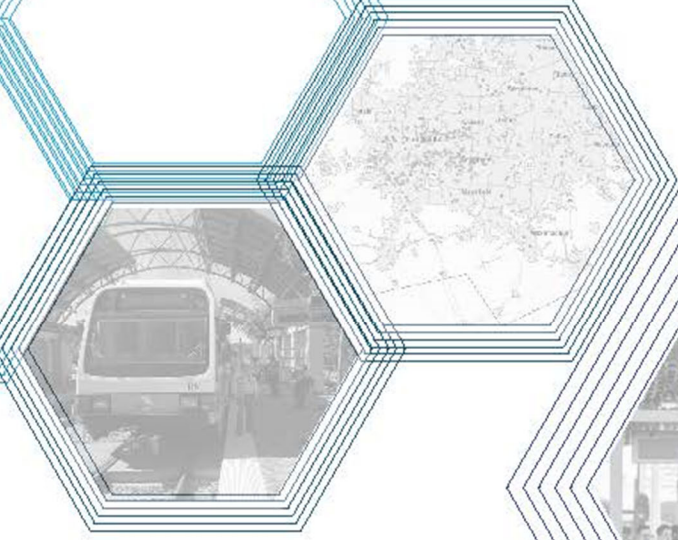




# Climate Resilience and Social Equity in Transportation: Planning for Underserved Populations and General Populations

Adjo Amekudzi-Kennedy, Ph.D.  
Adair Garrett  
Praful Patil  
Maya Orthous Inchauste



FINAL REPORT

**A STUDY OF THE RELATIONSHIP BETWEEN CLIMATE  
RESILIENCE AND SOCIAL EQUITY IN TRANSPORTATION:  
PLANNING FOR UNDERSERVED POPULATIONS AND  
GENERAL POPULATIONS**

**FINAL PROJECT REPORT**

By:

Adjo Amekudzi-Kennedy, Ph.D.  
Adair Garrett  
Praful Patil  
Maya Orthous Inchauste  
Georgia Institute of Technology

Sponsorship:  
CTEDD

For:

Center for Transportation, Equity, Decisions and Dollars **(CTEDD)**  
USDOT University Transportation Center  
The University of Texas at Arlington  
Woolf Hall, Suite 325  
Arlington TX 76019 United States  
Phone: 817-272-5138 | Email: [c-tedd@uta.edu](mailto:c-tedd@uta.edu)

In cooperation with United States Department of Transportation's Office of  
Research, Development, and Technology (RD&T)

## **Acknowledgments**

This work was supported by a grant from the Center for Transportation Equity, Decisions, and Dollars (CTEDD) funded by U.S. Department of Transportation Research and Innovative Technology Administration (OST-R) and housed at The University of Texas at Arlington. The report authors are grateful to Dr. Alex Karner, Dr. Jandel Crutchfield, Dr. Janille Smith-Colin, and, Dr. Brian Woodall. The authors are also grateful to all the students who participated in the research: Adair Garrett, Ph.D. Student; Collin Yarbrough, Ph.D. Student; Aqshems Egun Tola Ade Le Kon Nichols, Ph.D. Candidate; Angela Hall, Ph.D. Student; Praful Patil, M.S. Student; Maya Orthous Inchauste, Undergraduate Research Assistant (URA); Jad Darazim, URA; Jessamyn Lockett, URA; Joyah Mitchell, URA; Kayley Beard, URA; Caroline Delcroix, URA; Elizabeth Letizia, URA; and Taylor Sherwood, URA. The report authors are grateful to Dr. Alex Karner for reviewing the final report.

## **Disclaimer**

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated under the sponsorship of the U.S. Department of Transportation's University Transportation Centers Program, in the interest of information exchange. The Center for Transportation, Equity, Decisions and Dollars (CTEDD), the U.S. Government and matching sponsor assume no liability for the contents or use thereof.



<b>Technical Report Documentation Page</b>			
<b>1. Report No.</b> CTEDD 022-01	<b>2. Government Accession No.</b>	<b>3. Recipient's Catalog No.</b>	
<b>4. Title and Subtitle</b> A Study of the Relationship between Transportation System Resilience (to Climate Hazards) and Social Equity: Planning for Resilience for Underserved Populations and General Populations		<b>5. Report Date:</b> September 30, 2024	
		<b>6. Performing Organization Code</b>	
<b>7. Author(s)</b> Adjo Amekudzi-Kennedy, 0000-0003-4721-9176; Adair Garrett, 0000-0001-9990-4568; Praful Patil, Maya Orthous Inchauste		<b>8. Performing Organization Report No.</b>	
<b>9. Performing Organization Name and Address</b> Georgia Institute of Technology / School of Civil & Environmental Engineering		<b>10. Work Unit No. (TR AIS)</b>	
		<b>11. Contract or Grant No.</b> USDOT - 69A3551747134	
<b>12. Sponsoring Organization Name and Address</b> Center for Transportation, Equity, Decisions and Dollars (CTEDD), USDOT University Transportation Center, The University of Texas at Arlington, Woolf Hall, Suite 325, Arlington TX 76019 United States		<b>13. Type of Report and Period Covered</b> Final Report	
		<b>14. Sponsoring Agency Code</b>	
<b>15. Supplementary Notes</b> Additional project information is available at <a href="https://irg.ce.gatech.edu/transportation-system-resilience-social-equity-and-accessibility">https://irg.ce.gatech.edu/transportation-system-resilience-social-equity-and-accessibility</a> . Project performed under a grant from the U.S. Department of Transportation's University Transportation Centers (UTC) Program.			
<b>16. Abstract</b> Evolving climate disasters and the pandemic are a reminder that lower levels of social equity can leave populations more vulnerable. There is mounting evidence that while resilience is determined by the weakest or most vulnerable links in the (supply) chain, its effects tend to impact the entire (supply) chain and the communities it serves. Ensuring that transportation resilience building is socially equitable is therefore a means of improving system performance for vulnerable and all populations. This research project considers the relationships between transportation system resilience, social equity and transportation system performance and develops policy recommendations to build resilience in a more socially-equitable manner. The project translates negotiated resilience concepts into practical tools for implementation: a self-assessment tool and capability maturity model (CMM) for transportation practitioners. Transportation agencies at the state, regional and local levels may apply these tools to co-develop - with communities and stakeholders - a negotiated definition of resilience that pertains to and addresses tradeoffs between all relevant communities and participating stakeholders. The tools may also be used in continually updating resilience definitions as communities evolve and other factors change, and to measure agency levels of effectiveness with integrating the public into transportation and community resilience building. The second thrust of this study develops analytical procedures to incorporate transportation insecurity measures into climate vulnerability assessments to better identify areas that are socially vulnerable (e.g., cannot meet basic needs) whenever climate vulnerability assessments are conducted. Climate vulnerability assessments are being conducted increasingly to identify areas of high vulnerability and criticality. Such assessments may be conducted with a focus on transportation assets and without explicit identification of areas with the highest transportation insecurities. Analytical capabilities that integrate transportation insecurity measures in climate vulnerability assessments will help ensure that transportation insecurities are identified and addressed in climate resilience building activity to enhance transportation security in all communities. It will also ensure that unique vulnerability factors are addressed in all communities. Practitioners may use these tools collectively to co-define resilience with communities and stakeholders, conduct assessments to determine areas of the highest climate vulnerability and transportation insecurity, and identify and prioritize strategies to build resilience on an ongoing basis.			
<b>17. Key Words</b> Resilience, Climate, Social, Equity, Performance		<b>18. Distribution Statement</b> No restrictions. This document is available to the public through the Transport Research International Documentation (TRID) repository.	
<b>19. Security Classification (of this report)</b> Unclassified.	<b>20. Security Classification (of this page)</b> Unclassified.	<b>21. No. of Pages</b> 51	<b>22. Price</b> N/A

# Table of Contents

Abstract.....	9
Chapter I: Introduction.....	10
1.1 Background and Motivation.....	10
1.2 Project Objectives.....	13
1.3 Report Outline.....	13
Chapter II: Literature Synthesis.....	15
2.1 Negotiated Resilience and Public Involvement.....	15
2.1.1 Negotiated Resilience.....	15
2.1.2 Public Involvement Practices in Transportation.....	16
2.2 Capability Maturity Models.....	18
2.3 Transportation Insecurity and Climate Vulnerability.....	19
3.2.1 Climate Change and Socially Vulnerable Groups.....	19
2.3.2 Key Terms and Concepts.....	19
2.3.3 Status of Research and Practice.....	20
Chapter III: The NR-CMM Model and Self-Assessment Tool: Assessing the Impact of Processes on Social Equity and Disaster Preparedness Outcomes.....	22
3.1 Benefits of Implementing Negotiated Resilience in Transportation.....	22
3.2 Elements of Negotiated Resilience.....	23
3.2.1 Questions to Consider.....	23
3.2.2 Negotiated Resilience Principles.....	24
3.3 NR-CMM and Self-Assessment Tool Development.....	25
3.3.1 Approach.....	25
3.3.2 Stakeholder Feedback.....	27
3.4 Negotiated Resilience Capability Maturity Model.....	28
3.4.1 Final Themes and Capabilities.....	28
3.4.2 Example.....	30
3.5 Summary.....	31
Chapter IV: Incorporating Transportation Insecurity Measures in Climate Vulnerability Assessments.....	32
4.1 Transportation Security as a Basic Resilience Measure.....	32
4.2 Analytical Approach and Data.....	32
4.3 Example Application & Case Study.....	34
4.3.1 Example Application.....	34

4.3.2 Case Study: California.....	37
4.4 Summary .....	41
Chapter V: Policy Recommendations .....	42
5.1 Relevance of Research to Policy.....	42
5.2 Policy Recommendations.....	42
Chapter VI: Conclusion .....	44
References.....	46
Appendix A: Technology Transfer .....	52
Appendix B: Negotiated Resilience Capability Maturity Model and Supplementary Resources .....	56

## List of Tables

Table 1. Critiques of public involvement methods (PIM) in transportation planning (modified from Orthous Inchauste et al. In Review).....	17
Table 2. Questions and specific inquiries for negotiated resilience (Orthous Inchauste et al. In Review).....	24
Table 3. Final themes for NR-CMM (Orthous Inchauste et al. In Review).....	28
Table 4. Final capabilities and definitions for NR-CMM (Orthous Inchauste et al. In Review). .....	28
Table 5. Example of a capability as presented in the NR-CMM (Orthous Inchauste et al. In Review).....	30
Table 6. Example of recommendations resource for moving to higher levels of maturity (Orthous Inchauste et al. In Review). ....	31
Table 7. Statistical test results for transportation security and extreme/non-extreme weather variables in California.....	41
Table 8. Technology transfer activities during project term. ....	52
Table 9. Technology transfer activities after project term. ....	54

## List of Figures

Figure 1. FHWA Vulnerability Framework.....	12
Figure 2. NASEM Vulnerability Framework.....	12
Figure 3. NASEM Approach to Making Investment Decisions.....	12
Figure 4. Critical issues in transportation (NASEM 2024).....	22
Figure 5. Connection of principles of negotiated resilience with outcomes before, during, and after disasters (Orthous Inchauste et al. In Review).....	25
Figure 6. Negotiated resilience-capability maturity model and self-assessment tool development process (Orthous Inchauste et al. In Review).....	26
Figure 7. Geographic location of the expert interview practitioners (Orthous Inchauste et al. In Review).....	27
Figure 8. Example of the self-assessment tool interface and example questions (Orthous Inchauste et al. In Review). ....	30
Figure 9. Flowchart for Integrated Transportation Insecurity and Climate Vulnerability Assessment Approach. ....	34
Figure 10. Percent of Households with No Vehicle (County Scale; Georgia; data from American Community Survey, 2021). ....	35
Figure 11. Transportation Cost/Income (Census Tract Scale; Georgia; data from Center for Neighborhood Technology).....	35
Figure 12. Cumulative Tornado Events (County Scale; Georgia; data from SHELDDUS, 1990 - 2020).....	36
Figure 13. Tornadoes Emerging Hotspot (County Scale; Georgia; data from SHELDDUS, 1990 - 2020).....	36
Figure 14.1 - 14.4 Transportation Insecurity and Climate Vulnerability Indicators by Census Tract for California (Source: USDOT ETC, 2023).....	40

## Abstract

Evolving climate disasters and the pandemic are a reminder that lower levels of social equity can leave populations more vulnerable. There is mounting evidence that while resilience is determined by the weakest or most vulnerable links in the (supply) chain, its effects can impact the entire (supply) chain and the communities it serves. Ensuring that transportation resilience building is socially equitable is therefore one means of improving system performance not only for vulnerable populations but for all populations. **This research project considers the relationship between transportation system resilience, social equity and transportation system performance and develops planning and analytical tools and policy recommendations to build resilience in a more socially-equitable manner.** The project **translates negotiated resilience concepts into practical tools for implementation: a self-assessment tool and capability maturity model (CMM) for broad application by transportation practitioners.** Transportation agencies at the state, regional and local levels may apply these tools to co-develop, with communities and stakeholders, a negotiated definition of resilience that pertains to and addresses tradeoffs among all the relevant communities and participating stakeholders. The tools may also be used in continually updating resilience definitions as communities evolve and other factors change, and to measure agency levels of effectiveness in integrating the public into transportation and community resilience building. The second thrust of this study **develops analytical procedures to incorporate transportation insecurity measures into climate vulnerability assessments, whenever climate vulnerability assessments are conducted, to better serve areas that are socially vulnerable (that is, do not have transportation that enables them to meet their basic needs).** Climate vulnerability assessments are being conducted increasingly to identify areas of high vulnerability and criticality. Such assessments may be conducted with a focus on transportation assets and without explicit identification of areas with high levels of transportation insecurity. Analytical capabilities that integrate transportation insecurity measures in climate vulnerability assessments can help ensure that transportation insecurities are identified and addressed in climate resilience building activity to improve transportation security in all communities. It will also ensure that unique vulnerability factors are addressed in all communities. **Practitioners may use these tools collectively to co-define resilience with communities and stakeholders, conduct assessments to determine areas with the highest climate vulnerabilities and transportation insecurity, and identify and prioritize strategies to build resilience on an ongoing basis.**

**Keywords:** Resilience, Climate, Community, Equity, Performance

# Chapter I: Introduction

## 1.1 Background and Motivation

A growing number of communities have experienced increased frequencies and strengths of climate and weather disasters in the United States - some with cascading effects across infrastructure sectors. Several authoritative transportation entities such as the Federal Highway Administration (FHWA), the Transportation Research Board (TRB) of the National Academies and American Association of State Highway and Transportation Officials (AASHTO) have issued conceptual frameworks for climate vulnerability assessments and guidelines for building transportation system resilience ([FHWA 2017](#), [NASEM-a](#), [NASEM-b](#)). The historic Bipartisan Infrastructure Law (BIL) or Infrastructure Investment and Jobs Act (IIJA) was passed in 2021, making project funding available through the PROTECT (Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation) program. The purpose of this program is “to help make surface transportation more resilient to natural hazards, including climate change, sea level rise, flooding, extreme weather events, and other natural disasters through support of planning activities, resilience improvements, community resilience and evacuation routes, and at-risk coastal infrastructure” ([FHWA 2022](#)). The PROTECT program incentivizes (but does not require) transportation agencies to develop a Resilience Improvement Plan (RIP). If a transportation agency does create a RIP they receive financial incentives from the federal government. The agency is required to ([23 U.S.C. 176\(e\)](#))<sup>1</sup>:

1. demonstrate a **systemic approach to enhancing surface transportation system resilience** that is consistent with state and local mitigation plans,
2. include a **risk-based assessment of vulnerabilities** of transportation assets and systems to current and future weather events and disasters,
3. describe how the plan will **improve the ability of the agency to respond to** and prepare for disruptions,
4. state how any **regulatory measures will be adopted** and enforced,
5. consider the benefits of **combining hard surface assets and natural infrastructure**,
6. assess **resilience of community assets**,
7. use a **long-term planning** period, and

---

<sup>1</sup> There are additional recommended elements in the legislation that may be included in a Resilience Improvement Plan, including designation of evacuation routes, plans for anticipated emergencies, descriptions of resilience improvement policies, and investment plans for prioritizing projects and distributing funds.

8. include other relevant information as considered appropriate by the transportation agency.

**Figures 1 to 3** show examples of conceptual resilience frameworks issued by authoritative bodies ([FHWA 2017](#), [NASEM-a](#), [NASEM-b](#)). These frameworks generally apply risk-based approaches to determine portions of the asset portfolio that have the highest vulnerability (usually estimated as a product of climate hazard exposure, asset sensitivity and adaptive capacity) and criticality ([Amekudzi-Kennedy et al. 2023](#)).



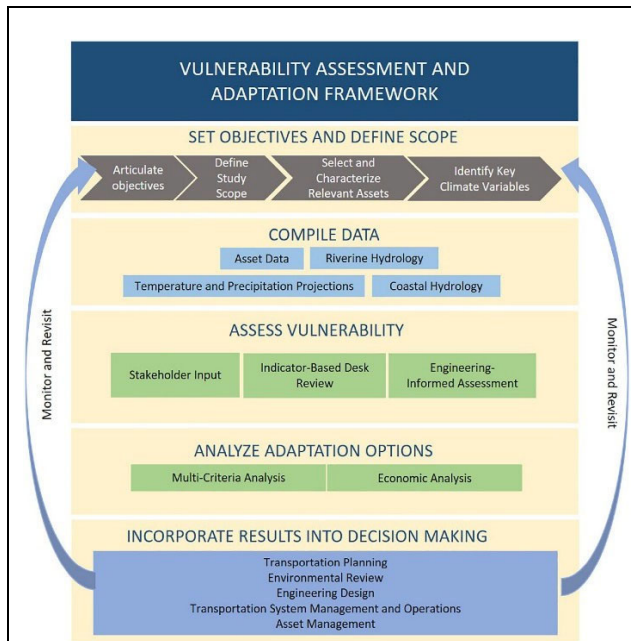


Figure 1. FHWA Vulnerability Framework.

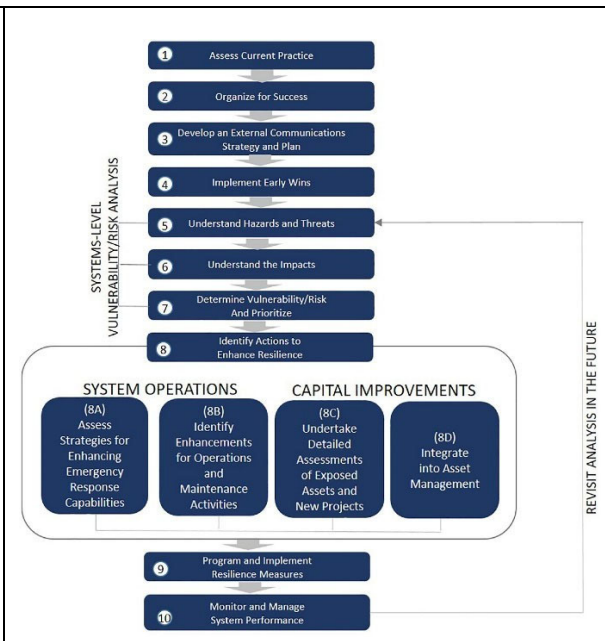


Figure 2. NASEM Vulnerability Framework

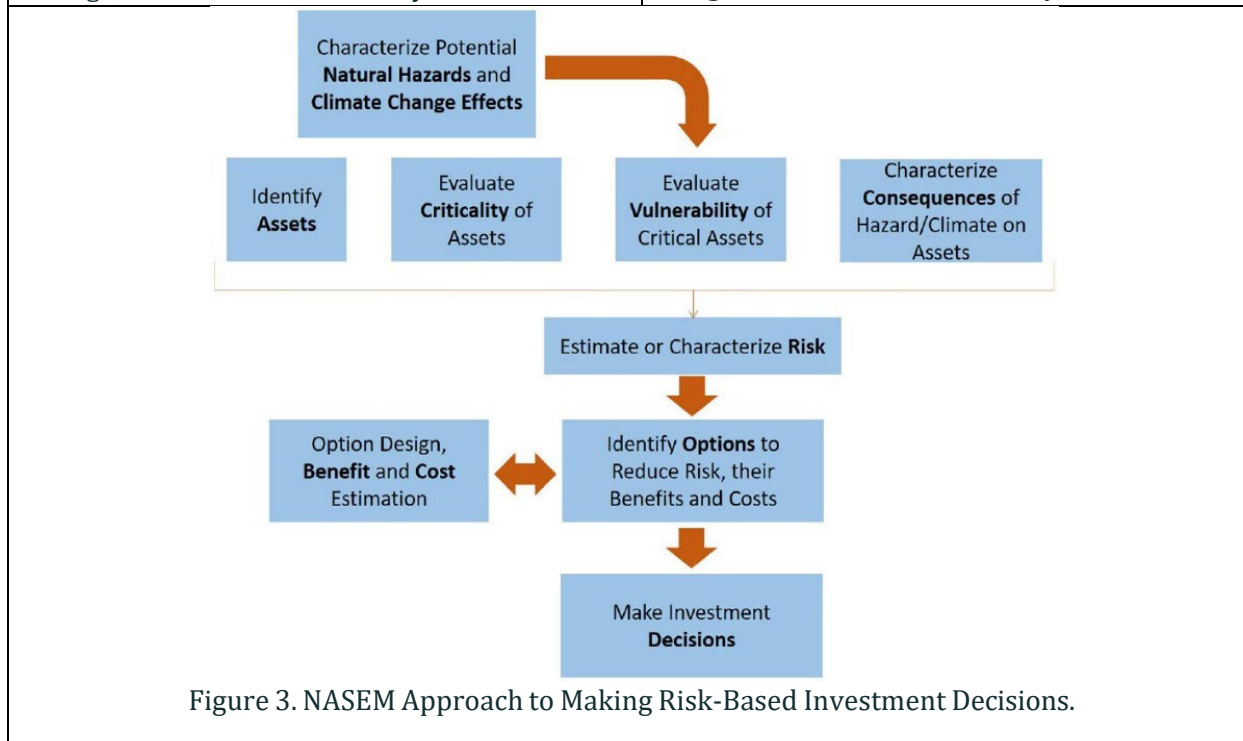


Figure 3. NASEM Approach to Making Risk-Based Investment Decisions.

