

NCHRP Research Report 1052: Integrating Resilience Concepts and Strategies into Transportation Planning: A Guide

EXECUTIVE SUMMARY

AUTHORS

Maria A. Pena

Charles Moser

AEM Corporation

Mara Campbell

Jacobs

Alan O'Connor

AJOC Consulting Engineers

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INTRODUCTION, BACKGROUND, AND OVERVIEW OF THE GUIDE

Transportation systems are vulnerable to natural and human-caused disasters such as extreme weather, climate change, and cyberattacks. These events and trends can result in unanticipated disruptions and increasing constraints on existing infrastructure.

Given the increasing frequency of these disasters, it is critical to design new and modify existing transportation systems to be adaptive. Investing in strategic resilience planning and implementation is the first step toward mitigating the risk associated with these events.

Federal policies, such as the 2022 Infrastructure Investment and Jobs Act (IIJA), the Fixing America's Surface Transportation (FAST) Act (2015), and Federal Highway Administration (FHWA) Order 5520 *Transportation System Preparedness and Resilience to Climate Change and Extreme Weather Events* (2014), have emphasized preparedness and resilience to climate change, extreme weather, and other disasters.

As part of the transportation planning process, state departments of transportation (DOT) and metropolitan planning organizations (MPO) consider many factors, including users (e.g., equity), demand (e.g., increased population), different modes of transportation (e.g., buses, bikes, trains), infrastructure (e.g., roadways, bridges), and technology (e.g., electric vehicles). Resilience has become another factor to consider at all stages of the planning process. Following are some of the ways that transportation agencies integrate resilience into planning:

- Measuring and monitoring the performance measures mandated by MAP-21 and the FAST Act.
- Conducting vulnerability assessments for assets that may be impacted by climate change.
- Performing economic analysis to compare adaptation options.
- Revising design guidance based on climate change projections.

While state DOTs and MPOs have made considerable progress in incorporating resilience concepts into transportation planning processes and policies, there is a need for new methodologies, tools, data, metrics, frameworks, and funding to support these efforts. Consequently, NCHRP 08-129 developed a

Key Definitions

Risk

"...the potential losses associated with a hazard and defined in terms of expected probability and frequency, exposure, and consequences" (FEMA, 1997)

Transportation Resilience

"Resilience is the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions." (FHWA Order 5520)

Transportation Planning

"A continuing, comprehensive, and collaborative process to encourage and promote the development of a multimodal transportation system to ensure safe and efficient movement of people and goods while balancing environmental and community needs..." (FHWA Glossary).

guide to help agencies integrate resilience concepts into all levels of transportation planning. The guide includes the following components:

- Lessons learned and associated gaps in agency resilience practices
- “Key building blocks” for success
- Capability maturity framework (CMF) to identify areas of improvement
- Roadmap to a resilience-focused agency
- Recommended actions for advancing a resilience program

LESSONS LEARNED AND ASSOCIATED GAPS IN AGENCY RESILIENCE PRACTICES

The research team conducted a series of research activities to lay the foundation for the guide. These activities included a state-of-practice review, workshops with state and regional transportation agencies and other public and private stakeholders, and case studies. The case studies included eleven “quick scan” studies and four “deep-dive” studies. Eight state DOTs (Arizona, Colorado, Florida, Georgia, Maryland, Minnesota, Oregon, and Vermont), one MPO (Texas Capital Area Metropolitan Planning Organization), one transit agency (Bay Area Transit Authority (BART)), and one international transportation agency (The Danish Road Directorate) participated in the quick scan case studies. Four of the state DOTs – Arizona, Colorado, Florida, and Minnesota – participated in the deep-dive case studies.

From these efforts, the team identified the areas where agencies experienced the most significant challenges, needs, and successes when incorporating resilience within their agency practices, particularly within transportation planning. These areas formed the basis for the “key building blocks,” which subsequently drove the development of the various components of the guide. Lessons learned from DOTs, and subsequently identified gaps, are summarized below.

Key Lessons

- Definitions of risk and resilience used by transportation agencies can impact the prioritization of investments.
- Many states cite MAP-21 and the FAST-Act as key drivers for incorporating resilience.
- Leadership and champions are a must. Some DOTs have their own resilience working groups or programs.
- Communication and collaboration, internal and external, are essential to breaking down silos.
- DOTs rely heavily on GIS for risk and resilience assessment. Some DOTs have developed their own tools and dashboards.
- Many DOTs have adopted the FHWA Vulnerability Assessment and Adaptability Framework to guide resilience assessments.

