identified 254 unique mitigation strategies

Mitigation Strategy by NCF-Climate-Driver-Mechanism



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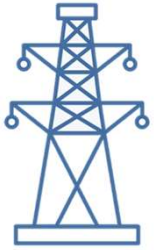
Evaluation of Example Strategy

NCF	Climate Driver	Mechanism
		
Distribute Electricity	**Flooding**	**Physical Damage**

Strategy:	Deploying Distributed Generation: Distributed PV, Microgrids, and Minigrids
Citation:	Gholami, Amin, Farrokh Aminifar, and Mohammad Shahidehpour. "Front lines against the darkness: Enhancing the resilience of the electricity grid through microgrid facilities." IEEE Electrification Magazine 4.1 (2016): 18-24.
Strength of Evidence:	Strong
Effectiveness:	Moderate impact
Feasibility:	Medium
Cyber Risk Mitigation:	Adds

Caveats and Implications

CAVEATS

- Strength of evidence varies widely across NCFs
- Risk assessment does not account for other sources of change, e.g., technological advances or population-based shifts
- Regional differences are not fully captured by national-scale risk ratings
- Ratings depend on how sub-functions are defined and how they collectively represent an NCF

IMPLICATIONS

- Regional variations in risks shapes mitigation needs
- Intersection of drivers, hazards, and infrastructure can help identify mitigation gaps and synergies
- Focused efforts will be needed where tested, feasible, effective mitigation strategies are few
- Mitigating climate risks may increase other risks – e.g. cyber risks

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