Several applications of these conceptual frameworks introduce some form of an index, e.g., social vulnerability index within the criticality function in an attempt to elevate the more vulnerable assets or asset components in the assessment (Amekudzi-Kennedy et al. 2023). However, such efforts to address the needs of the more vulnerable populations may fall short as weighted indices may not successfully isolate the critical issues for vulnerable populations. Carvalhaes et al. (2021) discuss the shortcomings of disaster

resilience indices (DRIs) for effective resilience planning in complex systems of which transportation is an example.

## 1.2 Project Objectives

To address these issues, the first research thrust of this project **translates negotiated resilience principles into a self-assessment tool and capability maturity model that can facilitate co-development and evolution of resilience definitions and strategies on an ongoing basis** by infrastructure agencies, the communities they serve and stakeholders. The term ‘community’ as used in this study is defined as follows: *a group of individuals who share a geographic location, common interests, or identity and whose lives are directly impacted by transportation systems and decisions, even if they lack specific professional knowledge or training in the field.* The term ‘stakeholder’ as used in this study is defined as: *individuals or groups with professional expertise or direct investment in transportation projects, whose knowledge and actions significantly impact or are impacted by transportation systems, planning, and operations* (Orthous Inchauste et al. *In Review*). The second research thrust **develops an approach to incorporate transportation insecurity measures in climate vulnerability assessments** (Patil et al. *In Review*).

Collectively, these tools are resources to help transportation agencies to maintain community-relevant definitions of resilience, articulate explicit tradeoffs, and keep them relevant as internal and external conditions change. Agencies may also apply the transportation insecurity measures to identify and eliminate transportation insecurities as climate vulnerability assessments are being conducted, bringing out contextual and unique issues that need to be addressed across different communities.

## 1.3 Report Outline

Chapter 2 of the report reviews the literature to explain how negotiated resilience differs from other more traditional definitions of resilience, what capability maturity models are and how they may be applied in building resilience culture; what transportation insecurity is and how transportation insecurity measures may be used in developing resilience equitably; and, key relationships connecting negotiated resilience, social equity and transportation system performance. Chapter 3 presents the NR-CMM (Negotiated Resilience Capability Maturity Model) and self-assessment tool and then illustrates how an agency may apply these tools to build resilience systematically and on a continual basis. Chapter 4 presents an approach for incorporating transportation insecurity measures in climate vulnerability assessments with an example application and case study. Chapter 5 presents policy recommendations that leverage the PROTECT Program and agency resilience improvement plans (RIPs), created by the Bipartisan Infrastructure Law. The report concludes by reiterating the significance of developing a negotiated definition of resilience among relevant communities, their representing agencies, and stakeholders; the

importance of evolving this resilience definition to keep it current over time, the importance for an agency to develop its negotiated resilience capabilities through enhanced public engagement and disaster management; and, the importance of pursuing the eradication of transportation insecurity as a resilience-building measure. The study provides tools to support agencies that want to build resilience equitably and eliminate transportation insecurity – efforts that lay strong foundations for building transportation system resilience inclusively.

## Chapter II: Literature Synthesis

This chapter discusses the concept of negotiated resilience, reviews the application of public engagement in transportation planning and decision making, presents capability maturity models (CMMs) as potentially effective tools for building a culture of resilience, and introduces the concept of transportation insecurity and its relationships with climate and other types of vulnerabilities impacting communities.

### 2.1 Negotiated Resilience and Public Involvement

#### 2.1.1 Negotiated Resilience

The concept of *negotiated resilience* was introduced by [Ziervogal et al. \(2017\)](#) to draw attention to how justice and social considerations should play a role in defining resilience strategies. The authors argue that *resilience* should be defined not only in terms of the **capabilities of the physical infrastructure** (e.g., transportation robustness) but also in terms of the **capabilities of those who rely upon the infrastructure** (e.g., community adaptive capacity). Public agencies may only understand these capabilities through collaboration with those communities. [Harris et al. \(2017\)](#) highlight the importance of the process and interactions surrounding resilience to better address equity concerns that may arise from resilience-building projects in the future. [Harris et al. \(2017\)](#) also state that organizations like transportation agencies must **continually redefine resilience and related actions to reflect changing conditions, needs, and values through “a process of negotiation”** – emphasizing the importance of understanding the “for whom, and against what” dimensions of resilience programs and plans. Negotiating resilience enables agencies to address potential consequences of transportation projects and climate disruptions by co-developing, with communities and stakeholders, a definition for resilience, updating this definition on a continual basis, and implementing resilience-building strategies.

A few studies have broadly examined the application of negotiated resilience to urban planning ([Fink et al. 2019](#), [Sethi et al. 2021](#), [Fitzgibbons and Mitchell 2021](#)). [Fink et al. 2019](#) examine the application of negotiated resilience to the development of a floating park in New York City by reviewing news coverage. [Sethi et al. 2021](#) consider the entry points for negotiated resilience at various scales of governance in India. [Fitzgibbons and Mitchell \(2021\)](#) explore an application of negotiated resilience to city planning, using the City of Toronto as a case study. This study applies a content analysis to Toronto’s original resilience strategy documentation followed by two rounds of interviews with city staff and community champions, concluding with a final content analysis of the city’s emerging resilience strategy document. **Although previous applications of negotiated resilience in urban planning found that negotiated resilience theory is valuable for planning**

**efforts, these studies did not provide an approach to integrate negotiated resilience into existing agency practices** (Orthous Inchauste et al. *In Review*).

Negotiated resilience has been broadly linked to urban planning, but few studies have examined the potential for negotiated resilience principles to be integrated into transportation practice to address deficiencies in transportation planning. The following section summarizes the history of public involvement in transportation planning and discusses its relevance to negotiated resilience.

### 2.1.2 Public Involvement Practices in Transportation

Public involvement has been legally mandated for transportation projects funded by the federal government for decades, as emphasized by the National Environmental Policy Act of 1969, the Clean Air Act of 1970, and the Federal-Aid Highway Act of 1973 (Meyer and Miller 2001; Orthous Inchauste et al. *In Review*). The Intermodal Surface Transportation Efficiency Act (ISTEA), passed in 1991, required metropolitan planning organizations (MPOs) to outline public involvement efforts when creating the metropolitan transportation plan and transportation improvement program. In 1998, the Transportation Equity Act for the 21<sup>st</sup> Century (TEA-21) reinforced ISTEA and introduced further requirements for public involvement and community engagement during the transportation planning process (Meyer and Miller 2001; Orthous Inchauste et al. *In Review*). Other notable legislation includes the Safe, Accountable, Flexible, Efficient Transportation Equity Act (SAFETEA-LU; 2005), Moving Ahead for Progress in the 21<sup>st</sup> Century (MAP-21; 2012), Fixing America's Surface Transportation Act (FAST Act; 2015), and the Bipartisan Infrastructure Law (BIL; 2021) (FHWA 2022).

Implementation of federal guidance on incorporating public involvement into transportation planning can vary between states. The US Department of Transportation defines **meaningful public involvement** as “**a process that proactively seeks full representation from the community, considers public comments and feedback, and incorporates that feedback into a project, program, or plan**” (USDOT 2023). To assist in the implementation of meaningful public involvement in transportation planning, the USDOT provided a guidebook (USDOT 2023). The National Academies of Science, Engineering, and Medicine's (NASEM) Transportation Research Board conducted a project on measuring the effectiveness of public involvement practices and provided additional guidance for transportation agencies (NASEM 2019). This project indicated that to measure the effectiveness of these practices, agencies should consider the influence and impact of feedback, transparency of project information, timing of efforts, inclusion of various groups, and ease of participation (NASEM 2019; USDOT 2023). These resources offer step-by-step guidance to improve public agencies' established engagement practices but do not explicitly consider the intensifying climate landscape.

In transportation planning, public involvement methods can be defined as *formal or informal* ([Ankner 2005](#); [Orthous Inchauste et al. In Review](#)). *Formal* public involvement methods are frequently employed to meet legal requirements, which can be described as "top-down" approaches where agencies typically only engage those directly affected by the project ([Schiefelbusch 2005](#)). *Formal* public involvement methods have been criticized for often involving an unrepresentative sample of the community; additionally, these methods may not promote opportunities for substantial feedback on transportation plans ([Stich and Eagle 2005](#)). *Informal* public involvement methods emphasize the inclusion of various groups through a collaborative and dynamic approach; example approaches include workshops, focus groups, and drop-in offices ([Schiefelbusch 2005](#); [Orthous Inchauste et al. In Review](#)). These methods are potentially more time-consuming than formal methods and thus may be employed less broadly in practice. **Table 1** summarizes some critiques to public involvement methods that have appeared across studies on transportation planning over time ([Orthous Inchauste et al. In Review](#)).

Table 1. Critiques of public involvement methods (PIM) in transportation planning (modified from [Orthous Inchauste et al. In Review](#)).

Critique	Sources
The public lacks the knowledge to understand proposed plans.	( <a href="#">Ankner, 2005</a> ) ( <a href="#">Grossardt &amp; Bailey, 2018</a> ) ( <a href="#">McAndrew &amp; Marcus, 2015</a> )
There are financial limitations and high costs for organizations implementing PIM.	( <a href="#">Ankner, 2005</a> ) ( <a href="#">McAndrew &amp; Marcus, 2015</a> )
Not all members/groups of society are involved in PIM.	( <a href="#">Schiefelbusch, 2005</a> ) ( <a href="#">Ankner, 2005</a> ) ( <a href="#">Karner &amp; Marcantonio, 2018</a> ) ( <a href="#">McAndrews &amp; Marcus, 2015</a> ) ( <a href="#">Townsend, 2021</a> ) ( <a href="#">Innes &amp; Booher, 2004</a> )
Results and advice from PIM are not implemented in transportation plans; PIM perceived as ineffective.	( <a href="#">Schiefelbusch, 2005</a> ) ( <a href="#">Cascetta &amp; Pagliara, 2013</a> ) ( <a href="#">Grossardt &amp; Bailey, 2018</a> ) ( <a href="#">Karner &amp; Marcantonio, 2018</a> ) ( <a href="#">Innes &amp; Booher, 2004</a> ) ( <a href="#">Townsend, 2021</a> ) ( <a href="#">McAndrews &amp; Marcus, 2015</a> )
PIM are often undertaken out of necessity to secure funding or comply with legal obligations rather than being driven by usefulness or desire for enhanced justice.	( <a href="#">Schiefelbusch, 2005</a> ) ( <a href="#">Cascetta &amp; Pagliara, 2013</a> ) ( <a href="#">Innes &amp; Booher, 2004</a> ) ( <a href="#">Grossardt &amp; Bailey, 2018</a> ) ( <a href="#">Karner &amp; Marcantonio, 2018</a> ) ( <a href="#">Townsend, 2021</a> ) ( <a href="#">Ankner, 2005</a> )
Transportation agencies continue to use engagement practices that have little success.	( <a href="#">Linovski &amp; Baker, 2023</a> ) ( <a href="#">Grossardt &amp; Bailey, 2018</a> )
Transportation institutions lack the knowledge, skills, and attitudes to achieve effective public involvement.	( <a href="#">Khisty, 2000</a> )
PIM are time-consuming for the institution and its citizens.	( <a href="#">Townsend, 2021</a> ) ( <a href="#">Innes &amp; Booher, 2004</a> ) ( <a href="#">McAndrews &amp; Marcus, 2015</a> ) ( <a href="#">Grossardt &amp; Bailey, 2018</a> ) ( <a href="#">Khisty, 2000</a> )



Critique	Sources
There is a lack of evaluation criteria for successful implementation of PIM.	( <a href="#">Grossardt &amp; Bailey, 2018</a> ) ( <a href="#">Schiefelbusch, 2005</a> )
PIM may result in a loss of trust between the agency and public participants.	( <a href="#">Innes &amp; Booher, 2004</a> ) ( <a href="#">Townsend, 2021</a> ) ( <a href="#">Grossardt &amp; Bailey, 2018</a> )
PIM do not create successful dialogue, making participants feel unheard.	( <a href="#">Karner &amp; Marcantonio, 2018</a> ) ( <a href="#">Innes &amp; Booher, 2004</a> ) ( <a href="#">McAndrews &amp; Marcus, 2015</a> )

**The next section describes the opportunity for transportation agencies to improve public involvement methods. Additionally, this section indicates a potential value added from an approach that facilitates the simultaneous monitoring of resilience and public involvement practices and outcomes – leveraging enhanced public involvement practices to build a culture of resilience.** The next section describes capability maturity models, an approach to integrate, quantify and monitor these concepts.

## 2.2 Capability Maturity Models

Capability maturity models (CMMs) offer a pathway for agencies in any sector to measure capabilities that would otherwise be difficult or impossible to track, and that may be used in supporting cultural change. CMMs typically have five maturity levels ([Paulk et al. 1993](#); [Orthous Inchauste et al. In Review](#)):

- Level 1 (*initial*): Key process areas are not yet identified; processes are ad hoc.
- Level 2 (*repeatable*): Basic processes and some key process areas are established.
- Level 3 (*defined*): More advanced key process areas, including organization process focus, definition, training, peer reviews, among others, have been established.
- Level 4 (*managed*): Detailed measures of processes are collected; key process areas include quantitative and quantitative process management.
- Level 5 (*optimizing*): Continuous process improvement is supposed by existing organizational processes and innovative techniques; key process areas are very advanced and include change management.

Capability maturity models have been created for measuring adaptive resilience ([Singh et al. 2023](#)), transportation communications ([NRC 2023](#)), complete streets effectiveness ([Jordan et al. 2022](#)), and more broadly for transportation performance management ([FHWA 2016](#)). These capability maturity models require users to review each capability and choose which level best reflects their maturity, which may take users a long time - and thus be less likely to be utilized in practice. These limitations highlight the **need for CMMs to be clearly defined, user-friendly, and easily incorporated into existing performance monitoring practices** ([Orthous Inchauste et al. In Review](#)).



## 2.3 Transportation Insecurity and Climate Vulnerability

### 3.2.1 Climate Change and Socially Vulnerable Groups

To better understand the relationship between climate change impacts and socially vulnerable groups, the U.S. Environmental Protection Agency conducted a four-part analysis of the 48 continental US states ([EPA 2021](#)). The assessment involves:

- 1) projecting how the climate will change across the US,
- 2) estimating health and economic impacts of the impacts of climate events,
- 3) identifying areas with highest estimated impacts, and
- 4) analyzing comparative risks for vulnerable groups.

The results of the EPA assessment indicate that socially vulnerable groups are more likely to live in areas with high climate impacts in the future ([EPA 2021](#)). Although health and economic impacts are considered, the role of transportation and other built systems is not examined.

### 2.3.2 Key Terms and Concepts

Transportation systems constitute part of the nation's critical infrastructure. They are, however, just one part of a larger network that keeps society functioning smoothly. Problems in one system can affect others, potentially causing cascading failures when a system deteriorates or fails. Climate change is a stressor that affects all sectors, with some extreme events damaging infrastructure assets across sectors. **Vulnerability assessments** in transportation generally consider **sensitivity** (related to physical infrastructure condition), **exposure** (related to climate hazard intensity and frequency), and **adaptive capacity** (related to elements beyond physical infrastructure that affects a system's ability to resist and absorb disruptions) ([Amekudzi-Kennedy et al. 2023](#)).

Even if physical infrastructure has high exposure to climate hazards or other threats, the asset may be considered resilient if it has low vulnerability – e.g., low sensitivity (i.e., it is in good condition) and high adaptive capacity (i.e., it is able to adapt to withstand or otherwise absorb the threat effectively). **Current vulnerability assessments overlook that even assets with low vulnerability can be inaccessible to users, especially during an extreme weather event or disruption.** Low accessibility can exacerbate **transportation insecurity**, defined in this study as **“the conditions in which people are unable to reach destinations to meet basic daily needs regularly, reliably, and safely”** ([USDOT 2023](#); [Patil et al. In Review](#)).

Transportation investments can be seen as a means to achieve higher standards of living for all by reducing barriers related to transportation insecurity. Defining the term ‘equity’ in the context of transportation planning can thus inform investment decisions, in particular, project prioritization. The definition of **equity** used in this study is: **“the allocation of resources such that underserved areas and their services, options, and assets reach the standards and quality of the services, options, and assets of the strongest areas in the network in a way that recognizes the unique needs, strengths, history, and culture of each area”** (Patil et al. *In Review*; adapted from [Khisty 1996](#), [Bozeman et al. 2022](#), [Robbennolt and Witmer 2023](#), [Litman 2023](#), and others). Performance measures may also reflect the objectives and targets declared to support equity goals, which must be rooted within an agency’s chosen definition of equity ([NASEM 2022](#)). An equitable transportation system is one where “no individual is disadvantaged due to a lack of transportation resources, where transportation burdens are not borne disproportionately by specific groups, and where no group is excluded from shaping the decisions that affect their lives” ([Amekudzi-Kennedy et al. 2021](#)).

Physical transportation systems, and the communities that rely on them, must be able to accommodate hazards and associated impacts to remain operational and provide minimum levels of service in disruptive conditions. Hazards may be predictable/known (e.g., seasonal storms) or unpredictable/unknown (e.g., pandemics such as COVID-19). Resilient systems, as a result, must be able to handle both known and unknown threats and any consequential impacts. Infrastructure **resilience** is defined in this study as the **“development of anticipatory, preparedness, response and recovery, adaptive, and transformative capabilities to reduce vulnerability to known and unknown threats while enhancing system performance and reducing disruption costs”** (adapted from [NRC 2012](#); [Manyena et al. 2019](#); and [UNDRR](#)).

Certain capabilities, such as robustness and reliability, enhance resilience, while other capabilities, such as vulnerability, constrain or reduce it. These terms are used to describe the physical infrastructure's ability to respond to known and unknown threats effectively but do not address the ability of communities to withstand and recover from disruptions. Thus, a revised definition of vulnerability is presented to incorporate this multifaceted approach to resilience. The proposed definition of **vulnerability** is **“a capability related to exposure, sensitivity, and adaptive capacity for a particular asset, community, organization, or institution”** (adapted from [IPCC 2007](#), [Amekudzi-Kennedy et al. 2023](#), [Amekudzi-Kennedy et al. 2024](#)).

### 2.3.3 Status of Research and Practice

Vulnerability assessments and other resilience building activities are becoming more common in transportation ([NASEM 2021](#)). While most transportation vulnerability

assessments do not include elements of equity or transportation insecurity ([Espinet et al. 2016](#)), some climate vulnerability assessments do within criticality ([Amekudzi-Kennedy et al. 2023](#)) or adaptive capacity ([Rowen et al. 2014](#)). These combined assessments may lead to a diluted result ([Carvalhaes et al. 2021](#)), which may not provide planners and policymakers with the information they need for equity- and climate-informed decisions.

In a study on the relationship between perceived and modeled impacts of sea level rise on Oahu, Hawai'i, [Shen and Shim 2021](#) find that residents perceive climate impacts the same way, regardless of car ownership or income. The authors examine the relationship between resident perceived climate vulnerability and factors related to transportation insecurity. The study is however conducted on a relatively small area and does not provide a replicable way to incorporate transportation insecurity considerations into climate vulnerability assessments.

Transportation assets are vulnerable to a variety of natural and anthropogenic disruptions, meaning that transportation agencies must establish clear metrics to handle competing investment priorities. Current approaches to conducting climate vulnerability assessments do not acknowledge that low exposure, low sensitivity assets may still be areas with high transportation insecurity and thus prevent basic transportation needs from being met. To identify which areas and transportation assets require improved transportation security or enhanced climate robustness and resilience, this study proposes an integrated assessment methodology to facilitate effective prioritization.

## Chapter III: The NR-CMM Model and Self-Assessment

### Tool: Assessing the Impact of Processes on Social Equity and Disaster Preparedness Outcomes

#### 3.1 Benefits of Implementing Negotiated Resilience in Transportation

The status quo for transportation systems and community preparedness for climate disruptions is not adequate to handle intensifying and more frequent hazards; this deficiency is worsened by ineffective public involvement practices in many communities. *Negotiated resilience* is an emerging concept that **harmonizes community engagement and climate resilience practices while acknowledging the dynamic nature of each area** (Harris et al. 2017, Orthous Inchauste et al. *In Review*). Thus far, studies on *negotiated resilience* have only discussed the theory or the potential to be integrated into practice; this study is the first to translate the concept of *negotiated resilience* into a practical tool.

TRB *Critical Issues in Transportation* defines critical issues as “long-term transportation problems or questions that are major policy issues or are expected to be major policy issues in the next decade” (NASEM 2024). The critical issues in 2024 include **mitigating and responding to climate change** and **promoting equity and inclusion** among other goals of enhancing economy, safety, and public health. **Figure 4** shows the critical issues in transportation presented by NASEM.