Key Gaps

- **Definitions of risk and resilience** – Many states do not have a formal definition of resilience.
- **Integration with planning** – Incorporating resilience into planning rarely extends beyond the Transportation Asset Management Plan (TAMP) and the Long Range Transportation Plan (LRTP).
- **Measurement and quantification of resilience** – Standard ways to measure and assess resilience are needed for decision-makers.
- **Tools** – To facilitate risk and resilience assessments, DOTs need tools that are easy to use.
- **Data for resilience assessments** – FEMA flood maps provide incomplete coverage. DOTs need climate data that is easily accessible.
- **Finance** – Few DOTs have dedicated funding for resilience efforts.

KEY BUILDING BLOCKS FOR SUCCESS

Based on the state of practice review and the gap analysis, the guide presents six “key building blocks” for agencies to focus on when developing a resilience-oriented action plan. These building blocks are illustrated in Figure 1.

Leadership & Agency Structure

Leadership and agency structure include the organizational structure of an institution and the level of support and endorsement provided by leadership for an initiative. Agency structure determines how the roles, power, and responsibilities are assigned, controlled, and coordinated and how information flows between the different levels of management. Leadership is the art of motivating staff toward achieving a common goal, directing the entire agency toward strategies that help the agency achieve its broader goals. Agency leadership can help support and make progress toward integrating resilience strategies within transportation planning and encourage modification of the organizational structure and policies to facilitate these efforts. The needs and goals of individual departments and functions can be incorporated into agency strategy to create a resilience understanding and culture.

Capacity & Competency

Transportation agencies need to have the right level of capacity and competency to effectively integrate resilient strategies within transportation planning efforts. Capacity and competency include the people managing the resilience effort within the organization as well as the people working hands-on to integrate resilience strategies at all levels of transportation planning. It is fundamental that employees have the skills and training needed to understand and support their resilience roles. Agency leadership needs to show strong support for resilience efforts and in motivating staff to participate. In addition, expectations and incentives for employees and groups to consider resilience can be tied to individual and group performance. Staffing needs should be regularly evaluated to ensure that new roles are created and that existing roles are modified as needed to support evolving requirements within resilient strategies/practices, and mitigation techniques.

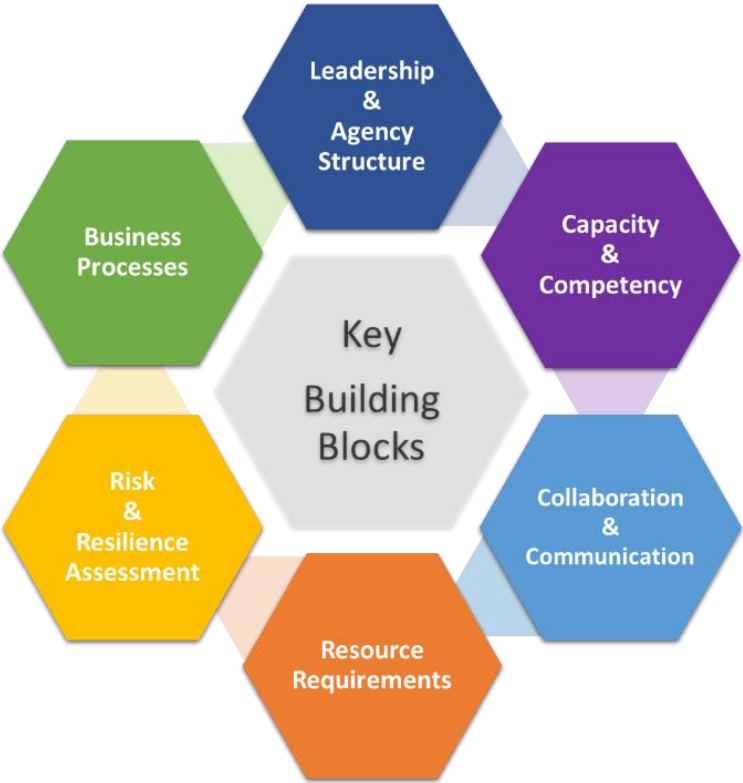


Figure 1. Key Building Blocks



Communication and Collaboration

Internal communication and collaboration enable DOTs to overcome challenges extending beyond the means of any single agency or department. Furthermore, external communication enables DOTs to extract the greatest possible benefit through the combined efforts of stakeholders and partners. In any case, communication and collaboration are most beneficial when there are mutual interests and goals, which foster consensus and a unity of effort.



