A Pathway to Infrastructure Resilience

Advisory Paper 1: Opportunities for systemic change

Contents

Executive Summary

The challenge we face

The events of recent years (global pandemic, bushfires, droughts, floods, other extreme weather events and cyber threats) have again highlighted Australia's vulnerability to natural and non-natural threats and their social, environmental and economic impacts.

By 2050, the annual economic cost of natural disasters in Australia is expected to more than double – from an average of $18 billion per year to more than $39 billion per year. In New South Wales, the expected total economic costs of natural disasters are projected to increase from $5.1 billion in 2020-21 to between $15.8 billion and $17.2 billion (real 2019-20 dollars) per year by 2061[1].

Increasing frequency and severity of shocks and stresses – in part due to the effects of climate change – will test our collective capacity to cope as their cumulative impact becomes more likely to exceed our limits.

The aim of this collaborative research project is to build expertise, momentum for change and set a strategic direction for how we plan infrastructure to respond to natural and non-natural threats.

A whole-of-system approach to infrastructure resilience starts with infrastructure planning

The infrastructure planning phase offers the most significant opportunity to plan for and achieve resilience. The decisions made at this stage establish the trajectory for the remaining phases of the infrastructure lifecycle. It is the stage when key decisions like location, design and management of assets are made, and interdependencies between assets are identified. There are also opportunities to build shared responsibility for outcomes between all stakeholders, including governments, infrastructure asset owners and operators, the community, Aboriginal and Torres Strait Islander people, and emergency services.

A collaboration between Infrastructure Australia and Infrastructure NSW

Recognising the increasingly complex role infrastructure now plays in supporting resilience, Infrastructure Australia and Infrastructure NSW partnered on the research project, *Pathway to Infrastructure Resilience*, to identify opportunities to improve how infrastructure is planned to increase resilience.

We collaborated with 600 experts from across Australia from government, industry, peak bodies, academia and civil society organisations.

From our *Pathway to Infrastructure Resilience* research project, we have delivered two papers:

- *Advisory Paper 1: Opportunities for systemic change* – identifies 10 directions for transformational and systemic change in infrastructure planning to achieve infrastructure for resilience.

- *Advisory Paper 2: Guidance for asset owners and operators in the short term* - identifies a series short-term actions for asset owners and operators as the first steps towards this change.

This paper, *Advisory Paper 1: Opportunities for systemic change*, is informed by the findings of The Royal Commission into National Natural Disaster Arrangements Report and the independent NSW Bushfire Inquiry. Its conclusions distil the knowledge and expertise of all those involved in the research project. This paper provides a vision, as well as evidence and guidance to inform and support infrastructure owners and operators to implement the actions outlined in *Advisory Paper 2: Guidance for asset owners and operators in the short term.*

A systems-based approach

Our vision is that future Australian communities be able to anticipate, resist, absorb, recover, transform and thrive in response to shocks and stresses, to realise positive economic, social and environmental outcomes.

A major finding of this research is that **achieving resilience requires a shift in focus from the resilience of assets themselves, to the contribution of assets to the resilience of the system** – what we call *infrastructure for resilience*. This approach requires consideration not only of how to strengthen the asset, network and sector, but also how to strengthen the place, precinct, city, and region that the infrastructure operates within. It requires considering the role of each asset within the broader network and/or system and a shift from individual to shared responsibility.

Taking a system view requires defining the outcomes and actions needed across all system levels, which are:

- Governance and Coordination

- Place

- Assets

- Community.

This paper outlines 10 directions for systemic change in infrastructure planning, across the four system levels.

Opportunities at the **Governance and Coordination** level

Governance and coordination mechanisms play a foundational role in enabling infrastructure for resilience. There is opportunity to improve alignment, coordination and accountability across infrastructure planning, emergency management, community resilience and land use planning. There is also opportunity to better utilise common future scenarios in planning to enable systems thinking and manage uncertainty.

We have identified three key directions at the governance and coordination level:

1. Improve strategic alignment of resilience governance

2. Manage uncertainty through scenario planning

3. Improve data collection and sharing for informed planning, action and decision-making.

Opportunities at the **Place** level

Taking a place-based approach creates a link between assets and networks of assets, local, context specific characteristics, and the ultimate beneficiaries of infrastructure services: the community. Place-based planning enables consideration of multiple issues at once, and a method for accounting for competing demands and the cumulative impacts of decisions.

Strategic land-use planning, if better informed by place-based risks, also presents an opportunity to deliver resilience outcomes.