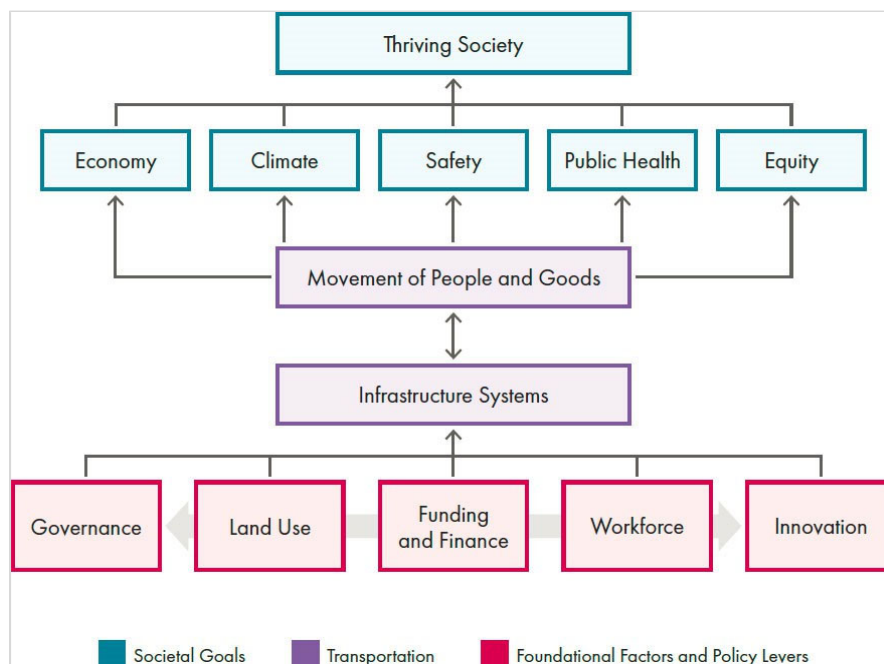


Figure 4. Critical issues in transportation (NASEM 2024).

The report by NASEM offers some metrics for monitoring some of these critical issues, but states that “**no single federal agency has responsibility for the development and reporting**” of metrics to promote equity and inclusion (NASEM 2024). For public agencies, an opportunity to promote equity and inclusion often arises during the public outreach and community engagement phase of transportation planning. This chapter not only examines what metrics should be used to **monitor the performance of public involvement efforts conducted by transportation agencies**, but also acknowledges the relationship between resilience and equity by further investigating what metrics are used to **monitor disaster management efforts**.

To translate negotiated resilience theory into practice, this chapter presents the ‘Negotiated Resilience Capability Maturity Model’ (NR-CMM) which integrates disaster management capabilities with the principles of public involvement in a five-level benchmarking tool (Orthous Inchauste et al. *In Review*). The NR-CMM and accompanying resources were co-developed with transportation and emergency management practitioners to enhance the usability of the resources across multiple scales (e.g., state, regional, local) and types of transportation agencies (e.g., highway, transit).

## 3.2 Elements of Negotiated Resilience

### 3.2.1 Questions to Consider

Harris et al. (2017) propose a set of questions for agencies to use to define and describe the potential motivation and outcomes for resilience-related investments: “resilience for whom, what, when, where, and why?” The authors emphasize the importance of reflecting on each question during each phase of transportation planning, implementation, and operation. These fundamental questions regarding resilience decisions and related trade-offs should be discussed by agencies, communities, and stakeholder groups within the project planning process. Meerow and Newell (2019) offer more specific inquiries for each question, as shown in **Table 2** (adapted by Orthous Inchauste et al. *In Review*) from Harris et al. (2017) and Meerow and Newell (2019).

Table 2. Questions and specific inquiries for negotiated resilience ([Orthous Inchauste et al. In Review](#)).

<b>5W Question</b>	<b>Specific Inquiries to Consider</b>
<i>Who?</i>	Who determines what is desirable for the community/organization/project? Whose resilience is prioritized? Who is included? Who is excluded? Whose interests are advanced?
<i>What?</i>	What are the ultimate objectives of this project? To what are we responding? What challenges should the community/organization/project be resilient to? What networks or sectors are included? Is the focus on generic or specific resilience? In what way are these interests advanced? What are the outcomes of these interests? What communities or stakeholders are given special consideration? What is the definition of resilience in this context?
<i>When?</i>	Is the focus on short-term resilience? Is the focus on long-term resilience? Is the focus on immediate change or gradual change? Is the focus on the resilience of present or future generations?
<i>Where?</i>	Where are the spatial boundaries of the community/organization/project? Is the resilience of some areas prioritized over others? Does building resilience in some areas affect resilience elsewhere?
<i>Why?</i>	Why are we building resilience? What is the motivation for building resilience in this context? Is the focus on the process or outcome?

### 3.2.2 Negotiated Resilience Principles

[Harris et al. \(2017\)](#) refer to critical elements of negotiated resilience; [Orthous Inchauste et al. \(In Review\)](#) explicitly define and relate the principles of negotiated resilience with disaster-related outcomes (**Figure 5**). Each of these six principles relate to agencies' ability to effectively collaborate with community and stakeholder groups before, during, and after a disaster. In the long run, these abilities can impact social quality of life and the return-on-investment of resilience-building projects.

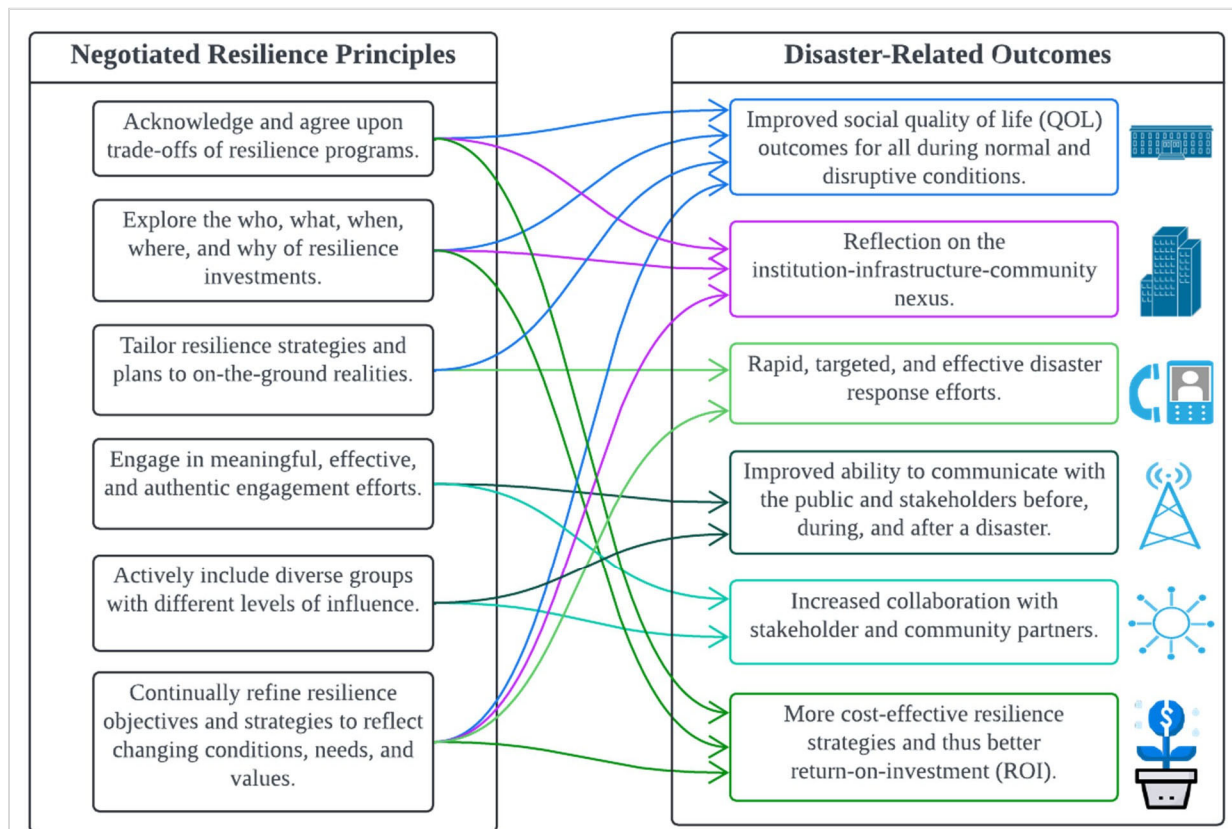


Figure 5. Connection of principles of negotiated resilience with outcomes before, during, and after disasters (Orthous Inchauste et al. *In Review*).

### 3.3 NR-CMM and Self-Assessment Tool Development

#### 3.3.1 Approach

Several capability maturity models related to transportation provided context and insight for the development of the NR-CMM and associated resources. These CMMs include: the *adaptive resilience capability maturity model* (Singh et al. 2023), the *transportation communications capability maturity model* (NRC 2023), the *complete streets capability maturity model* (Jordan et al. 2022), and the *transportation performance management capability maturity framework* (FHWA 2016). These CMMs not only informed the approach to develop the NR-CMM but also informed some of the capabilities (e.g., vulnerability and criticality assessments) and themes (e.g., tactical, programmatic). Based on the review of these models and the literature, the major capabilities related to the principles of negotiated resilience (e.g., considering the 5W questions, including diverse groups, acknowledging trade-offs) were determined and then included in the Negotiated Resilience-Capability Maturity Model developed by Orthous Inchauste et al. (*In Review*). Orthous Inchauste et al. (*In Review*) also created a self-assessment tool and recommendations resource to complement the NR-CMM. Three versions (1.0 - 1.2) of the NR-CMM and self-assessment tool were presented to transportation and emergency



management experts from state departments of transportation (DOTs), metropolitan planning organizations (MPOs), local transportation agencies, and consulting firms for feedback. Version 1.3 of the NR-CMM is included in the Appendix of this report. **Figure 6** summarizes the approach to developing the NR-CMM and associated resources.

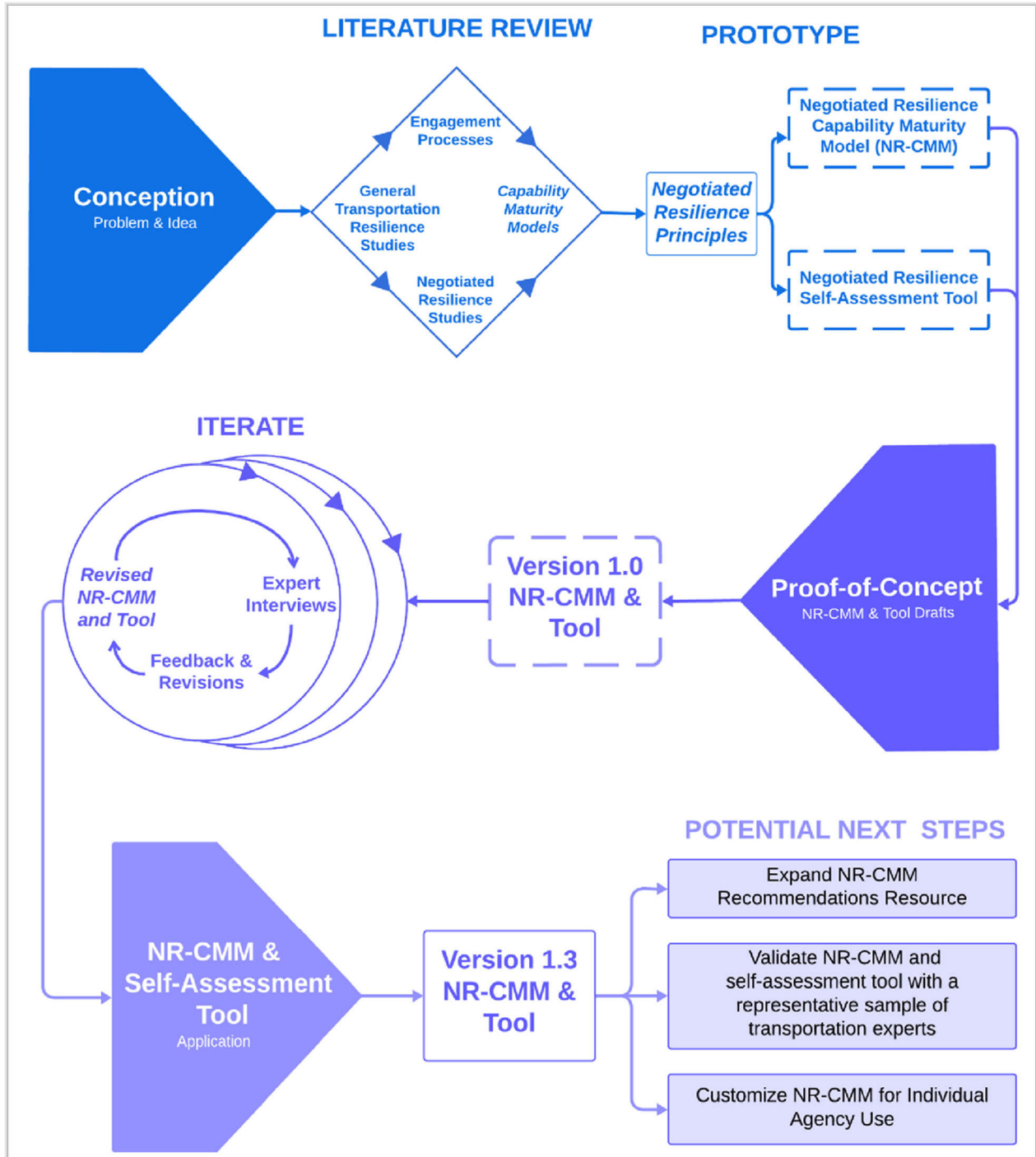


Figure 6. Negotiated resilience-capability maturity model and self-assessment tool development process (Orthous Inchauste et al. *In Review*).

Following the conceptual design of the NR-CMM, a self-assessment tool was built within a survey software platform to enhance the usability of the NR-CMM. Within the self-assessment tool, there are three sections of statements: 1) community and stakeholder engagement, 2) emergency management and preparedness, and 3) general agency practices. The tool takes less than 20 minutes to complete, allowing practitioners to obtain a score for each capability within the NR-CMM. Multiple versions of the self-assessment tool and NR-CMM were presented to transportation practitioners for feedback. The full approach is detailed in [Orthous Inchauste et al. \(In Review\)](#).

### 3.3.2 Stakeholder Feedback

Three rounds of expert target interviews were conducted with 12 practitioners to gather feedback; each interview had one to three practitioners from the targeted agency. The targeted organization types included representatives from three DOTs, three planning organizations, one consulting firm, and one local agency (local DOT). **Figure 7** shows the location of the agencies by state, where a darker color indicates more practitioners interviewed from that state ([Orthous Inchauste et al. In Review](#)). Each round of interviews refined the tool and NR-CMM to align better with practitioner feedback. The feedback and revisions applied are described in [Orthous Inchauste et al. \(In Review\)](#).

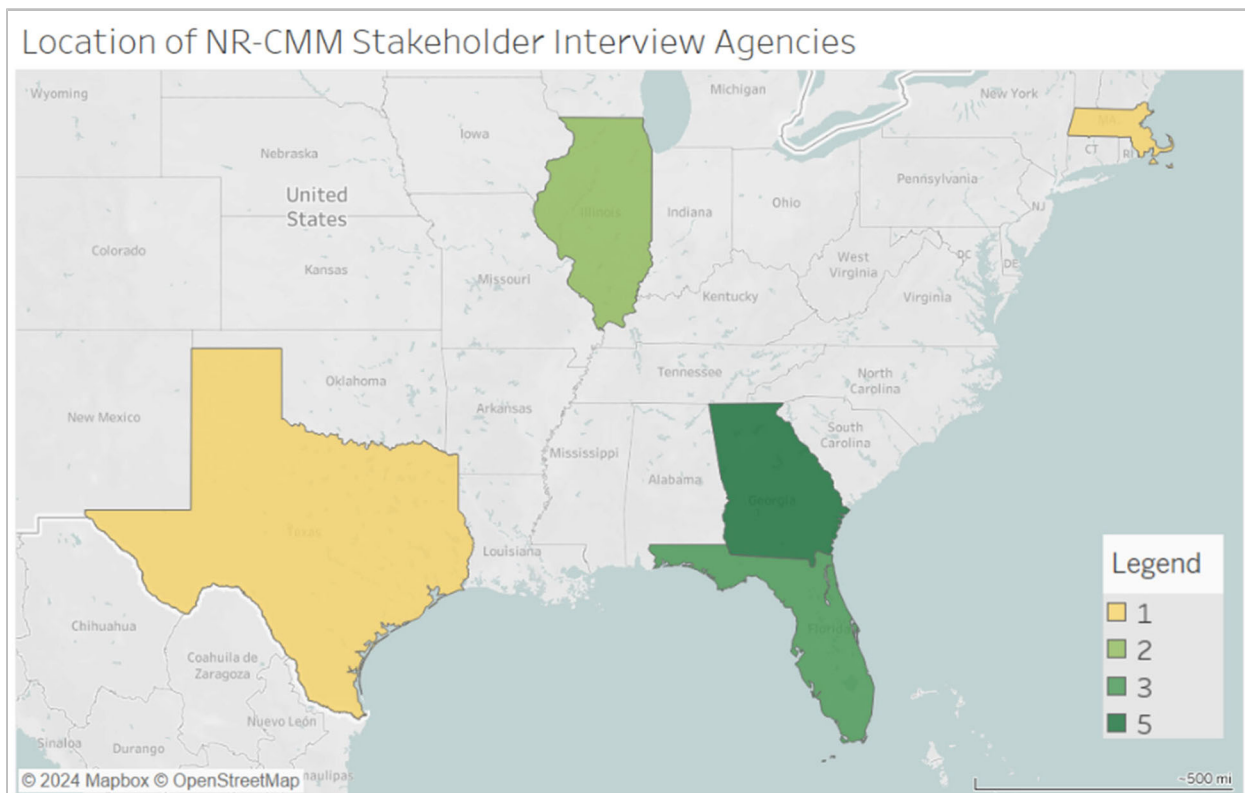


Figure 7. Geographic location of the expert interview practitioners ([Orthous Inchauste et al. In Review](#)).

## 3.4 Negotiated Resilience Capability Maturity Model

### 3.4.1 Final Themes and Capabilities

The NR-CMM is organized into four thematic areas: strategic, institutional, programmatic, and tactical. **Table 3** below shows the themes and descriptions.

Table 3. Final themes for NR-CMM (Orthous Inchauste et al. *In Review*).

Theme	Description
Strategic	Capabilities related to how an agency approaches stakeholder and community activities and engagement, in normal and disaster contexts.
Institutional	Capabilities related to organizational norms, ideas, and relationships that may impact an agency’s ability to effectively engage the public or handle disruptions.
Programmatic	Capabilities related to planning activities, such as setting objectives, targets, and performance measures, or to agency programs that handle activities like resource allocation or asset monitoring.
Tactical	Capabilities related to data management, technology, and technical implementation approaches that may impact an agency’s relationship with stakeholders or communities, in normal or disaster contexts.

The final NR-CMM is a 16-capability, five-level model for state, regional, and local transportation agencies. The final capabilities included in the NR-CMM are presented in **Table 4** below, where blue are strategic capabilities (also indicated by an “S”); green are institutional capabilities (indicated by an “I”); yellow are programmatic capabilities (indicated by a “P”); and red are tactical capabilities (indicated by a “T”).

Table 4. Final capabilities and definitions for NR-CMM (Orthous Inchauste et al. *In Review*).

Capability (Theme)	Definition
Stakeholder Engagement (S)	The extent to which quality of relationships and interactions with stakeholders, alongside the active involvement and integration of their feedback and collaboration into decision-making processes.
Stakeholder Collaboration Monitoring and Adjustment (S)	The degree to which stakeholder engagement is monitored and existing measures are improved.
Stakeholder Communication - Disaster Context (S)	The quality of relationships and interactions with stakeholders before, during, and after a disaster.
Community Engagement (S)	The quality of relationships and interactions with communities, alongside the active involvement and integration of their feedback and collaboration into decision-making processes.
Community Collaboration	The degree to which community engagement is monitored,

<b>Capability (Theme)</b>	<b>Definition</b>
Monitoring and Adjustment (S)	existing measures are improved; the diversity of community involvement is assessed.
Community Communication-Disaster Context (S)	The extent to which quality of relationships and interactions with communities are maintained before, during, and after a disaster.
Information Dissemination to Communities (S)	The process to distribute information to communities and the established communication networks.
Culture of Change (I)	The degree to which success of planning approaches are continually refined to encourage experimentation, innovation, and hands-on learning.
Resilience Strategy (I)	The extent to which a resilience strategy's documentation has been created, covering the five W's—who, what, when, where, and why—of resilience and integrating essential revisions.
Program Connectivity within Organization (I)	The degree to which office connectivity is facilitated via clear objectives, data exchange, and impact assessments, preventing any separation among offices.
Continuity and Talent Development (I)	The extent to which the organization is able to ensure a seamless transition of knowledge and skills across various levels and functions, while also developing employees' potential to meet both current and future organizational needs.
Vulnerability and Criticality Assessments (P)	The extent to which vulnerability and criticality assessments are conducted, evaluated, and continuously monitored, then integrated into system design, planning, and management processes.
Roadmapping (P)	The extent to which emphasis is placed on long-term planning and scenario analysis and emerging uncertainties; short-term needs and potential opportunities are considered.
Stakeholder & Community Data Management (T)	The degree to which data is managed, stored, shared, and protected through a standardized process to ensure both data quality and security measures are in place.
Technology & Implementation Approaches (T)	The degree to which technology is utilized to improve user experience and is consistently evaluated and upgraded.
Resilience Data Management (T)	The degree to which resilience assessment data stored, managed, and accessible for planning purposes.