Resource Requirements

Providing adequate, appropriate, and timely resources is vital to the successful incorporation of resilience into transportation planning. Often, familiar challenges exist around the collection or provision of reliable data and its management via information and communication technology (ICT) systems, flexible programming, provision/development of appropriate analysis tools, funding, and staffing. To facilitate the incorporation of resilience into planning activities it is vital that appropriate data sources, computing facilities, funding, and human resources are made available in an appropriate and timely manner. Here there is room for considerable innovation to be applied to maximize the potential of available resources. Furthermore, the provision of necessary and appropriate resources to facilitate professional training and development of staff, both current and future, is a vital component in developing expertise and champions for resilience-related efforts and activities.



Risk and Resilience (RnR) Assessment

Risk and Resilience (RnR) assessments are a key building block for incorporating resilience into transportation planning. RnR assessments are a critical responsibility of and for DOTs. Agencies conduct RnR assessments using different approaches and at different levels, with some employing the analysis at a project level but not necessarily in detailed planning activities. As a basic criterion, the scope and boundaries of the analysis should be identified and clearly defined. The outputs of the analysis can facilitate prioritization activities to be identified. To perform RnR analyses it is necessary to understand asset and corridor vulnerabilities and to consider criticality in the face of relevant hazards and threats.

Agencies may perform qualitative assessments, quantitative assessments, or some combination of the two depending on the objective of the analysis, the scale considered, and the available information. Qualitative methods are typically more suited to the assessment of a network or system rather than the assessment of individual elements. They can be employed to provide general information, identify high-level results, and facilitate comparative analysis. Quantitative tools can be beneficial as they provide an objective measure such that infrastructure components or networks may be analyzed in greater detail; however, this is commensurate with the level of effort required in the analysis. Quantitative analyses also have the advantage of allowing for the quantification and treatment of uncertainties in an appropriate context. Thereby their influence on the results of the analysis can be studied in detail and, where appropriate, reduced via the collection of additional information.

Key to both methodologies is the definition of appropriate thresholds against which the outputs of the analysis may be compared. In this way, a range of actions and interventions can be considered and prioritized from alternative perspectives (e.g., benefit-cost analysis). A significant benefit of quantitative assessments is the ability to rank alternative strategies in an objective sense.



Business Process

A business process is a series of steps performed by a team or individuals within a transportation agency, with each step in the process denoting a task established to achieve a tangible result or outcome. An established business process or processes within transportation planning can stipulate standardized ways of integrating resilience, particularly as a component of the various agency plans (e.g., LRTP, mid-range plans, Highway Safety Improvement Program (HSIP), Statewide Transportation Improvement Program (STIP), freight plans). Business processes for resilience activities need to be clearly defined, understood, and structured. Actions for incorporating resilience associated with the key building blocks are presented in the guide.

ROADMAP TO A RESILIENCE-FOCUSED AGENCY

The guide provides a roadmap consisting of six steps that transportation agencies can take to advance their resilience efforts in planning (