We have identified two key directions at the place level:

4. Adopt place-based approaches for resilience

5. Embed resilience into land use planning and development decisions.

Opportunities at the **Asset** level

No infrastructure asset exists in isolation. Failure of a single asset can amplify impacts for people, economies and the natural environment and increase the risk of cascading, systemic failures. There is opportunity to improve infrastructure investment decision-making by developing agreed methodologies and guidance on how to better value resilience through the infrastructure lifecycle. There is also an opportunity to improve information gathering on interdependencies between assets and information sharing between sectors. There are also opportunities to value natural assets that provide important functions for building resilience.

We have identified three key directions at the asset level:

6. Improve infrastructure investment decision-making

7. Collect and share information on asset and network vulnerability

8. Value blue and green infrastructure.

Opportunities at the **Community** level

To ensure system thinking and decision-making is effective, communities need to be engaged early and throughout the project lifecycle. This leads to better prepared communities and an improved social licence for infrastructure, but also ensures that all stakeholders learn from the community's knowledge of their 'place' and gain an understanding of how things work 'on the ground'. Importantly, embedding Aboriginal and Torres Strait Islander cultural knowledge in infrastructure and land-use planning is an opportunity to gain lessons on caring for Country in a sustainable way.

We have identified two key directions at the community level:

9. Build trust through more inclusive decision-making

10. Embed traditional ecological knowledge in decision-making.

Next steps

To achieve *infrastructure for resilience*, all stakeholders need to work more collaboratively. Organisations will need to build organisational resilience, develop personnel capabilities, and promote a learning culture. Communities will need support to foster meaningful participation and build their own resilience.

We acknowledge that achieving the level of collaboration we need to achieve *infrastructure for resilience* will be challenging and that a shared vision supported by trusted guidance and resources will be critical. **We encourage all levels of government, communities, industry and academia to build on and make use of this research.**

1   Introduction

1.1   The current situation

Throughout 2019, 2020 and into 2021, extreme bushfires, droughts, floods and the COVID-19 pandemic, as well as increasingly intensive cyber-attacks, have had a significant social, economic and environmental impact. This has focused attention on our resilience (across communities, assets and systems) to shocks and stresses.

Australia has environmental, social and physical features that expose it to a broad range of potential shocks. Some of these are highlighted in **Appendix A** and further described in this report. Alongside these shocks, the ongoing and compounding impact of a range of chronic stresses (such as inequality and reduced social cohesion) are constantly at play across our community.

Box 1: Defining shocks and stresses

Shocks are sudden, sharp events that have the potential to disrupt the services supplied via infrastructure.

Stresses are longer-term, chronic conditions that impact physical assets, organisations or communities. Stresses also include the increasing interdependencies between critical infrastructure that can exacerbate the impact of shock events.

Examples of various shocks and stresses include:

Shocks	Stresses
• Disease pandemic • Cyber attack • Bushfires • Extreme weather (including extreme heat, storm events, flooding) • Water crisis • Financial institution failure	• Aged infrastructure • Social cohesion and inclusion • Climate change • Drought • Housing affordability • Species extinction

Source: Shocks and stresses drawn from several sources including the Resilient Sydney Strategy, UN Habitat and the World Bank.

These shocks and stresses can result in loss of life, economic impacts, environmental impacts and harm to communities, including psychological distress. Our collective capacity to cope will be tested as the likelihood of severe events increases and the cumulative shocks and stresses become more likely to exceed our limits.

1.2   Infrastructure has a role to play

Disruptions to services that rely on infrastructure can result in loss of life and incur significant economic hardship. This is because infrastructure protects, provides for and connects the community and the environment. It enables delivery of essential services (such as food, water, energy, transport, telecommunications and health care) and ecosystem services (such as air quality, microclimate and water quality). Infrastructure therefore needs to be planned, delivered and operated in a way that supports continuity of service delivery and supports the community to respond, adapt, recover and thrive in the face of shocks and stresses.

The infrastructure planning phase offers the most significant opportunity to plan for and achieve resilience. The decisions made at this stage establish the trajectory for the rest of the infrastructure lifecycle.

It is the stage when important decisions like location, design and management of asset interdependencies are made, beyond the resilience of the infrastructure asset itself. It is also when shared responsibility for outcomes can be built between government and community.

The planning phase is where whole-of-system and whole-of-place outcomes can be assessed, and where build and non-build options can be considered equally, to find the most beneficial solution.

Ensuring that resilience is considered at these early stages will help achieve the vision outlined in **Section 1.5**. Without changes to how we plan infrastructure, the benefits we receive from existing and future investment in infrastructure will diminish in the face of increasing shocks and stresses.