### 3.4.2 Example

For an agency to measure the effectiveness of their stakeholder engagement practices, the agency can refer to the self-assessment tool (example of statements and interface shown in **Figure 8**). After receiving their scores, the agency may wish to refer to the NR-CMM and review the five levels (example of one capability shown in **Table 5**). If the agency would like to improve the effectiveness of their practices, they can refer to the recommendations resource (example shown in **Table 6**).

Figure 8. Example of the self-assessment tool interface and example questions (Orthous Inchauste et al. *In Review*).

Table 5. Example of a capability as presented in the NR-CMM (Orthous Inchauste et al. *In Review*).

<b>Stakeholder Communication - Disaster Context</b>					
The quality of relationships and interactions with stakeholders before, during, and after a disaster.					
Theme	Level 1 (initial)	Level 2 (repeatable)	Level 3 (defined)	Level 4 (managed)	Level 5 (optimizing)
Strategic	During a disaster, my agency struggles to communicate with stakeholders.	Communication efforts are reactive; no formal networks of communication with stakeholders.	Communication networks are established. After disasters, stakeholders can reach out to the agency to share thoughts or feedback.	Stakeholders are invited to make decisions about how to return the system to acceptable performance levels post-disaster. The agency documents what occurs during a disaster but may not use that information to inform future practices.	Communication efforts post-disaster are monitored and evaluated. The agency uses lessons learned to inform future emergency management efforts. The agency works with stakeholders to establish new goals for the system post-emergency and to return the system to acceptable performance levels.

Table 6. Example of recommendations resource for moving to higher levels of maturity (Orthous Inchauste et al. *In Review*).

Stakeholder Communication – Disaster Context		
Document Name	Source	Link
How to Communicate Effectively with Stakeholders in a Crisis	Crisis Ready Institute	<a href="https://www.linkedin.com/pulse/how-communicate-effectively-stakeholders-crisis-melissa-agnes/">https://www.linkedin.com/pulse/how-communicate-effectively-stakeholders-crisis-melissa-agnes/</a>
Emergency management coordination	The Washington State Department of Transportation	<a href="https://tsmowa.org/category/transportation-operations/emergency-management-coordination">https://tsmowa.org/category/transportation-operations/emergency-management-coordination</a>
Emergency Communication Strategies for Transit Agencies	American Public Transportation Association	<a href="https://www.apta.com/wp-content/uploads/APTA-SS-SEM-S-009-09_Rev1.pdf">https://www.apta.com/wp-content/uploads/APTA-SS-SEM-S-009-09_Rev1.pdf</a>
Lesson 3. Communicating in an Emergency	Federal Emergency Management Agency	<a href="https://training.fema.gov/emiweb/is/is242b/student%20manual/sm_03.pdf#page=2.36">https://training.fema.gov/emiweb/is/is242b/student%20manual/sm_03.pdf#page=2.36</a>

Version 1.3 of the NR-CMM, self-assessment tool, and recommendations resource can be found in Appendix B.

### 3.5 Summary

Integrating negotiated resilience principles into practice may help transportation agencies improve resilience to the changing climate in a way that leaves no one behind. This chapter describes how negotiated resilience principles can be translated from theory into practical tools and offers a practical approach to simultaneously monitor the effectiveness of public involvement and disaster management practices. Over time, these resources and others can provide insights for agencies looking to advance quality of life outcomes while reducing vulnerability to climate hazards.



# Chapter IV: Incorporating Transportation Insecurity Measures in Climate Vulnerability Assessments

## 4.1 Transportation Security as a Basic Resilience Measure

To build resilience to climate threats and reduce the impacts of climate disruptions, transportation agencies have begun incorporating climate vulnerability assessments in decision making (see, for example, the Vulnerability Assessment and Adaptation Framework by the Federal Highway Administration (**Figure 1** in this report) or the frameworks offered by the Transportation Research Board of the National Academies of Science, Engineering, and Medicine (**Figures 2 and 3** in this report)). At the same time, it is common knowledge that **chronic stressors, like transportation insecurity (that is, the conditions in which people are unable to reach destinations to meet basic daily needs regularly, reliably, and safely), can lower quality of life and exacerbate the impacts of climate hazards.** This is especially important in areas where there is increasing frequency and intensity of climate hazards with resilience strategies that include transportation.

Considering these challenges, this chapter aims to offer a methodology for identifying regions that lack transportation security due to poor access to basic services and to demonstrate how this information may be integrated in a climate vulnerability assessment to address both transportation challenges and climate risks. The purpose is to facilitate a better understanding of the vulnerabilities that populations experience at the intersection of climate hazards and transportation insecurity. This method can inform project prioritization and other transportation planning and decision-making processes in following way. By integrating transportation insecurity metrics with climate vulnerability data, decision makers can pinpoint areas most at risk. By mapping out areas of vulnerability, the methodology facilitates targeted engagement with local communities and stakeholders. After clear identification of high-priority areas and engagement with local communities, this methodology can help streamline resource allocation to regions where it will have most significant impact on both transportation security and climate resilience. Establishing baseline data on transportation access and climate vulnerability allows for ongoing monitoring of project outcomes. This iterative feedback loop can help ensure that transportation planning will evolve in response to changing conditions and emerging vulnerabilities.

Thus, by utilizing this methodology, planners and decision makers can address the interconnected challenges of transportation insecurity and climate vulnerability systematically, leading to more resilient and equitable infrastructure solutions.

## 4.2 Analytical Approach and Data



This section describes a methodology to integrate transportation insecurity and climate vulnerability assessments. The methodology involves gathering data on factors influencing transportation insecurity, including transportation cost burden, and climate vulnerability, including hazard exposure. Geographic exploratory data analyses are used to identify areas where transportation insecurity and climate hazard exposure are high. Following that analysis, a statistical analysis is conducted to examine if areas with higher climate hazard exposure (such as extreme precipitation and heat) also have high transportation insecurity. This methodology examines whether areas that face frequent climate disruptions like extreme rainfall and heat overlap with higher levels of transportation insecurity. More detail is described in [Patil et al. \(In Review\)](#).

Transportation insecurity factors can range by area and depend on the decision(s) to be made; some agencies may want to consider the *transportation cost burden* when deciding where to implement congestion pricing or tolled roads. Agencies may also want to consider the *percent of households with no vehicle* when deciding where to plan a transit line, for example. Other transportation insecurity factors include *transportation access* (the level of access a community has to needed services and desirable destinations via transportation) and *transportation safety burden* (the extent to which an area has high crash rates) ([USDOT ETC 2023](#)). These datasets are available for free use from the US Department of Transportation Equitable Transportation Community (ETC) Explorer, which provides transportation agencies with geographic insights on transportation disadvantage ([USDOT 2023](#)). This data source and others (e.g., American Community Survey, Center for Neighborhood Technology) provide input into exploratory data analysis for multiple transportation insecurity factors, enabling agencies to identify areas with high transportation insecurity. The resource will also enable practitioners to identify and prioritize areas where transportation insecurity exacerbates weather and climate vulnerabilities, as part of their climate resilience building efforts.

Climate vulnerability factors range by area. Transportation agencies in Texas and Georgia may wish to consider tropical cyclones and severe storms (79.2% and 69.7%, respectively, of total billion-dollar climate event costs to the two states between 1980 and 2024, [NOAA 2024](#)) during planning and decision making. On the west coast, California's transportation agencies may wish to consider wildfires (64.7% of total billion-dollar climate event costs to the state between 1980 and 2024, [NOAA 2024](#)). The [USDOT ETC](#) includes climate and disaster risk burden factors such as *annualized disaster losses*, *future climate and disaster risk burden*, and *impervious surfaces*. The [Spatial Hazard Events and Losses Database for the United States \(SHELDUS\)](#) is a national county-level data set that has information on approximately 18 different climate hazards from 1960 to the present. SHELDUS provides temporal data on a diverse set of hazards enabling trends and hotspots of hazard occurrence to be determined. For transportation planning decisions that need to consider mid- or end-century climate conditions, climate projection data can be utilized. The [Climate Risk and Resilience Portal \(ClimRR\)](#), developed by Argonne National Laboratory, is an open-access data platform for dynamically downscaled climate projection data. This data source includes climate exposure factors like *heat index*, *temperature*, *fire weather index*, *precipitation levels*, and others.

Once areas with high transportation insecurity and high climate hazard vulnerability have been identified, a statistical analysis can be conducted to help identify patterns and potential correlations between the variables. The combination of these three analyses can then inform planning and decision making. **Figure 9** summarizes the proposed approach ([Patil et al. In Review](#)).

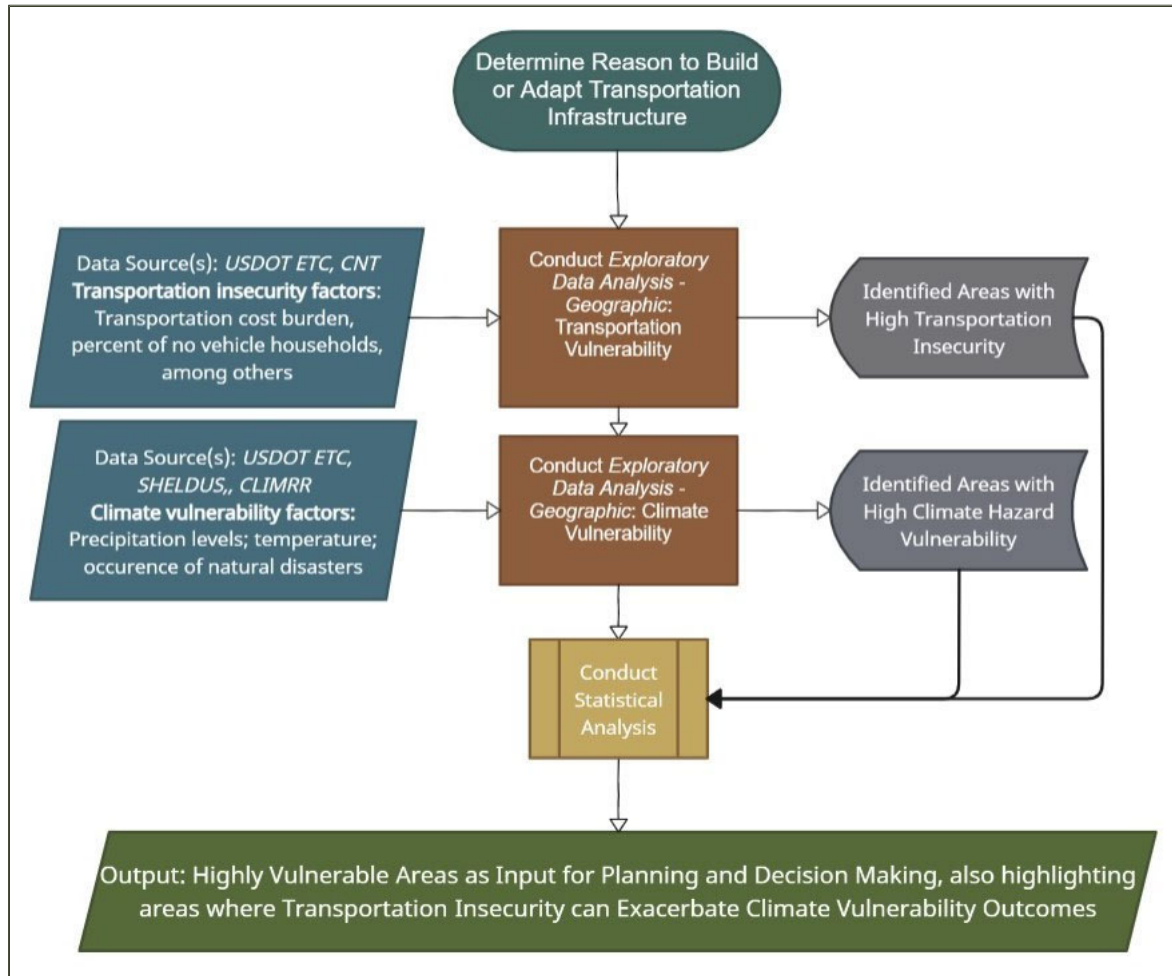


Figure 9. Flowchart for Integrated Transportation Insecurity and Climate Vulnerability Assessment Approach (Patil et al. *In Review*).

### 4.3 Example Application & Case Study

This approach could be integrated into climate vulnerability assessment tools, such as the MHEVRA Tool (i.e., Multi-Hazards Exposure, Vulnerability and Risk Analysis Tool), for improved transportation planning and decision-making considering transportation insecurity (see [Amekudzi-Kennedy et al. 2024](#) for more on the MHEVRA Tool and [Amekudzi-Kennedy et al. 2023](#) for more on the conceptual bases for the MHEVRA methodology). The steps to this approach are briefly described with an example application below.

#### 4.3.1 Example Application

##### Step 1: Consider Problem and Related Factors

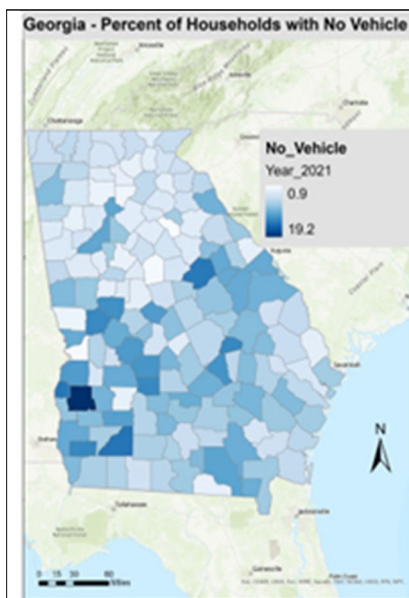
For this example, we consider a situation in which the Atlanta Regional Commission is trying to identify which areas are most vulnerable to tornadoes and whether these areas also have high transportation insecurity based on vehicle ownership and transportation costs.

## Step 2: Determine Transportation Insecurity Factors and Collect Data

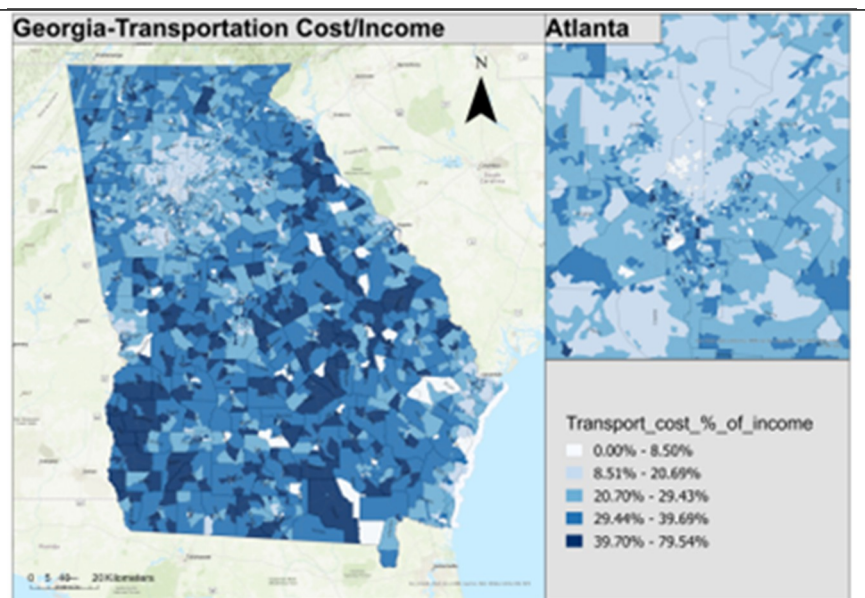
For this analysis, we would identify areas with low vehicle ownership rates and areas spending a relatively high proportion of income on transportation. This would provide insight into the resources these areas might need in the case of a disruption, like a tornado. All data sets would be reviewed and may need to be cleaned or prepared before mapping.

## Step 3: Conduct Geographic Exploratory Data Analysis – Transportation Insecurity

A geographic exploratory data analysis would be conducted to identify areas with low vehicle ownership rates and areas spending a relatively high proportion of income on transportation (Figures 10 and 11). Since the Atlanta Regional Commission is a multi-county entity, the agency may consider the county or Census tract scales, as shown in the figures below. Figures 10 and 11 show that these kinds of analysis are subject to the aerial unit problem and highlight the importance of using multiple unit scales, including the smallest unit, to conduct a sensitivity analysis on the analysis outputs. A multi-scalar analysis will also help to generate ideas for appropriate strategies at different scales, e.g., county-wide versus more local solutions.



**Figure 10.** Percent of Households with No Vehicle (County Scale; Georgia; data from American Community Survey, 2021)



**Figure 11.** Transportation Cost/Income (Census Tract Scale; Georgia; data from Center for Neighborhood Technology, 2019)

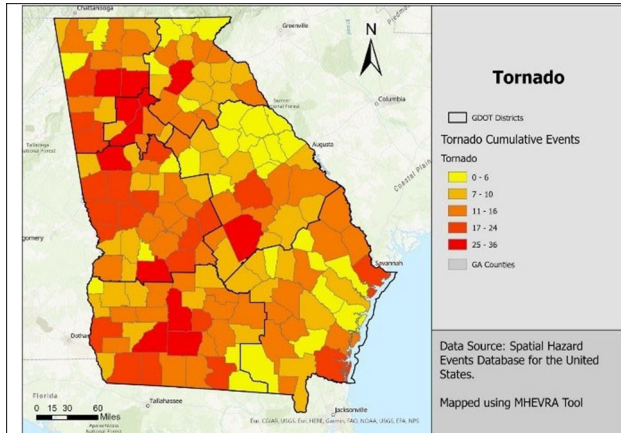
## Step 4: Determine Climate Vulnerability Factors and Assemble Data

As the Atlanta Regional Commission might be looking to find which areas are most vulnerable to tornadoes, we would utilize the Spatial Hazard Events and Losses Database

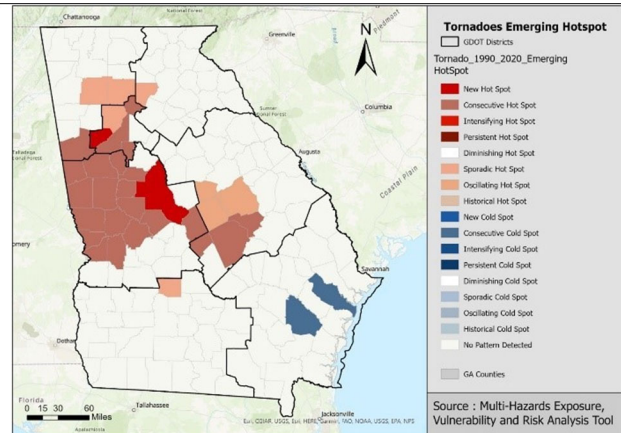
for the United States, which is available by subscription at the county-scale for 18 different hazard types. This data set also provides temporal information, so the Atlanta Regional Commission could identify the trends of the hazard in different counties and isolate and prioritize hotspots.

**Step 5: Conduct Geographic Exploratory Data Analysis – Climate Hazard Vulnerability**

A geographic exploratory data analysis could be conducted to identify the areas where Georgia is most vulnerable to tornadoes as shown in **Figures 12 and 13**.



**Figure 12.** Cumulative Tornado Events (County Scale; Georgia; data from SHELUDS, 1990 - 2020).



**Figure 13.** Tornadoes Emerging Hotspot (County Scale; Georgia; data from SHELUDS, 1990 - 2020).

**Step 6: Conduct Statistical Analysis**

Based on the problem at hand, we could select an appropriate analysis to combine the factors considered. Options include correlation analysis, regression analysis, and time series analysis, among others. For this example, the Atlanta Regional Commission would likely benefit from employing correlation analysis to assess the strength of the relationship between these factors. This analysis can be conducted in R or other programming languages using variables at the same scales.

For decision making considering both factors simultaneously, the agency may also want to conduct a spatial overlap in a Geographic Information System (GIS) like ArcGIS or QGIS to identify areas that experience high exposure to tornadoes and high transportation insecurity.

**Step 7: Input Insights into Planning and Decision Making**

The Atlanta Regional Commission might want to present these results in upcoming community meetings and incorporate them into the upcoming Long-Range Transportation Plan. The outputs may be refined as needed to enhance communicability to a general audience and to enable incorporation into existing planning tools and processes.



### 4.3.2 Case Study: California

California's regions struggle with climate hazards, such as extreme precipitation and heat, and transportation insecurity. These threats impact the ability of various populations to meet their daily needs. This analysis identifies whether there is a significant difference of future projections of climate risks (extreme precipitation and extreme heat) for areas currently facing socio-economic challenges (transportation costs and lack of vehicle ownership). Extreme heat and extreme precipitation are based on the Climate Mapping for Resilience and Adaptation (CMRA) dataset from NOAA and DOI. Projections use the RCP 8.5 model, with extreme heat measured by days above 90 degrees Fahrenheit and extreme precipitation by days with precipitation above the 99th percentile. Projections were used under the assumptions that the projections reflect the climate trends in each area (e.g., areas with projected extreme heat experience intensifying temperatures over time). Transportation cost burden data is calculated from the Consumer Expenditure Survey (CES), USDOT, and FTA's National Transit Database (NTD), covering auto costs, travel time, and transit spending per household. Vehicle ownership data is from the American Community Survey (2016-2020; more detail described in [Patil et al. In Review](#)). The approach outlined in Figure 9 is used for this case study. The variables for extreme precipitation and extreme heat were categorized based on whether they exceeded the 75<sup>th</sup> percentile thresholds. Levene's test was then conducted to assess the equality of variances between these groups (using a significance level of 0.05). Depending on the results of Levene's test, either a Welch test or a standard one-sided t-test was performed to compare transportation insecurity variables with presence of projected extreme weather conditions (using a significance level of 0.05).