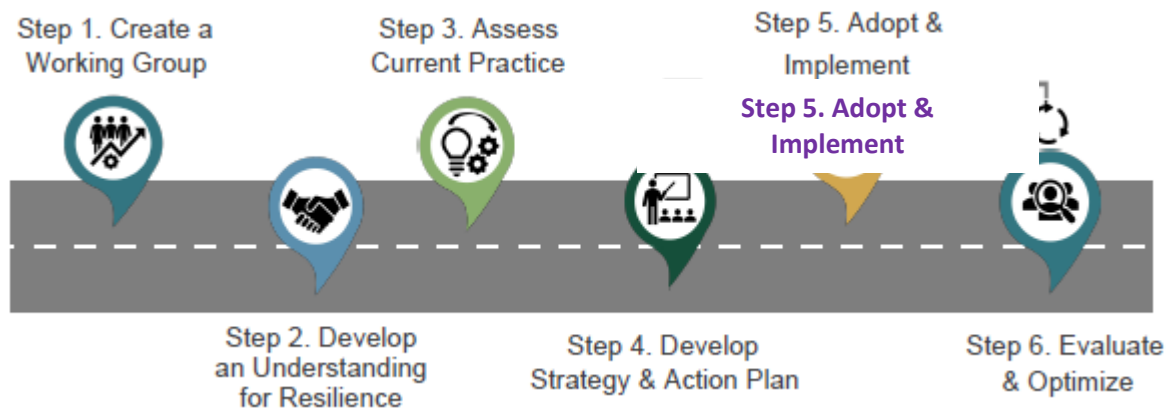


Figure 2). Whether an agency is just beginning to incorporate resiliency or has made considerable progress in incorporating resilience approaches and initiatives, following the roadmap can help ensure that agencies continue to head in the right direction.

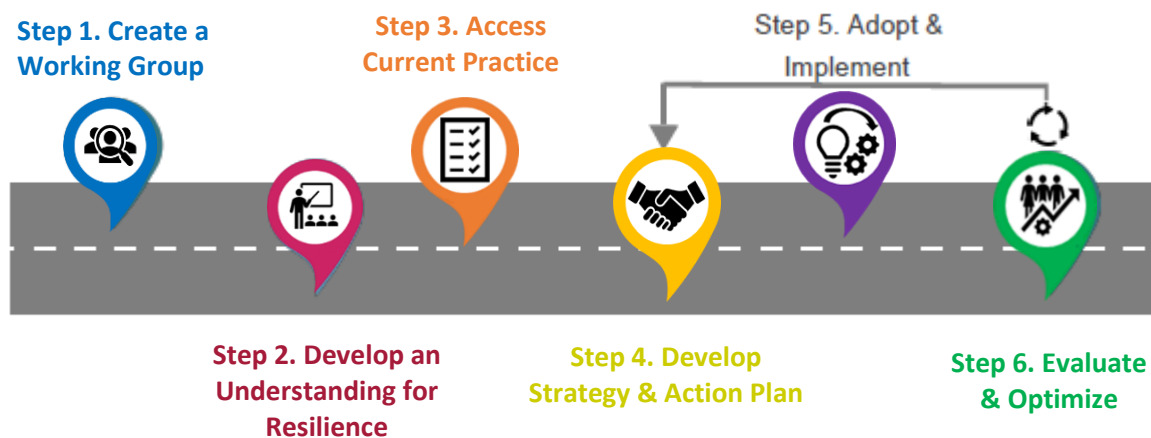


Figure 2. Roadmap for a Resilience-Focused Agency

Roadmap Steps



Step 1. Create a Working Group | The first step on the roadmap involves the identification of champions and key staff from different areas of the agency involved in transportation planning to create a working group. The working group will lead the process of incorporating resilience concepts and strategies into agency culture and activities, specifically into transportation planning. Some essential steps to consider for the working group are as follows:

- Define goals
- Identify a leader
- Recruit team members
- Establish a meeting schedule
- Establish milestones
- Establish external communications



Step 2. Develop an Understanding of Resilience | Step 2 on the roadmap involves the adoption or development of training material by agency champions and the working group to provide general knowledge and understanding of resilience to planning staff. Training material can be developed using the information provided in the guide and from a variety of outside resources referenced at the end of Step 1. Training material used by peer agencies could also be adopted. Some of the key topics to be included in the training include:

- Risk and resilience definitions
- Understanding the difference between risk and resilience
- Detailing existing methodologies to estimate risk and resilience
- Implementation of risk and resilience analysis within different areas of the organization, including transportation planning
- Benefits of the implementation of risk and resilience decision-based strategies



Step 3. Assess Current Practice | Step 3 on the roadmap involves assessing the agency's capability maturity using the CMF provided in the guide. Maturity frameworks focus on general process development and institutional environments and help to assess/measure the degree of formality and the optimization of processes for an organization, from ad hoc practices to formally defined and followed processes. Applying a CMF offers opportunities for process improvement in the different areas the framework is applied. Maturity frameworks have been used successfully in multiple sectors, including transportation. The CMF provided in this guide is based on the more general framework provided in NCHRP Project 20-117, "Deploying Transportation Resilience Practices in State DOTs" and is focused more specifically on resilience in transportation planning. This CMF can help agencies identify their capability maturity for each of the six key building blocks for incorporating resilience into transportation planning.