#### **T-Tests Conducted:**

- **Transportation Costs:** Compares transportation costs in areas with high versus low precipitation and extreme versus non-extreme heat.
- **No-Vehicle Households:** Compares the percentage of no-vehicle households in areas with high versus low precipitation and extreme versus non-extreme heat.
- **Combined Impact:** Examines the effect of areas with both high precipitation and extreme heat on transportation costs and the percentage of no-vehicle households.

This analysis helps to identify potential overlaps and impacts between projected future climate conditions and current socio-economic challenges, aiding in the development of targeted resilience strategies.

#### **Northwest California**

**Climate Risk:** Future projections indicate that extreme precipitation will be a climate risk, threatening to disrupt transportation infrastructure and increase maintenance costs.

**Current Socio-Economic Condition:** Residents in this region already face a substantial transportation cost burden.

**Statistical Analysis:**

- **Transportation Costs:** There is no significant difference in transportation costs between areas with high and low precipitation (t-statistic = 0.697, p-value = 0.243).
- **Interpretation:** There is no significant difference in transportation costs between areas projected to experience extreme precipitation.

**Figures 14.1-14.4** indicate the areas in the north are projected to experience high precipitation compared to other areas, but the current transportation cost burden is quite high across the state (except in urban areas). This reflects the need to prioritize affordable means of transportation to improve accessibility in rural areas in order to alleviate transportation cost burden.

**Southeast California**

**Climate Risk:** Extreme heat is identified as a future climate risk, potentially affecting transportation infrastructure and users (e.g., pedestrians, transit users).

**Current Socio-Economic Condition:** Residents face a substantial transportation cost burden, compounded by a high percentage of zero-vehicle households.

**Statistical Analysis:**

- **Transportation Costs:** Transportation costs are significantly higher in areas with projected extreme heat conditions compared to those with non-extreme heat (t-statistic = 7.950, p-value =  $1.151 \times 10^{-15}$ ).
- **No-Vehicle Households:** There is no statistically significant difference in the percentage of no-vehicle households between regions projected to experience extreme heat and other regions (t-statistic = -3.295, p-value = 0.999).
- **Interpretation:** The overlap between high transportation costs and projected extreme heat highlights the need for strategies to enhance transportation resilience against extreme heat while enhancing transportation affordability. Improving public transportation and developing heat-resistant infrastructure are crucial to address these challenges and support households without access to personal vehicles.



## **Southern Central Valley**

**Climate Risk:** Extreme heat poses a future climate threat, potentially affecting transportation infrastructure and users.

**Current Socio-Economic Condition:** Residents endure high transportation costs, with many households lacking vehicle access.

### **Statistical Analysis:**

- **Transportation Costs:** Transportation costs are significantly higher in areas with both high precipitation and extreme heat (t-statistic = 7.367, p-value =  $1.396 \times 10^{-13}$ ).
- **No-Vehicle Households:** The percentage of no-vehicle households does not significantly differ in these areas (t-statistic = -1.399, p-value = 0.919).
- **Interpretation:** The overlap between high transportation costs and future combined climate risks (high precipitation and extreme heat) necessitates urgent strategies to enhance transportation resilience.

**Figure 14.1-14.4** below show the transportation insecurity and climate factors mapped for the state of California (Patil et al. *In Review*).

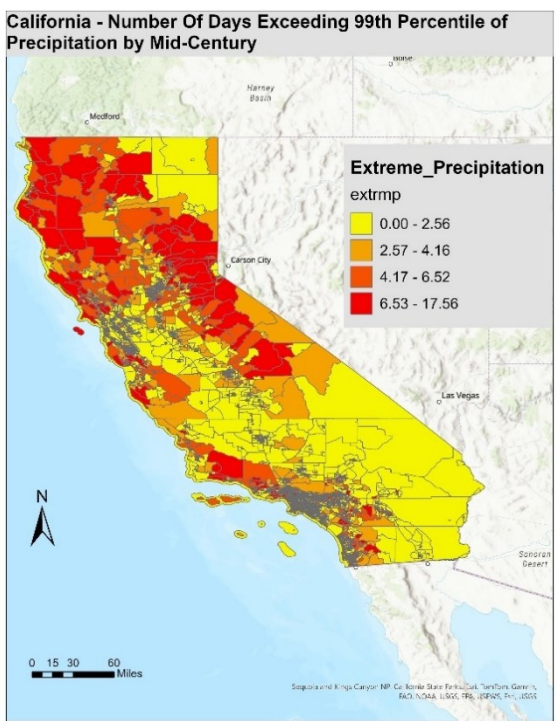
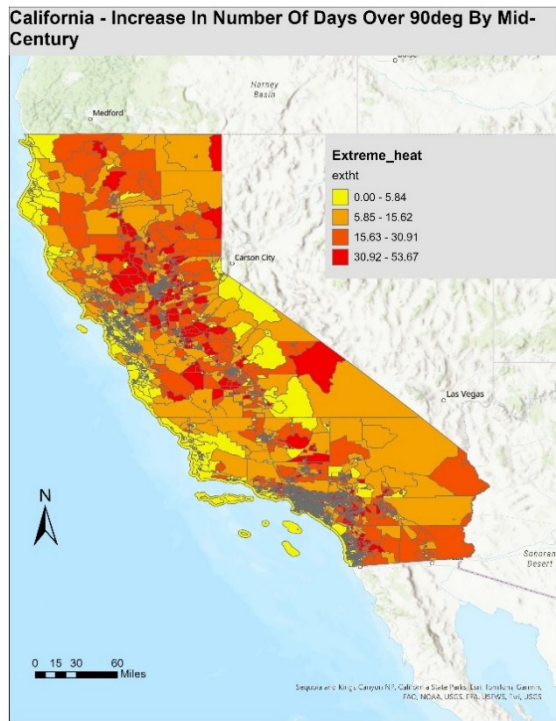
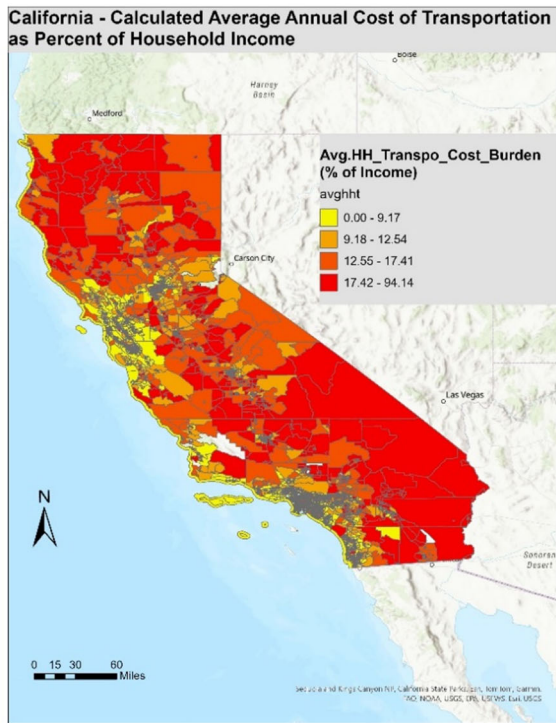
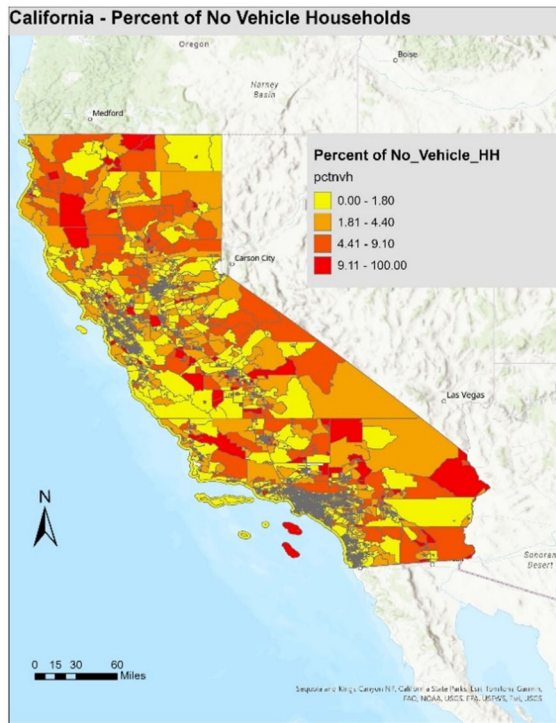


Figure 14.1 - 14.4 Transportation Insecurity and Climate Vulnerability Indicators by Census Tract for California (Source: USDOT ETC, 2023).

**Table 7** summarizes the statistical test results for the entire state. The shaded boxes indicate that there is a statistical difference between means of the two groups tested.

Table 7. Statistical test results for transportation security and extreme/non-extreme weather variables in California (Patil et al. *In Progress*).

Variables	t-statistic	p-value
Transportation costs in high versus low precipitation areas	0.697	0.243
Transportation costs in extreme versus non-extreme heat areas	7.950	1.151 x 10 <sup>-15</sup>
Percent of no-vehicle households in high versus low precipitation areas	0.406	0.342
Percent of no-vehicle households in extreme versus non-extreme heat areas	-3.295	0.999
Transportation costs in high precipitation and extreme heat areas versus areas with non-extreme weather conditions	7.367	1.396 x 10 <sup>-13</sup>
Percent of no-vehicle households in high precipitation and extreme heat areas versus areas with non-extreme weather conditions	-1.399	0.919

This analysis indicates that transportation costs are significantly higher in areas with projected extreme heat conditions across California. This analysis also demonstrates that transportation costs are significantly higher in areas with projected extreme heat and high precipitation. For transportation planners, these findings can inform project prioritization and long-term transportation planning efforts in some of these areas to address social and climate vulnerabilities simultaneously.

This case study elucidates how this methodology can provide insights into areas where transportation insecurity may be exacerbated by climate vulnerability.

#### 4.4 Summary

The proposed methodology will help agencies identify regions with high levels of both transportation insecurity and exposure to climate hazards. It will also identify areas where transportation insecurity could worsen the impact of climate vulnerability. This can be significant for transportation agencies looking to incorporate transportation insecurity considerations in climate (and other) vulnerability assessments for planning and project prioritization.

## Chapter V: Policy Recommendations

### 5.1 Relevance of Research to Policy

As climate hazards intensify and socio-economic disparities persist, more transportation practitioners and researchers stand to benefit from examining how to advance resilient and equity outcomes simultaneously. This research project has examined the intersection of resilience and equity from multiple perspectives, yielding a comprehensive capability maturity model to enable transportation practitioners to assess and improve their disaster management and community engagement strategies. Additionally, the research project has developed a flexible methodology for evaluating climate hazard vulnerability with transportation insecurity considerations as an inherent and identifiable component of the analysis.

The findings of this research project underscore the need for policy interventions to address basic transportation vulnerability considerations in climate hazard vulnerability assessments at multiple points along the disruption-recovery timeline. The recommendations apply to the PROTECT Program at the national level and the development of Resilience Improvement Plans by state and regional entities. Other relevant federal initiatives include Executive Order 14008 on Tackling the Climate Crisis at Home and Abroad ([The White House 2021](#)) and Executive Order 13985 on Advancing Racial Equity and Support for Underserved Communities ([The White House 2021](#)). These orders direct federal agencies to incorporate equity and climate resilience considerations into policies and programs; the recommendations below aim to facilitate implementation of existing institutions. These recommendations are intended to be a reference for policymakers looking to promote systems that can withstand and adapt to future challenges while advancing desirable transportation outcomes for all.

### 5.2 Policy Recommendations

The first two policy recommendations are targeted at transportation agencies at the state, metropolitan and local levels. The final three policy recommendations are targeted at congressional decision makers.

- **Policy Recommendation 1:** Require application of negotiated resilience principles for co-development of resilience definition with affected communities and stakeholders. Continue to update resilience definition on an ongoing basis.
- **Policy Recommendation 2:** Mandate the inclusion of transportation insecurity measures in climate vulnerability assessments to identify and prioritize areas with transportation insecurities and to ensure that no community gets left behind while resilience improvements are being made.

- **Policy Recommendation 3:** Require application of a performance monitoring approach - such as the NR-CMM and self-assessment tool - in disaster planning and decision-making processes.
- **Policy Recommendation 4:** Allocate dedicated funds for eradicating transportation insecurity in all communities. Ensure that funds may be leveraged for addressing other transportation priorities simultaneously to enhance co-benefits.
- **Policy Recommendation 5:** Establish community engagement and performance monitoring standards for Resilience Improvement Plans.

## Chapter VI: Conclusion

As climate hazards intensify, transportation and other infrastructure agencies seek solutions to address environmental, economic, and social stressors. Socially vulnerable populations generally tend to be the most impacted by increased external stressors due to lack of resources to address these stressors, further exacerbating social inequities and potentially reducing system resilience. Transportation systems are complex systems that evolve not only as infrastructure is built and rehabilitated but also as people and communities change the way they use the infrastructure (e.g., the use of electric scooters on streets and sidewalks, and the use of curb space for rideshare services). Understanding how the needs of transportation users evolve over time is a complex but necessary task to ensure that people can get where they need to go during normal and disruptive conditions.

This research investigated the relationship between climate resilience and equity in transportation planning and decision making. The principles of negotiated resilience were consolidated to create a practical tool and supporting resources to enable practitioners to monitor negotiated resilience implementation in future infrastructure projects and programs. A methodology for incorporating transportation insecurity indicators into climate vulnerability assessments was also developed. Practitioners may use these two sets of resources to define and keep their resilience definitions current, to integrate enhanced public involvement on an ongoing basis in their resilience building activities, and, to ensure that transportation security considerations are a basic and undiluted component of any efforts to identify and eliminate climate and other forms of vulnerability.

The policy recommendations presented in this research are targeted at transportation agencies at the national, state, metropolitan and local levels. The recommendations include requiring the incorporation of negotiated resilience and transportation insecurity considerations into existing planning processes. Additionally, the recommendations encourage practitioners to incorporate tools like CMMs into existing performance monitoring practices. Finally, the recommendations include establishing standards for community engagement, supported by performance monitoring, when developing Resilience Improvement Plans.

This research demonstrates that transportation planning that considers exposure, sensitivity, adaptive capacity, and insecurity, informed and guided by the principles of negotiated resilience, and explicitly including the goal of transportation insecurity eradication, is a promising and practical approach for decision makers to prioritize investments and strengthen long-term resilience in a manner that leaves no one behind.



## References

1. FHWA. Vulnerability Assessment and Adaptation Framework. Publication FHWA-HEP-18-020. FHWA, U.S. Department of Transportation, 2017.
2. National Academies of Sciences, Engineering, and Medicine (NASEM-a). (2021). Mainstreaming System Resilience Concepts into Transportation Agencies: A Guide. *The National Academies Press*, Washington, D.C., 2021.
3. National Academies of Sciences, Engineering, and Medicine (NASEM-b). (2021) Investing in Transportation Resilience: A Framework for Informed Choices. *The National Academies Press*, Washington, D.C.
4. FHWA. Bipartisan Infrastructure Law Fact Sheet. FHWA, U.S. Department of Transportation, 2022. <https://www.fhwa.dot.gov/bipartisan-infrastructure-law/protect-fact-sheet.cfm>
5. The White House. Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Program. 23 U.S.C. 176(e). <https://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title23-section176&num=0&edition=prelim>
6. Amekudzi-Kennedy, A., Singh, P., Williams, E., Cuadra, M., Ashuri, B., Woodall, B., Garrett, A., Tennakoon, M., Clark, R., & Dheeraj, A. (2023). Developing Transportation Resilience Adaptively to Climate Change. *Transportation Research Record*, 2678(4). <https://doi.org/10.1177/03611981231186989>
7. Carvalhaes, T.M., Chester, M.V., Reddy, A.T., & Allenby, B.R. (2021). An overview & synthesis of disaster resilience indices from a complexity perspective. *International Journal of Disaster Risk Reduction*, 57. <https://doi.org/10.1016/j.ijdrr.2021.102165>
8. Ziervogel, G., Pelling, M., Cartwright, A., Chu, E., Deshpande, T., Harris, L., Hyams, K., Kaunda, J., Klaus, B., & Michael, K. (2017). Inserting rights and justice into urban resilience: A focus on everyday risk. *Environment and Urbanization*, 29(1). <https://doi.org/10.1177/0956247816686905>
9. Harris, L. M., Chu, E. K., & Ziervogel, G. (2017). Negotiated resilience. *Resilience*, 6(3). <https://doi.org/10.1080/21693293.2017.1353196>
10. Fink, K., Finewood, M. H., & Molnar, L. (2019). Framing Pier 55: negotiated resilience and contested waterfronts. *Journal of Environmental Studies and Sciences*, 9. <https://doi.org/10.1007/s13412-018-0531-4>
11. Sethi, M., Sharma, R., Mohapatra, S., & Mittal, S. (2021). How to tackle complexity in urban climate resilience? Negotiating climate science, adaptation and multi-level governance in India. *PLoS One*, 16(7). <https://doi.org/10.1371/journal.pone.0253904>

12. Fitzgibbons, J., & Mitchell, C. L. (2021). Inclusive resilience: Examining a case study of equity-centered strategic planning in Toronto, Canada. *Cities*, 108. <https://doi.org/10.1016/j.cities.2020.102997>
13. Orthous Inchauste, M., Garrett, A., Amekudzi-Kennedy, A., Yarbrough, C., & Woodall, B. Enhancing Disaster Resilience and Authentic Public Partnership in Transportation: A Maturity Model for Integrating Negotiated Resilience in Disaster Preparedness. *In Review*. Submitted July 2024.
14. Meyer, M. D., & Miller, E. J. (2001). *Urban transportation planning: A decision-oriented approach*. McGraw-Hill. ISBN 0072423323.
15. FHWA. (2022). Legislation, Regulations, and Guidance. *USDOT FHWA*. Accessed July 16, 2024 from: <https://www.fhwa.dot.gov/resources/legsregs/>
16. United States Department of Transportation (USDOT). (2023). *Promising Practices for Meaningful Public Involvement in Transportation Decision-Making*. <https://www.transportation.gov/public-involvement>
17. National Academies of Sciences, Engineering, and Medicine. (2019). Measuring the Effectiveness of Public Involvement in Transportation Planning and Project Development. Washington, DC: *The National Academies Press*. <https://doi.org/10.17226/25447>.
18. Ankner, W. D. (2005). Revisiting transportation planning. *Public Works Management & Policy*, 9(4), 270-277. <https://doi.org/10.1177/1087724X05276417>
19. Schiefelbusch, M. (2005). Citizens' involvement and the representation of passenger interests in public transport: Dimensions of a long-neglected area of transport planning and policy with case studies from Germany. *Transport reviews*, 25(3). <https://doi.org/10.1080/0144164042000335904>
20. Stich, B., & Eagle, K. (2005). Planning to include the public: Transportation policy implementation with effective citizen involvement. *Public Works Management & Policy*, 9(4). <https://doi.org/10.1177/1087724X05275672>
21. Grossardt, T., & Bailey, K. (2018). Public participation in transportation planning and design: Theory, process, and practice. *Transportation planning and public participation*, 1-26. <https://doi.org/10.1016/B978-0-12-812956-2.00002-5>
22. McAndrews, C., & Marcus, J. (2015). The politics of collective public participation in transportation decision-making. *Transportation Research Part A: Policy and Practice*, 78. <https://doi.org/10.1016/j.tra.2015.06.014>
23. Karner, A., & Marcantonio, R. A. (2018). Achieving transportation equity: Meaningful public involvement to meet the needs of underserved communities. *Public Works Management & Policy*, 23(2). <https://doi.org/10.1177/1087724X17738792>
24. Innes, J. E., & Booher, D. E. (2004). Reframing public participation: strategies for the 21st century. *Planning theory & practice*, 5(4), 419-436. <https://doi.org/10.1080/1464935042000293170>

25. Townsend, R. M. (2021). 'Eligible to be heard' in transportation planning. *Journal of applied communication research*, 49(1).  
<https://doi.org/10.1080/00909882.2020.1849768>
26. Cascetta, E., & Pagliara, F. (2013). Public engagement for planning and designing transportation systems. *Procedia-Social and Behavioral Sciences*, 87.  
<https://doi.org/10.1016/j.sbspro.2013.10.597>
27. Linovski, O., & Baker, D. M. (2023). Community-Designed Participation: Lessons for Equitable Engagement in Transportation Planning. *Transportation Research Record*.  
<https://doi.org/10.1177/03611981221145131>
28. Khisty, C. J. (2000). Citizen involvement in the transportation planning process: What is and what ought to be. *Journal of Advanced Transportation*, 34(1).  
<https://doi.org/10.1002/atr.5670340107>
29. Paulk, M. C., Curtis, B., Chrissis, M. B., & Weber, C. V. (1993). Capability maturity model, version 1.1. *IEEE software*, 10(4). <https://doi.org/10.1109/52.219617>
30. Singh, P., Amekudzi-Kennedy, A., & Kassa, H. (2022). Performance Dashboard Tool to Visualize Adaptive Resilience Maturity of Transportation Agencies. *Transportation Research Record*, 2676(11).  
<https://doi.org/10.1177/03611981221092404>
31. National Research Council. 2023. Business Case and Communications Strategies for State DOT Resilience Efforts. Washington, DC: The National Academies Press.  
<https://doi.org/10.17226/27426>.
32. Jordan, S. W., Ivey, S., Levy, M., Lipinski, M., Palazolo, P., & Waldron, B. (2022). Complete streets: A new capability maturity model. *Journal of Urban Planning and Development*, 148(1). [https://doi.org/10.1061/\(ASCE\)UP.1943-5444.0000812](https://doi.org/10.1061/(ASCE)UP.1943-5444.0000812)
33. FHWA. Capability Maturity Frameworks for Transportation Systems Management and Operations (TSM&O) Program Areas. FHWA, U.S. Department of Transportation, 2016. <https://ops.fhwa.dot.gov/publications/fhwahop16031/index.htm>
34. EPA. (2021). Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts. *U.S. Environmental Protection Agency*, EPA 430-R-21-003.  
[www.epa.gov/cira/social-vulnerability-report](http://www.epa.gov/cira/social-vulnerability-report)
35. USDOT. Transportation Insecurity. U.S. Department of Transportation, 2023.  
<https://www.transportation.gov/priorities/equity/justice40/transportation-insecurity#:~:text=Transportation%20Insecurity%20is%20a%20key,regularly%2C%20reliably%2C%20and%20safely>.
36. Khisty, C.J. (1996). Operationalizing Concepts of Equity for Public Project Investments. *Transportation Research Record. The Journal of the Transportation Research Board*. Washington, D.C. <https://doi.org/10.1177/0361198196155900112>
37. Bozeman, J.F., Nobler, E., & Nock, D. (2022). A Path Toward Systemic Equity in Life Cycle Assessment and Decision-Making: Standardizing Sociodemographic Data