Step 4. Develop a Resilience Action Plan | After the agency evaluates its resilience capability maturity the next step is to identify the areas where improvements can be made. Thus, Step 4 involves the development of an action plan to increase the agency's capabilities within each of the six key building blocks. Based on the state of practice review, agency interviews, and webinars designed to obtain feedback from industry stakeholders, the research team developed and validated 27 recommended actions to assist agencies in

their journey toward establishing/advancing a resilience program. Agencies can select the actions that are most appropriate based on specific agency requirements, needs, and resources. Many of the actions will help agencies to increase their capability maturity in more than one area (key building block). Agencies have the flexibility to select and prioritize the specific actions that will build their action plan. It is important to highlight that not all actions need to be implemented and implementation will depend on where an agency wants to be at the time.



Step 5. Adopt and Implement | In Step 5, the agency will adopt and implement the action plan developed in Step 4. The agency will identify the key components and resources to support implementation including people, resources, structure, systems, and culture. These components should be in place to move the action plan into practice. In addition, it is critical to specifically outline the necessary tasks that should be completed within the action plan and to create some type of accountability (e.g., through performance measures) to ensure progress is made.



Step 6. Evaluate and Optimize | In Step 6, the agency continuously evaluates and optimizes the resilience action plan. As part of the monitoring process, it is important to evaluate if each strategy from the action plan has been implemented and if the expected outcome has been achieved. The action plan should be updated based on successes and setbacks.

CAPABILITY MATURITY FRAMEWORK TO IDENTIFY AREAS FOR IMPROVEMENT

Step 3 of the roadmap calls for agencies to conduct a self-assessment. The guide provides a CMF to assist agencies in assessing their capabilities and level of maturity for incorporating resilience into transportation planning. The CMF contains six steps (from 0 / “predefining” to 5 / “optimizing”) and is shown in **Error! Reference source not found.** Regardless of where an agency is, the CMF can help agencies to baseline, measure, and advance their capability maturity. It is also important to highlight

that different agencies may have different goals or needs, and it is not necessary that all agencies achieve the highest level of maturity on any or all the key building blocks.

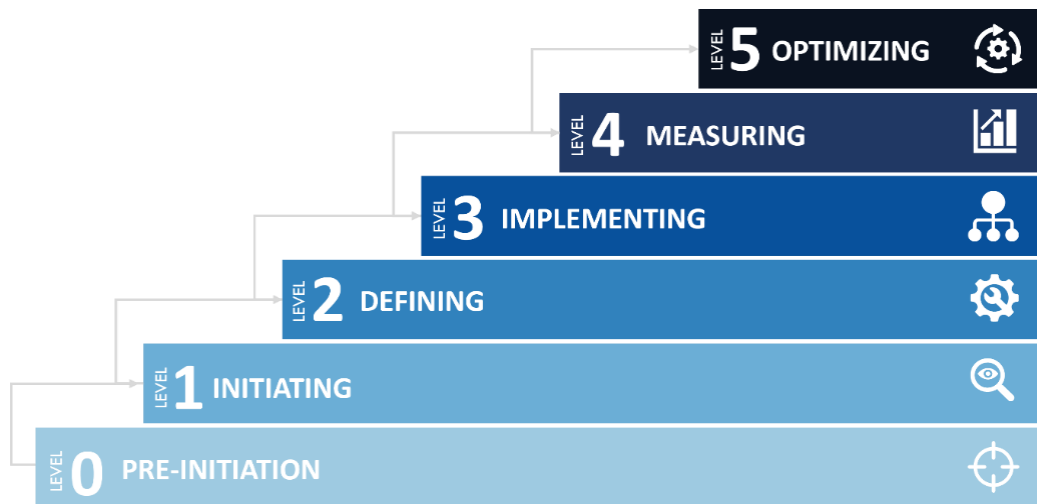


Figure 3. Capability Maturity Framework

Following is a description of the maturity levels (0 – 5):