- Practices. *Environmental Engineering Science*, 39(9).  
<https://doi.org/10.1089/ees.2021.0375>
38. Robbennolt, D., & Witmer, A. (2023). GIS-Based Approach to Dynamic Accessibility: Incorporating a User Perspective to Recognize Social Equity Implications. *Transportation Research Record*, 2677(7).  
<https://doi.org/10.1177/03611981221150917>
39. Litman, T. (2023). Evaluating Transportation Diversity. *Victorian Transport Policy Institute*. <https://www.vtpi.org/choice.pdf>
40. National Academies of Sciences, Engineering, and Medicine. (2022). Accessibility Measures in Practice: A Guide for Transportation Agencies. Washington, DC: *The National Academies Press*. <https://doi.org/10.17226/26793>
41. Amekudzi-Kennedy, A., Woodall, B., Karner, A., Akosa, A., Franklin, H., Simao, J.L., Gudmundsson, H., & Smith-Colin, J. (2021). Value-Focused Infrastructure Development: Affecting the Development of Shared Regional Prosperity. *ASCE Journal of Urban Planning and Development*, 147(4).  
[https://doi.org/10.1061/\(ASCE\)UP.1943-5444.0000758](https://doi.org/10.1061/(ASCE)UP.1943-5444.0000758)
42. NRC. 2012. Disaster Resilience: A National Imperative. Washington, DC: *The National Academies Press*. <https://doi.org/10.17226/13457>
43. Manyena, B., Machingura, F., & O'Keefe, P. (2019). Disaster Resilience Integrated Framework for Transformation (DRIFT): A new approach to theorizing and operationalizing resilience. *World Development*, 123.  
<https://doi.org/10.1016/j.worlddev.2019.06.011>
44. UNDRR. Resilience. United Nations Office for Disaster Risk Reduction. (n.d.) Accessed July 19, 2023 from: <https://www.undrr.org/terminology/resilience>
45. IPCC. AR4 Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland, 2007.  
<https://www.ipcc.ch/report/ar4/syr/>
46. Amekudzi-Kennedy, A., Yang, Z., Singh, P., & Garrett, A. (2024). A Performance-Based Approach to Developing Capabilities for Building Specific and General Resilience to Climate Hazards in Transportation Systems. *Smart and Resilient Transportation*.  
<http://dx.doi.org/10.1108/SRT-12-2023-0017>
47. National Academies of Sciences, Engineering, and Medicine. (2021). Investing in Transportation Resilience: A Framework for Informed Choices. Washington, DC: *The National Academies Press*. <https://doi.org/10.17226/26292>
48. Espinet, X., Schweikery, A., van den Heever, N., & Chinowsky, P. (2016). Planning resilient roads for the future environment and climate change: Quantifying the vulnerability of the primary transport infrastructure system in Mexico. *Transport Policy*, 50, 78-86. <http://dx.doi.org/10.1016/j.tranpol.2016.06.003>

49. Rowan, E., Snow, C., Choate, A., Rodehorst, B., Asam, S., Hyman, R., Kafalenos, R., & Gye, A. (2014). Indicator Approach for Assessing Climate Change Vulnerability in Transportation Infrastructure. *Transportation Research Record, 2459*(1), 18-28. <https://doi.org/10.3141/2459-03>
50. Shen, S., & Shim, D. (2021). Building Capacity for Climate Adaptation: Assessing the Vulnerability of Transportation Infrastructure to Sea Level Rise for Safety Enhancement in RITI Communities. *INE/CSET21.07*. <http://hdl.handle.net/11122/12244>
51. National Academies of Sciences, Engineering, and Medicine. 2024. Critical Issues in Transportation for 2024 and Beyond. Washington, DC: *The National Academies Press*. <https://doi.org/10.17226/27432>.
52. Meerow, S., & Newell, J. P. (2019). Urban resilience for whom, what, when, where, and why? *Urban geography, 40*(3). <http://dx.doi.org/10.1080/02723638.2016.1206395>
53. Amekudzi-Kennedy, A., Ashuri, B., Clark, R., Woodall, B., Singh, R., Morano, K., Cuadra, M., Garrett, A., Tennakoon, M., & Yang, Z. (2023). Incorporation Resilience Considerations in Transportation Planning, TSMO and Asset Management. *FHWA-GA-23-2012*. <https://rosap.ntl.bts.gov/view/dot/73032>
54. Patil, P., Garrett, A., & Amekudzi-Kennedy, A. Incorporating Transportation Insecurity Considerations in Climate Vulnerability Assessments to Enhance System Resilience and Equity: Case Studies of Georgia and California. *In Review*. Submitted August 2024.
55. USDOT. Equitable Transportation Community (ETC) Explorer. *U.S. Department of Transportation, 2023*. <https://www.transportation.gov/priorities/equity/justice40/etc-explorer>
56. NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2024). <https://www.ncei.noaa.gov/access/billions/state-summary/>, DOI: [10.25921/stkw-7w73](https://doi.org/10.25921/stkw-7w73)
57. Spatial Hazard Events and Losses Database for the United States (SHELDUS). <https://cemhs.asu.edu/sheldus>
58. Argonne National Laboratory. 2023. Climate Risk and Resilience Portal (ClimRR). Accessed: [July 17, 2024]. <https://disgeoportal.egs.anl.gov/ClimRR/>
59. The White House. Executive Order on Tackling the Climate Crisis at Home and Abroad. Office of the President of the United States, January 27, 2021. <https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/>
60. The White House. Executive Order On Advancing Racial Equity and Support for Underserved Communities Through the Federal Government. Office of the President

of the United States, January 20, 2021. <https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/20/executive-order-advancing-racial-equity-and-support-for-underserved-communities-through-the-federal-government/>



## Appendix A: Technology Transfer

*An Appendix should be included in this final report to document the Technology Transfer activities conducted during the project term, accomplishments towards T2 adoption and implementation by relevant stakeholders, as well as any relevant post-project T2 plans.*

Table 8. Technology transfer activities during project term.

Event	Description	Participants
Stakeholder Meeting	The project team shared the research progress with the stakeholder and requested insight and data.	Tejas Kotak, Atlanta Regional Commission, Georgia
Stakeholder Meeting	The project team met with the stakeholders to discuss the stakeholders' project examining the resilience and sustainability of a transit project in Clayton County.	Audra Rotak and Katie Shannon, VHB, Georgia
Community Knowledge Change	A knowledge exchange workshop was held in July 2023. A total of 23 stakeholders participated. When asked what materials provided during the workshop will be used by stakeholders moving forward, practitioners reported that they'd use the Adaptation Planning Guidebook, principles of Negotiated Resilience, and MHEVRA tools presented.	Brandon North, Technology Planner, GDOT, Georgia; Emily Fish, Assistant State Maintenance Engineer – Emergency Operations, GDOT, Georgia; Tom Sills, CBMPO, Georgia; TJ Imberger, Griffin, Spalding County; Tejas Kotak, ARC, Georgia; Elizabeth Backe, Southern Georgia Regional Commission (SGRC), Georgia; James Horton, SGRC, Georgia; Bradley Bilsback, GDOT, Georgia; and others
Asset-Based Community Development Lecture in graduate-level Infrastructure Systems course (CEE 6651) at Georgia Institute of Technology	This lecture summarized Asset-Based Community Development, a concept highly related to negotiated resilience and other elements of this research. This lecture can result in future applications of this research by the students participating in the class.	10-15 Transportation Systems Engineering and City Planning graduate students
NR-CMM Research Presentation at Georgia ITE Monthly Meeting	During the research presentation portion of a Georgia section Institute of	100+ practitioners attended as well as current



	Transportation Engineers (ITE), Orthous Inchauste presented the Negotiated Resilience Capability Maturity Model and gave the audience an opportunity to open the tool on their phone (via QR code) and provide feedback.	transportation engineering students at GT
NR-CMM and Tool Presentation, Review, and Stakeholder Feedback	During this meeting, a representative from the project team presented the NR-CMM and self-assessment tool for practitioner feedback (interview format).	Emily Fish, GDOT Emergency Management, Georgia
NR-CMM and Tool Presentation, Review, and Stakeholder Feedback	During this meeting, a representative from the project team presented the NR-CMM and self-assessment tool for practitioner feedback (interview format).	Marsha Anderson Bomar, City of Atlanta, Georgia
NR-CMM and Tool Presentation, Review, and Stakeholder Feedback	During this meeting, a representative from the project team presented the NR-CMM and self-assessment tool for practitioner feedback (interview format).	Giacomo Yaquinto, TxDOT, Texas
NR-CMM and Tool Presentation, Review, and Stakeholder Feedback	During this meeting, a representative from the project team presented the NR-CMM and self-assessment tool for practitioner feedback (interview format).	Austin Wang, GDOT, Georgia
NR-CMM and Tool Presentation, Review, and Stakeholder Feedback	During this meeting, a representative from the project team presented the NR-CMM and self-assessment tool for practitioner feedback (interview format).	Kyung-Hwa Kim, Atlanta Regional Commission, Georgia

NR-CMM and Tool Presentation, Review, and Stakeholder Feedback	During this meeting, a representative from the project team presented the NR-CMM and self-assessment tool for practitioner feedback (interview format).	Elizabeth Flanagan, Kittelson & Associates, Inc.
NR-CMM and Tool Presentation, Review, and Stakeholder Feedback	During this meeting, a representative from the project team presented the NR-CMM and self-assessment tool for practitioner feedback (interview format).	Jennifer Carver, FDOT, Florida; Tony Frye, FDOT, Florida; Leo Hampton, FDOT, Florida
NR-CMM and Tool Presentation, Review, and Stakeholder Feedback	During this meeting, a representative from the project team presented the NR-CMM and self-assessment tool for practitioner feedback (interview format).	Kate Evasic, Chicago Metropolitan Agency for Planning, Illinois; Michael Fricano, West Central Municipal Conference, Illinois

Table 9. Technology transfer activities after project term.

Activity	Description	Potential Participants
<i>Enhancing Disaster Resilience and Authentic Public Partnership in Transportation: Capability Maturity Model for Integrating Negotiated Resilience Principles in Disaster Preparedness</i> paper submission; presentation	This paper has been submitted to the Transportation Research Board for presentation and publication. If accepted, this activity will provide a means to disseminate the research. TRB is a large conference with over 13,000 participants that occurs annually in Washington, D.C.	TRB conference participants; TRR journal audience
NR-CMM and Resources Website	If allowed by the project funders, the NR-CMM and associated resources will be made open-access on a website to be maintained for 3-5 years after the project end date. This will enable practitioners and researchers interested in negotiated resilience to access the resources.	Transportation practitioners (DOT, MPO, local agencies); researchers [online]
<i>Incorporating Transportation Insecurity Considerations in Climate</i>	This paper will be submitted to a relevant transportation journal following the project term.	Journal audience

<i>Vulnerability Assessments to Enhance System Resilience and Equity: Case Studies of Georgia, California and Texas</i> paper submission		
--	--	--

## **Appendix B: Negotiated Resilience Capability Maturity Model and Supplementary Resources**

This section includes the Negotiated Resilience Capability Maturity Model, the Qualtrics-based self-assessment tool (as a pdf), and the recommendations resource.



# Negotiated Resilience Capability Maturity Model

Infrastructure  
Resilience Research  
Group

Developed by:  
Maya Orthous Inchauste  
Adair Garrett

# *Negotiated Resilience Capability Maturity Model*

Please select a capability to explore further.

Strategic	Institutional	Programmatic	Tactical
<u>Stakeholder Engagement</u>	<u>Culture of Change</u>	<u>Vulnerability and Criticality Assessments</u>	<u>Stakeholder &amp; Community Data Management</u>
<u>Stakeholder Collaboration</u> <u>Monitoring and Adjustment</u>	<u>Resilience Strategy</u>	<u>Roadmapping</u>	<u>Technology &amp; Implementation Approaches</u>
<u>Stakeholder Communication - Disaster Context</u>	<u>Program Connectivity within Organization</u>		<u>Resilience Data Management</u>
<u>Community Engagement</u>	<u>Continuity and Talent Development</u>		
<u>Community Collaboration</u> <u>Monitoring and Adjustment</u>			
<u>Community Communication - Disaster Context</u>			
<u>Information Dissemination to Communities</u>			

# *4 Main Themes*

<b>Strategic</b>	Capabilities related to how an agency approaches stakeholder and community activities and engagement, in normal and disaster contexts.
<b>Institutional</b>	Capabilities related to organizational norms, ideas, and relationships that may impact an agency's ability to effectively engage the public or handle disruptions.
<b>Programmatic</b>	Capabilities related to planning activities, such as setting objectives, targets, and performance measures, or to agency programs that handle activities like resource allocation or asset monitoring.
<b>Tactical</b>	Capabilities related to data management, technology, and technical implementation approaches that may impact an agency's relationship with stakeholders or communities, in normal or disaster contexts.



# *Important Definitions*

<b>Stakeholders</b>	Individuals or groups with professional expertise or direct investment in the transportation project, whose knowledge and actions significantly impact or are impacted by transportation systems, planning, and operations. Ex: other modal agencies, state or district engineers, freight companies.
<b>Community</b>	A group of individuals who share a geographic location, common interests, or identity and whose lives are directly impacted by transportation systems and decisions, even if they lack specific professional knowledge or training in the field. Ex: neighborhood associations, environmental groups, advocacy groups, church groups.
<b>Resilience Strategies</b>	Are any investments or actions an agency can take to increase transportation system or community resilience, including adaptation.
<b>Vulnerability</b>	Is defined as the propensity or predisposition to be adversely affected by changes or disruptions (NASEM 2013).
<b>Criticality</b>	Is defined as the importance or value of an asset to users, owners, or society (NASEM 2021).

# Stakeholder Engagement

The quality of relationships and interactions with stakeholders, alongside the active involvement and integration of their feedback and collaboration into decision-making processes.

Theme	Level 1 (initial)	Level 2 (repeatable)	Level 3 (defined)	Level 4 (managed)	Level 5 (optimizing)
Strategic	No engagement and no involvement by the stakeholders.	The stakeholders receive information but lack active engagement or feedback participation. Relevant information and details are shared with the stakeholders through a single medium, but there is no opportunity for community members to reply, ask questions, or provide feedback.	The stakeholders are engaged through various mediums, with the agency actively seeking input and feedback. However, there is no guarantee that the input provided will be incorporated into decisions.	The stakeholders are engaged through various mediums, which may create the perception that the stakeholders have input. However, decisions are still made behind closed doors, and the decision-making authority primarily resides with the agency. The stakeholders do not define problems or create solutions.	The engagement is characterized by open communication, trust, and respect. The relationship fosters productive collaboration. Trade-offs across stakeholder and community groups are incorporated into decisions. The stakeholders have established a strong relationship with the agency, where stakeholders actively participate in defining problems, creating solutions, and making decisions alongside other relevant stakeholders.

# Stakeholder Collaboration Monitoring and Adjustment

The degree to which stakeholder engagement is monitored, existing measures are improved, the diversity of stakeholder involvement is assessed.

Theme	Level 1 (initial)	Level 2 (repeatable)	Level 3 (defined)	Level 4 (managed)	Level 5 (optimizing)
Strategic	Engagement with stakeholders is not monitored, and there are no efforts being made to enhance engagement. Diversity of stakeholders are never recognized or assessed.	Engagement with the stakeholders is sometimes being monitored, but there are no efforts being made to enhance engagement. Diversity of stakeholders are recognized but never assessed.	Engagement with the stakeholders is always being monitored, but there are no efforts being made to enhance engagement. Diversity of stakeholder engagement is recognized but assessment efforts are inconsistent and lack formal organization.	Engagement with the stakeholders is always being monitored, and there are sometimes efforts being made to enhance engagement. However, agencies currently lack guidelines or strategies to systematically promote diversity in engagement activities.	Engagement with the stakeholder is always being monitored and there are always efforts being made to enhance engagement. Agencies diligently assess their endeavors, setting guidelines and strategies to promote diversity in engagement activities.

[Back to the Overview NR-CMM](#)

# Stakeholder Communication - Disaster Context

The quality of relationships and interactions with stakeholders before, during, and after a disaster.

Theme	Level 1 (initial)	Level 2 (repeatable)	Level 3 (defined)	Level 4 (managed)	Level 5 (optimizing)
Strategic	During a disaster, my agency struggles to communicate with stakeholders.	Communication efforts are reactive; no formal networks of communication with stakeholders.	Communication networks are established. After disasters, stakeholders can reach out to the agency to share thoughts or feedback.	Stakeholders are invited to make decisions about how to return the system to acceptable performance levels post-disaster. The agency documents what occurs during a disaster but may not use that information to inform future practices.	Communication efforts post-disaster are monitored and evaluated. The agency uses lessons learned to inform future emergency management efforts. The agency works with stakeholders to establish new goals for the system post-emergency and to return the system to acceptable performance levels.

[Back to the Overview NR-CMM](#)

# Community Engagement

The quality of relationships and interactions with communities, alongside the active involvement and integration of their feedback and collaboration into decision-making processes.

Theme	Level 1 (initial)	Level 2 (repeatable)	Level 3 (defined)	Level 4 (managed)	Level 5 (optimizing)
Strategic	No engagement and no involvement by the community.	Relevant information and details are shared with the community through various mediums, but there is no opportunity for community members to ask questions or provide feedback. The agency sees community engagement as necessary to secure funding but does not participate in engagement beyond federal requirements. The community receives information but lacks active engagement or feedback participation.  Ex: Announcement, Newsletter, Maillist	The community is engaged through various mediums, with the agency actively seeking input and feedback. However, there is no guarantee that the input provided will be incorporated into decisions.  Ex: Public Meetings, Survey, Seeking Written Feedback	The community is engaged through various mediums, which may create the perception that the community has input. However, decisions are still made behind closed doors, and the decision-making authority primarily resides with the agency. The community receives information and provides feedback; the agency responds in order to help alleviate potential conflicts or dissatisfaction, but citizens do not define problems or create solutions.	The engagement is characterized by open communication, trust, and respect. The relationship fosters productive collaboration. Trade-offs across stakeholder and community groups are incorporated into decisions transparently. The community has established a strong relationship with the agency, where citizens actively participate in defining problems, creating solutions, and making decisions. Additionally, engagement practices encompass public education programs.  Ex: Co-creation of Projects, Co-development of Solutions

[Back to the Overview NR-CMM](#)

# Community Collaboration Monitoring and Adjustment

The degree to which community engagement is monitored, existing measures are improved, the diversity of stakeholder involvement is assessed.

Theme	Level 1 (initial)	Level 2 (repeatable)	Level 3 (defined)	Level 4 (managed)	Level 5 (optimizing)
Strategic	Engagement with community is not monitored, and there are no efforts being made to enhance engagement. Diversity in community engagement is never recognized or assessed.	Engagement with the community is sometimes being monitored, but there are no efforts being made to enhance engagement. Diversity in community engagement are recognized but never assessed.	Engagement with communities is always being monitored, but there are no efforts being made to enhance engagement. Diversity of community engagement is recognized but assessment efforts are inconsistent and lack formal organization.	Engagement with the community is always being monitored, and there are sometimes efforts being made to enhance engagement. Efforts are made to actively seek input from diverse communities. However, agencies currently lack guidelines or strategies to systematically promote diversity in engagement activities.	Engagement with the community is always being monitored and there are always efforts being made to enhance engagement. Efforts are actively made to seek input from diverse communities. Agencies diligently assess their endeavors, setting guidelines and strategies to promote diversity in engagement activities.

[Back to the Overview NR-CMM](#)

# *Community Communication - Disaster Context*

The quality of relationships and interactions with stakeholders before, during, and after a disaster.

Theme	Level 1 (initial)	Level 2 (repeatable)	Level 3 (defined)	Level 4 (managed)	Level 5 (optimizing)
Strategic	During a disaster, my agency struggles to communicate with the community.	Communication efforts are reactive; no formal networks of communication with the community.	Communication networks are established. After disasters, community members can reach out to the agency to share thoughts or feedback.	Community members are invited to make decisions about how to return the system to acceptable performance levels post-disaster. The agency documents what occurs during a disaster but may not use that information to inform future practices.	Communication efforts post-disaster are monitored and evaluated. The agency uses lessons learned to inform future emergency management efforts. The agency works with communities to establish new goals for the system post-emergency and to return the system to acceptable performance levels.

[Back to the Overview NR-CMM](#)



# Information Dissemination to Communities

The process of distributing information to communities and the established communication networks.