- **Level 0 - Pre-Initiation** | Incorporation of resilience initiatives and strategies into transportation planning has not been initiated.
- **Level 1 - Initiating** | Need or desire for incorporating resilience initiatives and strategies into transportation planning has been identified. Agency structure and approaches for resilience are being determined.
- **Level 2 - Defining** | Incorporation of resilience concepts and strategies into transportation planning is being planned, performed, and documented. Internal and external collaboration is being established. Metrics are being identified. An action plan is being developed. Initial small-scale incorporation of resilience strategies is being initiated. There is still a need for process improvement.
- **Level 3 - Implementing** | Resilience strategies in transportation planning are being implemented and are becoming systematic. The agency’s resilience initiatives are more proactive than reactive and are being incorporated into different areas. Guidance for the implementation of resilience processes across projects, programs, and portfolios is set. The agency understands the challenges, how to address them, and the goals for improvement.
- **Level 4 - Measuring** | Resilience strategies are being incorporated into multiple transportation plans and programs. Resilience processes are well-documented, measured, and effective. The agency uses quantitative data to determine agency and stakeholder needs and is ahead of risks based on data-driven performance.
- **Level 5 - Optimizing** | Resilience strategies are fully incorporated throughout the agency and are highly effective. The agency demonstrates a commitment to monitoring the performance of resilience processes and actions and facilitates constant improvement in response to new opportunities.

RECOMMENDED ACTIONS FOR ADVANCING A RESILIENCE PROGRAM

Step 4 of the roadmap calls for agencies to develop an action plan. The guide provides a list of actions (shown in Table 1) for transportation agencies to consider when developing action plans for advancing their resilience programs. These actions will help agencies raise the level of maturity within different areas of focus (key building blocks). Table 1 lists 27 recommended actions. The colors for each column correlate with one of the six building blocks.

Each action is discussed in detail along with examples of implementation and in some cases, links to additional resources. Many of the actions will help to improve the capability maturity within more than one key building block. Moreover, the CMF can be used to assess the success of the action plan, creating a feedback loop, steps four through six of the roadmap.

Table 1. Recommended Actions for Incorporating Resilience into Transportation Planning

RECOMMENDED ACTIONS		ASSOCIATED KEY BUILDING BLOCKS					
1	Develop / adopt definition of resilience	✓	✓	✓	✓	✓	✓
2	Promote importance of resilience	✓	✓	✓	✓	✓	✓
3	Develop policies to integrate resilience efforts into planning	✓		✓			✓
4	Incorporate resilience into vision, goals, and objectives	✓		✓			✓
5	Identify and assign champions to lead resilience efforts	✓	✓	✓	✓		✓
6	Encourage collaboration on resilience initiatives across agency silos	✓		✓			✓
7	Establish collaboration / communication with stakeholders and external agencies to further resilience efforts in planning	✓		✓			✓
8	Create an agency resilience program and / or committee	✓		✓	✓		✓
9	Participate in training to increase staff competencies		✓	✓	✓	✓	
10	Develop an effective knowledge management (KM) program to preserve and disseminate institutional knowledge		✓	✓	✓		✓
11	Identify and secure funding to support resilience projects / efforts				✓	✓	
12	Develop and implement a centralized RnR data acquisition and management system				✓	✓	✓
13	Develop/adopt RnR performance measures					✓	✓
14	Establish a framework for RnR assessments and management				✓	✓	✓
15	Select/develop RnR assessment methodologies and tools tailored to the agency's needs and capability				✓	✓	
16	Characterize threats and hazards to identify potential problem areas					✓	
17	Conduct vulnerability assessments to identify susceptible assets / areas					✓	
18	Conduct qualitative local / regional / state RnR assessments					✓	
19	Conduct scenario planning to advance transportation system resilience					✓	
20	Conduct quantitative local / regional / state RnR assessments					✓	
21	Identify critical assets or corridors for incorporating resilience alternatives						
22	Incorporate RnR assessments into project prioritization	✓				✓	✓
23	Identify and select resilience improvement alternatives for priority projects	✓				✓	✓
24	Develop plans and programs that incorporate resilience initiatives	✓	✓	✓		✓	✓
25	Incorporate resilience in project development			✓	✓	✓	✓
26	Periodically monitor, review and report on the performance of RnR strategies	✓		✓		✓	✓
27	Develop a business case and communication plan for resilience	✓		✓	✓	✓	✓