Theme	Level 1 (initial)	Level 2 (repeatable)	Level 3 (defined)	Level 4 (managed)	Level 5 (optimizing)
Strategic	There have been no communication efforts made or established.	Communication efforts are reactive and focused only on conflict resolution; no formal networks of communication with communities.	Communication networks are established. Basic processes for information dissemination to communities are defined and documented.	Multiple communication networks are established. Information dissemination to communities is integrated into planning.	Multiple communication networks are established and improved over time. Communication efforts with the community are continuously monitored and evaluated.

[Back to the Overview NR-CMM](#)

# Culture of Change

The success of planning approaches to be continuously refined to encourage experimentation, innovation, and hands-on learning.

Theme	Level 1 (initial)	Level 2 (repeatable)	Level 3 (defined)	Level 4 (managed)	Level 5 (optimizing)
Institutional	Rigid and static management, design, and planning practices hinder experimentation and learning. Systems are rebuilt to pre-disruption states, and institutions don't evolve.	The agency acknowledges the importance of experimentation, innovation, and hands-on learning. However, rigid and static management, design, and planning practices often impede such endeavors. Despite this recognition, systems continue to be rebuilt to revert to pre-disruption states and institutions don't evolve.	Although management, design, and planning practices undergo continuous refinement, they fail to foster experimentation, innovation, and hands-on learning. However, the agency consistently neglects to highlight the importance of institutional adaptability and resilience.	Although management, design, and planning practices undergo continuous refinement, they do not foster experimentation, innovation, or hands-on learning. Systems are mainly constructed to incorporate lessons learned from past disruptions. However, highlighting the importance of adaptability and resilience is not consistently included.	Management, design, and planning practices are continuously refined, fostering experimentation, innovation, and hands-on learning. Systems are always constructed to incorporate lessons learned from past disruptions. Cross-training is commonplace in the agency, and workforce development practices are regularly reviewed and improved as needed, fostering a culture of continuous learning and development.

[Back to the Overview NR-CMM](#)

# Resilience Strategy

The extent to which a resilience strategy's documentation has been created, covering the five Ws—who, what, when, where, and why—of resilience and integrating essential revisions.

Theme	Level 1 (initial)	Level 2 (repeatable)	Level 3 (defined)	Level 4 (managed)	Level 5 (optimizing)
Institutional	No outline of resilience strategy has been established.	The resilience strategy is abstract, lacking formalization or consistency in resilience practices.	The resilience strategy has been established but has never been updated.	The resilience strategy is adapted according to changing conditions; however, it isn't tailored to on-the-ground realities, and questions about "who," "what," "where," "when," and "why" regarding investments in resilience are never addressed.	Established resilience strategies are adjusted in response to changing conditions and tailored to on-the-ground realities. Utilizes scenario planning when making resilience investment decisions. Efforts to enhance resilience strategies consistently delve into the questions of "who," "what," "where," "when," and "why" regarding investments in resilience.

[Back to the Overview NR-CMM](#)

# Program Connectivity within Organization

The degree to which office connectivity is facilitated via clear objectives, data exchange, and impact assessments, preventing any isolation among offices.

Theme	Level 1 (initial)	Level 2 (repeatable)	Level 3 (defined)	Level 4 (managed)	Level 5 (optimizing)
Institutional	The organization's siloed offices do not collaborate to set objectives or share information.	While there is recognition of the need for connectivity within the organization and for information sharing, there is still a lack of standardized processes for connectivity. Currently, communication and data sharing occur only on a case-by-case basis, relying on individual initiative.	While the organization has communication channels for sharing information, they are rarely utilized. Furthermore, the absence of a standardized process for collaboration leads to a lack of cooperation in achieving objectives or minimizing the impact of cascading failures during periods of disruption.	The organization has communication channels for sharing information. Collaboration is considered important to the organization, but, in practice, the organization falls short on some information sharing actions.	Offices and departments are highly integrated and interconnected, facilitating collaboration on set objectives, data sharing, and impact assessments. Communication channels and collaboration processes are robust, enabling seamless information flow. The agency has integrated and standardized processes for information sharing and collaboration.

[Back to the Overview NR-CMM](#)

# Continuity and Talent Development

To what extent is the organization able to ensure a seamless transition of knowledge and skills across various levels and functions, while also developing employees' potential to meet both current and future organizational needs.

Theme	Level 1 (initial)	Level 2 (repeatable)	Level 3 (defined)	Level 4 (managed)	Level 5 (optimizing)
Institutional	No succession planning processes, mentorship, or investment in development initiatives occur.	Informal processes for knowledge transfer and succession planning have been established, with minimal investment in training and development initiatives. Informal mentorship and coaching occur sporadically.	Defined practices for succession planning include the implementation of periodic training and development initiatives, as well as the introduction of structured mentorship and coaching programs.	The organization maintains existing processes for knowledge transfer and succession planning without seeking improvement. However, systematic training and development programs are implemented, and formal mentorship and coaching programs are established with clear objectives.	A continuous improvement approach to knowledge transfer and succession planning is adopted, alongside proactive identification of high-potential employees and successors. Advanced mentorship and coaching programs are tailored to individual development plans.

[Back to the Overview NR-CMM](#)

# Vulnerability and Criticality Assessments

The extent to which vulnerability and criticality assessments are conducted, evaluated, and continuously monitored, then integrated into system design, planning, and management processes.

Theme	Level 1 (initial)	Level 2 (repeatable)	Level 3 (defined)	Level 4 (managed)	Level 5 (optimizing)
Programmatic	The agency does not track metrics related to disaster vulnerability. Additionally, the agency has never conducted these assessments.	The agency may want to conduct vulnerability and criticality assessments related to disasters; however, there is no formalized process in place.	Criticality assessments of hazard exposure and vulnerability assessments of system assets are conducted infrequently and do not impact programs or plans.	Vulnerability and criticality assessments are occasionally conducted. However, the integration of outputs across all phases of system design, planning, and management is sporadic.	Vulnerability and criticality assessments are conducted, evaluated, and monitored continuously. The outputs of these assessments are integrated across all phases of system design, planning, and management.

# Roadmapping

The extent to which emphasis is placed on long-term planning and scenario analysis and emerging uncertainties, short-term needs and potential opportunities are taken into account.

Theme	Level 1 (initial)	Level 2 (repeatable)	Level 3 (defined)	Level 4 (managed)	Level 5 (optimizing)
Programmatic	There is no formalized process for planning, resulting in decisions made reactively. Additionally, there is no documentation of goals or strategy related to resilience or engagement.	There is recognition of the need for strategic planning encompassing goals. However, there is limited documentation of agency goals or strategy, and the planning process does not adequately reflect these goals.	The planning primarily reflects short-term goals, with overall agency goals outlined; however, these goals are only occasionally reflected in the plans. The agency never participates in scenario planning.	While long-term planning is considered within short-term plans, there are no efforts to mitigate path dependencies for future plan changes incorporated into short-term strategies. The agency occasionally participates in scenario planning.	There is an intentional focus on long-term planning, considering emerging uncertainties, while also addressing short-term demands and urgencies. Efforts to reduce path dependencies for future changes in plans are incorporated into strategies. Scenario planning is integrated into operations and management practices.



# Stakeholder & Community Data Management

The degree to which data is managed, stored, shared, and protected through a standardized process to ensure both data quality and security measures are in place.

Theme	Level 1 (initial)	Level 2 (repeatable)	Level 3 (defined)	Level 4 (managed)	Level 5 (optimizing)
Tactical	Stakeholder and community data is not collected, stored, or protected.	Stakeholder and community data is collected, but not stored, protected, or managed in a consistent way.	Stakeholder and community data is rarely managed. There are no formal processes or guidelines in place, and data is managed inconsistently across the organization.	Formal stakeholder and community data management processes and guidelines are established. Roles and responsibilities for data management are defined, and basic data quality standards are implemented. However, data management practices may still be siloed within departments.	Data management practices are standardized across the organization, with clear policies, procedures, and governance structures in place. Data quality is actively monitored and maintained, and there is integration between different data systems and sources. Data security measures protect sensitive information.

[Back to the Overview NR-CMM](#)

# Technology & Implementation Approaches

The degree to which technology is utilized to improve user experience and is consistently evaluated and upgraded.

Theme	Level 1 (initial)	Level 2 (repeatable)	Level 3 (defined)	Level 4 (managed)	Level 5 (optimizing)
Tactical	No technology is utilized in community or stakeholder engagement	Technology is rarely utilized. In-person or virtual meetings are not recorded. There are no support teams or evaluation of the technology used.	Only virtual, not in-person, community meetings are recorded with permission and shared with absent participants. Virtual meetings take place on a platform accessible to all. However, no technology support teams are available.	Virtual or in-person community meetings are recorded with permission and shared with absent participants. Virtual meetings take place on a platform accessible to all, and sometimes, technology support teams are available.	All in-person and virtual community meetings are recorded with permission and shared with absent participants. Support teams facilitate virtual meetings, ensuring widespread participation. Virtual meetings take place on a platform accessible to all. Technology is utilized to enhance communication and is consistently evaluated and improved.

[Back to the Overview NR-CMM](#)

# Resilience Data Management

To what degree are resilience assessment data stored, managed, and accessible for planning purposes.

Theme	Level 1 (initial)	Level 2 (repeatable)	Level 3 (defined)	Level 4 (managed)	Level 5 (optimizing)
Tactical	Data is not collected, stored, or managed.	Data is collected, but not stored, protected, or managed in a consistent way.	Data is rarely managed. There are no formal processes or guidelines in place, and data is managed inconsistently across the organization.	Data is collected, but there are no formal processes or guidelines in place, nor is there an established data management plan. Furthermore, the data is stored in a manner that restricts access to only certain individuals.	Data management practices are standardized across the organization, with clear policies, procedures, and governance structures in place. Data quality is actively monitored and maintained. The data is managed on an accessible dashboard that can be utilized by whoever needs to access it.


[Back to the Overview NR-CMM](#)

# *Further Resources*



The Dropbox includes access to the NR-CMM, tool and the suggestions document.

<https://www.dropbox.com/scl/fo/pnpkibszsdkswf0b3gogf/APKOfFgJKGenKtS5xMpH0Ck?rlkey=q3y7hpswyycpz707qvv1j2s9u&dl=0>



# **Suggestions for Improvement in NR-CMM**

Infrastructure Resilience Research Group

Developed by:  
Maya Orthous Inchauste

# ***Negotiated Capability Maturity Model***

Press on a capability to see recommendations

<b>Strategic</b>	<b>Institutional</b>	<b>Programmatic</b>	<b>Tactical</b>
<b><u>Stakeholder Engagement</u></b>	<b><u>Culture of Change</u></b>	<b><u>Vulnerability and Criticality Assessments</u></b>	<b><u>Stakeholder &amp; Community Data Management</u></b>
<b><u>Stakeholder Collaboration Monitoring and Adjustment</u></b>	<b><u>Resilience Strategy</u></b>	<b><u>Roadmapping</u></b>	<b><u>Technology &amp; Implementation Approaches</u></b>
<b><u>Stakeholder Communication - Disaster Context</u></b>	<b><u>Program Connectivity within Organization</u></b>		<b><u>Resilience Data Management</u></b>
<b><u>Community Engagement</u></b>	<b><u>Continuity and Talent Development</u></b>		
<b><u>Community Collaboration Monitoring and Adjustment</u></b>			
<b><u>Community Communication - Disaster Context</u></b>			
<b><u>Information Dissemination to Communities</u></b>			

# Stakeholder Engagement

Document Name	Source	Link
Guidelines of Stakeholder Engagement	Michigan Department of Transportation	<a href="https://www.michigan.gov/mdot/-/media/Project/Websites/MDOT/About-Us/Policies/CSS/Guidelines-Stakeholder-Engagement.pdf?rev=ec59e528ff9b468683850586f3922844&amp;hash=A48241BDF353C6C94A00C1A853BF21F5#page=5.10">https://www.michigan.gov/mdot/-/media/Project/Websites/MDOT/About-Us/Policies/CSS/Guidelines-Stakeholder-Engagement.pdf?rev=ec59e528ff9b468683850586f3922844&amp;hash=A48241BDF353C6C94A00C1A853BF21F5#page=5.10</a>
Project Communications Handbook	California Department of Transportation	<a href="https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/pids/f0009367-project-communication-handbook-2nd-ed-a11y.pdf">https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/pids/f0009367-project-communication-handbook-2nd-ed-a11y.pdf</a>
Guidebook for Multi-Agency Collaboration for Sustainability and Resilience	National Cooperative Highway Research Program	<a href="https://onlinepubs.trb.org/Onlinepubs/nchrp/docs/NCHRP08-36Task142.pdf">https://onlinepubs.trb.org/Onlinepubs/nchrp/docs/NCHRP08-36Task142.pdf</a>
External Collaboration and Coordination	U.S Department of Transportation	<a href="https://www.tpmttools.org/wp-content/uploads/2016/09/guidebook-component-b.pdf">https://www.tpmttools.org/wp-content/uploads/2016/09/guidebook-component-b.pdf</a>
Communication and Coordination with External Stakeholders for Transit Asset Management	The North American Transportation Services Association	<a href="https://www.apta.com/wp-content/uploads/APTA-SUDS-TAM-RP-006-19.pdf#page=7.10">https://www.apta.com/wp-content/uploads/APTA-SUDS-TAM-RP-006-19.pdf#page=7.10</a>



# Stakeholder Collaboration Monitoring and Adjustment

Document Name	Source	Link
Guidelines of Stakeholder Engagement	Michigan Department of Transportation	<a href="https://www.michigan.gov/mdot/-/media/Project/Websites/MDOT/About-Us/Policies/CSS/Guidelines-Stakeholder-Engagement.pdf?rev=ec59e528ff9b468683850586f3922844&amp;hash=A48241BDF353C6C94A00C1A853BF21F5#page=5.10">https://www.michigan.gov/mdot/-/media/Project/Websites/MDOT/About-Us/Policies/CSS/Guidelines-Stakeholder-Engagement.pdf?rev=ec59e528ff9b468683850586f3922844&amp;hash=A48241BDF353C6C94A00C1A853BF21F5#page=5.10</a>
External Collaboration and Coordination	U.S Department of Transportation	<a href="https://www.tpmttools.org/wp-content/uploads/2016/09/guidebook-component-b.pdf">https://www.tpmttools.org/wp-content/uploads/2016/09/guidebook-component-b.pdf</a>
Communication and Coordination with External Stakeholders for Transit Asset Management	The North American Transportation Services Association	<a href="https://www.apta.com/wp-content/uploads/APTA-SUDS-TAM-RP-006-19.pdf#page=7.10">https://www.apta.com/wp-content/uploads/APTA-SUDS-TAM-RP-006-19.pdf#page=7.10</a>

# Stakeholder Communication

## – Disaster Context

Document Name	Source	Link
How to Communicate Effectively with Stakeholders in a Crisis	Crisis Ready Institute	<a href="https://www.linkedin.com/pulse/how-communicate-effectively-stakeholders-crisis-melissa-agnes/">https://www.linkedin.com/pulse/how-communicate-effectively-stakeholders-crisis-melissa-agnes/</a>
Emergency management coordination	The Washington State Department of Transportation	<a href="https://tsmowa.org/category/transportation-operations/emergency-management-coordination">https://tsmowa.org/category/transportation-operations/emergency-management-coordination</a>
Emergency Communication Strategies for Transit Agencies	American Public Transportation Association	<a href="https://www.apta.com/wp-content/uploads/APTA-SS-SEM-S-009-09_Rev1.pdf">https://www.apta.com/wp-content/uploads/APTA-SS-SEM-S-009-09_Rev1.pdf</a>
Lesson 3. Communicating in an Emergency	Federal Emergency Management Agency	<a href="https://training.fema.gov/emiweb/is/is242b/student%20manual/sm_03.pdf#page=2.36">https://training.fema.gov/emiweb/is/is242b/student%20manual/sm_03.pdf#page=2.36</a>

# Community Engagement

Document Name	Source	Link
Promising Practices for Meaningful Public Involvement in Transportation Decision Making	U.S Department of Transportation	<a href="https://www.transportation.gov/priorities/equity/promising-practices-meaningful-public-involvement-transportation-decision-making">https://www.transportation.gov/priorities/equity/promising-practices-meaningful-public-involvement-transportation-decision-making</a>
How to Engage People Tool	Texas A&M Transportation Institute	<a href="https://policy.tti.tamu.edu/public-engagement/how-to-engage-people/">https://policy.tti.tamu.edu/public-engagement/how-to-engage-people/</a>
Engage the Community	Transportation Efficient Communities	<a href="https://www.transportationefficient.org/engage-the-community/">https://www.transportationefficient.org/engage-the-community/</a>
Webinar: Community Engagement in Transportation	Joint Office of Energy and Transportation	<a href="https://driveelectric.gov/webinars/community-engagement">https://driveelectric.gov/webinars/community-engagement</a>
Community Engagement	Street Smart	<a href="http://www.thinkstreetsmart.org/community-engagement.html">http://www.thinkstreetsmart.org/community-engagement.html</a>
Community Engagement: Values, Techniques, and Process	Atlanta Regional Commission	<a href="https://cdn.atlantaregional.org/wp-content/uploads/arc-cep-values-techniques-process.pdf#page=4.09">https://cdn.atlantaregional.org/wp-content/uploads/arc-cep-values-techniques-process.pdf#page=4.09</a>
Community Impact Assessment	U.S. Department of Transportation Federal Highway Administration	<a href="file:///Users/mayaorthous/Downloads/dot_50870_DS1.pdf#page=51.15">file:///Users/mayaorthous/Downloads/dot_50870_DS1.pdf#page=51.15</a>
Coordinating Transportation Services: Local Collaboration and Decision-Making	Creative Action, Inc	<a href="https://factsd.org/wp-content/uploads/2012/02/Local-Collaboration-Decision-Making-pdf-for-LIBRARY-page.pdf#page=4.45">https://factsd.org/wp-content/uploads/2012/02/Local-Collaboration-Decision-Making-pdf-for-LIBRARY-page.pdf#page=4.45</a>
Inclusive Public Participation in Transit Decision-Making	National Academies of Sciences, Engineering, and Medicine	<a href="https://doi.org/10.17226/26940">https://doi.org/10.17226/26940</a>

# Community Collaboration Monitoring and Adjustment

Document Name	Source	Link
Performance Measures for Public Participation Methods	Texas A&M Transportation Institute	<a href="https://policy.tti.tamu.edu/public-engagement/performance-measures-for-public-participation-methods/">https://policy.tti.tamu.edu/public-engagement/performance-measures-for-public-participation-methods/</a>
A Communications Evaluation Guide	Asibey Consulting	<a href="https://www.luminafoundation.org/files/resources/arewethereyet.pdf#page=4.05">https://www.luminafoundation.org/files/resources/arewethereyet.pdf#page=4.05</a>
Coordinating Transportation Services: Local Collaboration and Decision-Making	Creative Action, Inc	<a href="https://factsd.org/wp-content/uploads/2012/02/Local-Collaboration-Decision-Making-pdf-for-LIBRARY-page.pdf#page=4.45">https://factsd.org/wp-content/uploads/2012/02/Local-Collaboration-Decision-Making-pdf-for-LIBRARY-page.pdf#page=4.45</a>
Promising Practices for Meaningful Public Involvement in Transportation Decision-Making	U.S Department of Transportation	<a href="https://www.transportation.gov/priorities/equity/promising-practices-meaningful-public-involvement-transportation-decision-making">https://www.transportation.gov/priorities/equity/promising-practices-meaningful-public-involvement-transportation-decision-making</a>
Measuring the Effectiveness of Public Involvement in Transportation Planning and Project Development	National Cooperative Highway Research Program	<a href="https://www.trb.org/Publications/Blurbs/179069.aspx">https://www.trb.org/Publications/Blurbs/179069.aspx</a>

# Community Communication - Disaster Context

Document Name	Source	Link
SBCC for Emergency Preparedness I-KIT	Health Communication Capacity Collaborative	<a href="https://sbccimplementationkits.org/sbcc-in-emergencies/lessons/unit-4-audience-analysis-and-segmentation/">https://sbccimplementationkits.org/sbcc-in-emergencies/lessons/unit-4-audience-analysis-and-segmentation/</a>
Lesson 3. Communicating in an Emergency	Federal Emergency Management Agency	<a href="https://training.fema.gov/emiweb/is/is242b/student%20manual/sm_03.pdf#page=2.36">https://training.fema.gov/emiweb/is/is242b/student%20manual/sm_03.pdf#page=2.36</a>
Communication during Disaster Recovery	The World Bank's Global Facility for Disaster Reduction and Recover	<a href="https://www.gfdr.org/sites/default/files/publication/Communications_Sector_Guidance_Note_0.pdf#page=3.11">https://www.gfdr.org/sites/default/files/publication/Communications_Sector_Guidance_Note_0.pdf#page=3.11</a>
Communication with Vulnerable Populations: A Transportation and Emergency Management Toolkit	National Academies of Sciences, Engineering, and Medicine.	<a href="https://doi.org/10.17226/22845">https://doi.org/10.17226/22845</a>
Best Practices in Disaster Public Communications: Evacuation Alerting and Social Media	Mineta Transportation Institute	<a href="https://transweb.sjsu.edu/research/2254-Best-Practices-Disaster-Public-Communications">https://transweb.sjsu.edu/research/2254-Best-Practices-Disaster-Public-Communications</a>

# *Information Dissemination to Communities*

<b>Document Name</b>	<b>Source</b>	<b>Link</b>
Uses of Social Media in Public Transportation	Transit Cooperative Research Program	<a href="https://transportationops.org/research/uses-social-media-public-transportation">https://transportationops.org/research/uses-social-media-public-transportation</a>
Engaging the Public Through Print and Web Outreach	U.S. Department of Transportation Federal Highway Administration	<a href="https://safety.fhwa.dot.gov/intersection/roundabouts/fhwas11025.pdf">https://safety.fhwa.dot.gov/intersection/roundabouts/fhwas11025.pdf</a>
Public Participation Guide: Printed Information	U.S. Environmental Protection Agency	<a href="https://www.epa.gov/international-cooperation/public-participation-guide-printed-information">https://www.epa.gov/international-cooperation/public-participation-guide-printed-information</a>
Chapter 5 - Dissemination of Information	Bureau of Transportation Statistics	<a href="https://www.bts.gov/archive/publications/guide_to_good_statistical_practice_in_the_transportation_field/chapter_05">https://www.bts.gov/archive/publications/guide_to_good_statistical_practice_in_the_transportation_field/chapter_05</a>
Information Dissemination Plan	Transportation Research Board	<a href="https://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_L07_IDP.pdf">https://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_L07_IDP.pdf</a>

# Culture of Change

Document Name	Source	Link
An integrated approach to behavior change	ICF	<a href="https://www.icf.com/insights/public-policy/an-integrated-approach-to-behavior-change?utm_medium=emp-social&amp;utm_source=LinkedIn&amp;utm_campaign=thehub">https://www.icf.com/insights/public-policy/an-integrated-approach-to-behavior-change?utm_medium=emp-social&amp;utm_source=LinkedIn&amp;utm_campaign=thehub</a>
14 Important Things Cross-Training Can Help An Agency Achieve	Forbes	<a href="https://www.forbes.com/sites/forbesagencycouncil/2021/07/28/14-important-things-cross-training-can-help-an-agency-achieve/?sh=756b8920cce7">https://www.forbes.com/sites/forbesagencycouncil/2021/07/28/14-important-things-cross-training-can-help-an-agency-achieve/?sh=756b8920cce7</a>
Advances In Developing A Cross-Trained Workforce	National Cooperative Highway Research Program	<a href="https://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-68A_13-01.pdf">https://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-68A_13-01.pdf</a>



# Resilience Strategy

Document Name	Source	Link
Resilience Primer for Transportation Executives	National Academies of Sciences, Engineering, and Medicine	<a href="https://nap.nationalacademies.org/catalog/26195/resilience-primer-for-transportation-executives">https://nap.nationalacademies.org/catalog/26195/resilience-primer-for-transportation-executives</a>
U.S Climate Resilience Toolkit	U.S. Climate Resilience Toolkit Website	<a href="https://toolkit.climate.gov/">https://toolkit.climate.gov/</a>
Mainstreaming System Resilience Concepts into Transportation Agencies: A Guide	National Cooperative Highway Research Program	<a href="https://nap.nationalacademies.org/read/26125/chapter/1">https://nap.nationalacademies.org/read/26125/chapter/1</a>
Investing in Transportation Resilience: A Framework for Informed Choices	National Academies of Sciences, Engineering, and Medicine	<a href="https://nap.nationalacademies.org/catalog/26292/investing-in-transportation-resilience-a-framework-for-informed-choices">https://nap.nationalacademies.org/catalog/26292/investing-in-transportation-resilience-a-framework-for-informed-choices</a>

# Program Connectivity within Organization

Document Name	Source	Link
How to Add More Human Connection to Your Teams, Your Culture, and Your Business	Harvard Business Review	<a href="https://hbr.org/sponsored/2023/03/how-to-add-more-human-connection-to-your-teams-your-culture-and-your-business">https://hbr.org/sponsored/2023/03/how-to-add-more-human-connection-to-your-teams-your-culture-and-your-business</a>
Cross-Silo Leadership	Harvard Business Review	<a href="https://hbr.org/2019/05/cross-silo-leadership">https://hbr.org/2019/05/cross-silo-leadership</a>
Breaking Down Silos in the Hybrid Workplace	BDI	<a href="https://bdiagency.com/breaking-down-silos-in-the-hybrid-workplace/">https://bdiagency.com/breaking-down-silos-in-the-hybrid-workplace/</a>
Dealing with market disruption	PWC	<a href="https://www.strategyand.pwc.com/gx/en/insights/2016/dealing-market-disruption/dealing-with-market-disruption.pdf">https://www.strategyand.pwc.com/gx/en/insights/2016/dealing-market-disruption/dealing-with-market-disruption.pdf</a>

# Continuity and Talent Development

Document Name	Source	Link
A Promising Approach for Succession Planning	U.S Department of Transportation Federal Railroad Administration	<a href="https://railroads.dot.gov/elibrary/expertise-management-promising-approach-succession-planning">https://railroads.dot.gov/elibrary/expertise-management-promising-approach-succession-planning</a>
Workforce Development and Succession Planning to Prepare the Rural Transit Industry for the Future	National Center for Transit Research	<a href="https://rosap.ntl.bts.gov/view/dot/31278">https://rosap.ntl.bts.gov/view/dot/31278</a>
Strategies to Attract and Retain a Capable Transportation Workforce	National Academies of Sciences, Engineering, and Medicine	<a href="https://doi.org/10.17226/14475">https://doi.org/10.17226/14475</a>
Sample Leadership Succession Management Process	National Academies of Sciences, Engineering, and Medicine	<a href="https://doi.org/10.17226/13324">https://doi.org/10.17226/13324</a>

# Vulnerability and Criticality Assessments

Document Name	Source	Link
Regional Resilience Toolkit	Federal Railroad Administration	<a href="https://www.epa.gov/sites/default/files/2019-07/documents/regional_resilience_toolkit.pdf">https://www.epa.gov/sites/default/files/2019-07/documents/regional_resilience_toolkit.pdf</a>
Guide to Assessing Criticality in Transportation Adaptation Planning	U.S. Department of Transportation Federal Highway Administration	<a href="https://www.fhwa.dot.gov/environment/sustainability/resilience/tools/criticality_guidance/">https://www.fhwa.dot.gov/environment/sustainability/resilience/tools/criticality_guidance/</a>
Vulnerability Assessment Scoring Tool	U.S. Department of Transportation Federal Highway Administration	<a href="https://www.fhwa.dot.gov/environment/sustainability/resilience/tools/scoring_tools_guide/">https://www.fhwa.dot.gov/environment/sustainability/resilience/tools/scoring_tools_guide/</a>
FHWA INVEST Tool – Infrastructure Resiliency Criteria	The Adaptation Clearinghouse	<a href="https://www.adaptationclearinghouse.org/resources/fhwa-invest-tool-eo-infrastructure-resiliency-criteria.html">https://www.adaptationclearinghouse.org/resources/fhwa-invest-tool-eo-infrastructure-resiliency-criteria.html</a>

# Road Mapping

Document Name	Source	Link
Climate Adaptation Planning	Federal Emergency Management Agency	<a href="https://www.fema.gov/sites/default/files/documents/fema_climate-adaptation-planning-guide_2024.pdf#page=4.10">https://www.fema.gov/sites/default/files/documents/fema_climate-adaptation-planning-guide_2024.pdf#page=4.10</a>
Scenario planning for transport practitioners.	Transportation Research Interdisciplinary Perspectives	<a href="https://doi.org/10.1016/j.trip.2021.100438">https://doi.org/10.1016/j.trip.2021.100438</a>
Scenario Planning	U.S Department of Transportation	<a href="https://www.planning.dot.gov/planning/topic_scenarioplanning.aspx">https://www.planning.dot.gov/planning/topic_scenarioplanning.aspx</a>
Supporting Performance-Based Planning and Programming through Scenario Planning	U.S. Department of Transportation Federal Highway Administration	<a href="https://www.fhwa.dot.gov/planning/scenario_and_visualization/scenario_planning/scenario_planning_guidebook/">https://www.fhwa.dot.gov/planning/scenario_and_visualization/scenario_planning/scenario_planning_guidebook/</a>
Planning Resource Library	Federal Transit Administration	<a href="https://www.transit.dot.gov/regulations-and-guidance/transportation-planning/planning-resource-library#ScenarioPlanning">https://www.transit.dot.gov/regulations-and-guidance/transportation-planning/planning-resource-library#ScenarioPlanning</a>

# Stakeholder and Community Data Management

Document Name	Source	Link
Promising Practices for Meaningful Public Involvement in Transportation Decision Making	U.S Department of Transportation	<a href="https://www.transportation.gov/priorities/equity/promising-practices-meaningful-public-involvement-transportation-decision-making">https://www.transportation.gov/priorities/equity/promising-practices-meaningful-public-involvement-transportation-decision-making</a>
Engage the Community	Transportation Efficient Communities	<a href="https://www.transportationefficient.org/engage-the-community/">https://www.transportationefficient.org/engage-the-community/</a>
Community Engagement: Values, Techniques, and Process	Atlanta Regional Commission	<a href="https://cdn.atlantaregional.org/wp-content/uploads/arc-cep-values-techniques-process.pdf#page=4.09">https://cdn.atlantaregional.org/wp-content/uploads/arc-cep-values-techniques-process.pdf#page=4.09</a>

# Technology & Implementation Approaches

Document Name	Source	Link
Promising Practices for Meaningful Public Involvement in Transportation Decision Making	U.S Department of Transportation	<a href="https://www.transportation.gov/priorities/equity/promising-practices-meaningful-public-involvement-transportation-decision-making">https://www.transportation.gov/priorities/equity/promising-practices-meaningful-public-involvement-transportation-decision-making</a>
Virtual Public Involvement (VPI)	U.S. Department of Transportation Federal Highway Administration	<a href="https://www.fhwa.dot.gov/innovation/everydaycounts/edc_6/virtual_public_involvement.cfm">https://www.fhwa.dot.gov/innovation/everydaycounts/edc_6/virtual_public_involvement.cfm</a>
Practices for Online Public Involvement	National Cooperative Highway Research Program	<a href="https://www.trb.org/Publications/Blurbs/179304.aspx">https://www.trb.org/Publications/Blurbs/179304.aspx</a>

# Resilience Data Management

Document Name	Source	Link
5 data management best practices to help you do data right	SAS	<a href="https://www.sas.com/en_us/insights/articles/data-management/5-data-management-best-practices.html">https://www.sas.com/en_us/insights/articles/data-management/5-data-management-best-practices.html</a>
What is data management?	IBM	<a href="https://www.ibm.com/topics/data-management">https://www.ibm.com/topics/data-management</a>
Data Management Best Practices	UC San Diego	<a href="https://library.ucsd.edu/research-and-collections/research-data/plan-and-manage/data-management-best-practices.html">https://library.ucsd.edu/research-and-collections/research-data/plan-and-manage/data-management-best-practices.html</a>



## *Dropbox Access*



The Dropbox includes access to the NR-CMM,  
tool and the suggestions document.

<https://www.dropbox.com/scl/fo/pnpkibszsdkswf0b3gogf/APKOFfgJKGenKtS5xMpH0Ck?rlkey=q3y7hpswyycpz707qvv1j2s9u&dl=0>

## Introduction

# Public Engagement, Resilience, and Emergency Management Rating System Assessment for Transportation Agencies

This tool is designed for U.S. transportation agencies to assess their public engagement, resilience, and emergency management practices. The results of the first application of this tool will be used to establish a baseline of existing public engagement, resilience, and emergency management efforts at the agency level across the country. This baseline information will be then used to support the development of transportation agency best practices for public engagement, resilience and emergency management.

You do not have to be your agency's public engagement, resilience, or emergency management expert to use this tool. The assessment should take no more than 15 – 20 minutes to complete. No identifiable information you input will be shared with anyone.

Video Explanation: <https://youtu.be/opAQaGObw2k>

For any questions, comments, or additional information, please contact:

Maya Orthous Inchauste (Undergraduate Research Assistant, [morthous3@gatech.edu](mailto:morthous3@gatech.edu)), Adair Garrett (PhD Student, [adairgarrett@gatech.edu](mailto:adairgarrett@gatech.edu)), or Dr. Adjo Amekudzi-Kennedy (PI, [adjo.amekudzi@ce.gatech.edu](mailto:adjo.amekudzi@ce.gatech.edu)).

## CMM Assessment

This is the longest section. It should take less than 10 minutes. There are six parts with questions asking you to rank your agency practices. The responses range from "Strongly Disagree" to "Strongly Agree". Select "N/A" if your department does not participate in community or stakeholder engagement.

For this section, consider the following definitions:

**Community:** A group of individuals who share a geographic location, common interests, or identity and whose lives are directly impacted by transportation systems and decisions, even if they lack specific professional knowledge or training in the field. Ex: neighborhood associations, environmental groups, advocacy groups, church groups.

**Stakeholders:** Individuals or groups with professional expertise or direct investment in the transportation project, whose knowledge and actions significantly impact or are impacted by transportation systems, planning, and operations. Ex: other modal agencies, state or district engineers, freight companies.

**Before** community engagement efforts, my agency:

	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	N/A
Does not participate in community engagement efforts beyond minimum requirements.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	N/A
My agency internally considers how to enhance knowledge, skills, and attitudes to achieve effective community involvement.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Actively seeks input from diverse community members.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	N/A
Sets guidelines and strategies to promote diversity in community engagement for projects.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Provides in-person and virtual options to ensure community members can engage regardless of availability or location.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Creates technological support teams to assist those who may not be familiar with communication platform interface.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**Before** stakeholder engagement efforts, my agency:

	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	N/A
Works closely with stakeholders to define problems, create solutions, and make decisions.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sets guidelines and strategies to promote diversity in stakeholder	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

engagement.

	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	N/A
Identifies and classifies stakeholders from least essential to most essential.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**During** community engagement efforts, my agency:

	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	N/A
Ensures the decision-making process is characterized by transparency.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Collects any data on the community members that attend, including demographic data or number of attendees.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
--	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------

Notifies that not all relevant community members/groups of society are involved in engagement.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
--	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------

	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	N/A
Finds that citizens actively participate in defining problems, creating solutions, and making decisions.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Creates multiple communication networks to disseminate information to community members throughout the project (i.e., website, social media, newsletters).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
--	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------

	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	N/A
Has a method of collecting, processing, storing, and protecting community data.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**During** stakeholder engagement efforts, my agency:

	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	N/A
Incorporates trade-offs across stakeholder and community groups into decisions.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Notifies that not all relevant stakeholders are involved in engagement.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Finds that stakeholders actively participate in defining problems, creating solutions, and making decisions.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Has a method of collecting, processing, storing, and protecting stakeholder data.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**After** community engagement efforts, **I think**:

	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	N/A
Results and feedback from community engagement were implemented in project plans.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	N/A
The engagement was done in a way that led to a loss of trust between partner agencies and community participants.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

There was a lack of evaluation criteria for successful community engagement.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
--	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------

	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	N/A
The community has established a strong relationship with the agency.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Evaluation criteria for successful community engagement is continuously informing future engagement efforts.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
--	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------

Community members can easily access summary documents and recordings if they were unable to participate during an event.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
--	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------

**After stakeholder engagement efforts, I think:**

	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	N/A
Results and feedback from stakeholder engagement were implemented in project plans.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	N/A
The engagement was done in a way that led to a loss of trust between partner agencies and stakeholders.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

The stakeholder engagement created a successful dialogue, making participants feel heard.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
---	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------

	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	N/A
There was a lack of evaluation criteria for successful implementation of stakeholder engagement.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

The stakeholders have established strong relationships with the agency.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
---	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------

Evaluation criteria for successful stakeholder engagement is continuously informing future engagement efforts.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
--	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------

This is the second section out of three. It should take less than 5 minutes. The responses range from "Never" to "Operationalized". For this section, consider the following definitions:

**Vulnerability** is defined as the propensity or predisposition to be adversely affected by changes or disruptions (NASEM 2013).

**Criticality** is defined as the importance or value of an asset

to users, owners, or society (NASEM 2021).

**Before** emergency preparation and planning, my agency:

	Operationalized	Frequently	Ongoing	Just Starting	Never
Performs climate vulnerability and criticality assessments.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Plans for potential failures within the current system.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Utilizes scenario planning to explore how the agency would react in various potential future scenarios.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Effectively considers the trade-offs between managing short-term demands and long-term needs.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The storage and management of resilience assessment data follow a formal standardized process.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Resilience assessment data are accessible via a dashboard that can be accessed by the intended audience.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**During** an emergency, my agency:

		Operationalized	Frequently	Ongoing	Just Starting	Never
Has various methods to communicate with impacted communities.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Works across departments within the agency to minimize cascading failures.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Has to react on the spot because there are no formalized plans in place to respond to an emergency.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Has a method to disseminate information to the stakeholders during a disaster. Methods are evaluated and improved over time.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**After** an emergency, my agency:

		Operationalized	Frequently	Ongoing	Just Starting	Never
Collaborates with impacted communities to establish new goals for the system and to return the system to acceptable performance levels.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Works with communities to learn how communication activities and other agency actions can be improved.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Uses lessons learned to inform future emergency management efforts.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

				Just Starting	Never
	Operationalized	Frequently	Ongoing		
Works with stakeholders to establish new goals for the system post-emergency and to return the system to acceptable performance levels.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

This is the last section. It should take less than 3 minutes. The responses can range from "False" to "True".

For this section, consider this definition of **resilience**: "the ability of a system, community, or society exposed to hazards to resist, absorb, accommodate, adapt to, transform, and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management" (UNDRR).

**Resilience strategies** are any investments or actions an agency can take to increase transportation system or community resilience, including adaptation.

**In general**, my agency:

	True	Somewhat True	Neither True Nor False	Somewhat False	False
States collaboration is a core component of the agency's culture and values.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	True	Somewhat True	Neither True Nor False	Somewhat False	False
Encourages continuous and reflective experimentation, innovative strategies, and learning by doing.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Does not consider resilience in planning, operations, maintenance, etc.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Encourages training and education within the agency.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Regularly develops a new definition of resilience to reflect the changing conditions and threats.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	True	Somewhat True	Neither True Nor False	Somewhat False	False
Encourages departments to incorporate climate vulnerability and criticality assessments across phases of design, planning, and management of systems.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Considers the "who," "what," "where," "when," and "why" when planning investments to enhance resilience.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ensures resilience strategies enhance the quality of life for communities (referring to on-the-ground realities discovered during community engagement).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Uses scenario planning to decide when resilience strategies should be implemented.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	True	Somewhat True	Neither True Nor False	Somewhat False	False
My agency creates metrics and targets for information dissemination.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Facilitates collaboration when defining objectives, sharing and managing data, and assessing projects.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fosters a culture of continuous learning and development.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Succession planning and knowledge transfer practices continue to improve.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Formal mentorship and coaching programs help cultivate high-potential employees and successors.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## Scores

Thank you for using the tool. The following scores are out of 5 (to be aligned with the NR-CMM). These scores are intended to help benchmark your agency's or department's practices in tandem with the NR-CMM; these scores are not stored. Please reach out to the NR-CMM team if you would like to discuss options about how store your agency's scores for performance monitoring or if you would like an individualized version of the tool.

Here are your scores:

**Strategic Theme (Stakeholder Engagement):**

Stakeholder Engagement:

Stakeholder Collaboration Monitoring and Adjustment:

Stakeholder Communication – Disaster Context:

**Strategic Theme (Community Engagement):**

Community Engagement:

Community Collaboration Monitoring & Adjustment:

Information Dissemination to Communities:

Community Communication – Disaster Context

**Institutional Theme:**

Culture of Change:

Resilience Strategy:

Program Connectivity within Organization:

Continuity and Talent Development:

**Programmatic Theme:**

Vulnerability and Criticality Assessments:

Roadmapping:

**Tactical Theme:**

Stakeholder and Community Data Management:

Technology & Implementation Approaches:

Resilience Data Management:

**Please refer to the NR-CMM document in Dropbox to learn more about what each score indicates. For example, a 3 in Resilience Data Management capability score aligns with Level 3 (*Defined*) on the table in the image below, taken from the CMM available at the link.**



## Resilience Data Management

To what degree are resilience assessment data stored, managed, and accessible for planning purposes.

Theme	Level 1 (initial)	Level 2 (repeatable)	Level 3 (defined)	Level 4 (managed)	Level 5 (optimizing)
Tactical	Data is not collected, stored, or managed.	Data is collected, but not stored, protected, or managed in a consistent way.	Data is rarely managed. There are no formal processes or guidelines in place, and data is managed inconsistently across the organization.	Data is collected, but there are no formal processes or guidelines in place, nor is there an established data management plan. Furthermore, the data is stored in a manner that restricts access to only certain individuals.	Data management practices are standardized across the organization, with clear policies, procedures, and governance structures in place. Data quality is actively monitored and maintained. The data is managed on an accessible dashboard that can be utilized by whoever needs to access it.

[Back to the Overview NR-CMM](#)

### Dropbox

**Link:** [https://www.dropbox.com/scl/fo/pnpkibszsdkswf0b3rlkey=q3y7hpswy\\_cpz707qvv1j2s9u&dl=0](https://www.dropbox.com/scl/fo/pnpkibszsdkswf0b3rlkey=q3y7hpswy_cpz707qvv1j2s9u&dl=0)

If you or your agency would like a copy of the scores and tool responses, enter an email below.

Powered by Qualtrics



**( ENTER FOR TRANSPORTATION  
EQUITY. DECISIONS & DOLLARS**

The Center for Transportation, Equity, Decisions and Dollars (CTEDD) is a USDOT University Transportation Center, leading transportation policy research that aids in decision making and improves economic development through more efficient, and cost-effective use of existing transportation systems, and offers better access to jobs and opportunities. We are leading a larger consortium of universities focused on providing outreach and research to policy makers, through innovative methods and educating future leaders of the transportation field.

**A** UNIVERSITY OF  
**TEXAS**  
ARLINGTON

**O\LPOLY**  
SAN LUIS OBISPO

**Georgia /  
Tech**  
=e

**1111**  
UNIVERSITY OF  
SOUTH FLORIDA

 **WISCONSIN**  
UNIVERSITY OF WISCONSIN-MADISON