1.3   The purpose of this research project

Recognising the increasingly complex role infrastructure plays in supporting resilience, Infrastructure Australia and Infrastructure NSW partnered in a cross-government and cross-sectoral collaboration to identify new pathways to increase resilience of infrastructure. This culminated in the *Pathway to Infrastructure Resilience* research project and the release of this paper.

This work aligns with our respective functions and legislative obligations as infrastructure advisory bodies with broad remit across all infrastructure sectors. The functions and legislative obligations of Infrastructure Australia and Infrastructure NSW can be found in the *Infrastructure Australia Act 2008*[6] and *Infrastructure NSW Act 2011.*[7]

Infrastructure Australia's core functions include providing advice on infrastructure policy, including climate change. Similarly, Infrastructure NSW was established with the legislative purpose of securing the efficient, effective, co-ordinated and whole-of-lifecycle asset management of infrastructure that is required for the economic and social wellbeing of the New South Wales community. It also seeks to ensure that decisions about infrastructure projects are informed by expert professional analysis and advice.

The aim of this collaborative research project is to build expertise, momentum for change and set a strategic direction for how we plan infrastructure to respond to natural and non-natural threats.

From our *Pathway to Infrastructure Resilience* research project, we have delivered two papers:

- *Advisory Paper 1: Opportunities for systemic change* – identifies 10 directions for transformational and systemic change in infrastructure planning to achieve infrastructure for resilience.

- *Advisory Paper 2: Guidance for asset owners and operators in the short term*- identifies a series of short-term actions for asset owners and operators as the first steps towards this change.

Paper 1 (this paper) provides the findings of the Pathway to Infrastructure Resilience research project to assist infrastructure owners and operators to implement the actions outlined in Paper 2.

These two papers identify opportunities and actions for all stakeholders in infrastructure. Understanding the opportunities and taking action will improve the capacity of communities, help government and industry to better respond to resilience risks, and help resolve the underlying vulnerabilities that lead to these risks.

We acknowledge that achieving this requires collaboration across many stakeholders and we encourage all levels of government, communities, industry and academia to build on and make use of this research.

This research will also inform future resilience policy work, including the upcoming 2021 *Australian Infrastructure Plan* and the 2022 *NSW State Infrastructure Strategy*.

1.4   The scope of this paper

This paper sets out opportunities to improve how we plan infrastructure to strengthen Australia's resilience to shocks and stresses.

This paper considers a broad range of infrastructure sectors, including 'traditional' economic sectors of energy, water, waste, transport and telecommunications, as well as vital blue and green infrastructure (such as waterways and parks) and social infrastructure. We include infrastructure assets associated with arts and culture, health and aged care, social housing, education and recreation as well as justice infrastructure (see **Appendix B**).

The research also considers the diversity of infrastructure needs across differing urban and regional geographies, using the five geographic categories defined in Infrastructure Australia's 2019 *Australian Infrastructure Audit* (see **Appendix C**): [8]

- national

- fast-growing cities

- smaller cities and regional centres

- small towns, rural communities and remote areas

- developing regions and northern Australia.

A broad range of potential shocks and chronic stresses that are applicable to infrastructure in an Australian context is also considered (see **Box 1**). These were drawn from a number of leading sources including 100 Resilient Cities, UN Habitat and the World Bank. [9]

This paper did not seek to investigate the cost of proposed initiatives, identify physical infrastructure interventions or outline funding or funding reform mechanisms.

1.5   Methodology

To develop this paper, we collaborated with experts from across Australia, from government, industry, peak bodies, as well as academia and civil society organisations. This paper's conclusions are informed by the findings of The Royal Commission into National Natural Disaster Arrangements Report and the independent NSW Bushfire Inquiry.

A vision for this project was developed to provide a framework for this collaboration and to provide a definition for 'resilience outcomes'.

Our vision is that future Australian communities be able to anticipate, resist, absorb, recover, transform and thrive in response to shocks and stresses, to realise positive economic, social and environmental outcomes.

This vision drew on existing policy frameworks, including the 2018 *NSW State Infrastructure Strategy,* [10] *Sendai Framework for Disaster Risk Reduction 2015–2030,* [11] Lloyd's *Future Cities: Building Infrastructure Resilience (2017),* [12] *City Resilience Framework* (2015) [13] and the *National Disaster Risk Reduction Framework* (2018). [14]

Over 600 individuals from across Australia contributed to the research project to identify short-term and longer-term opportunities to achieve change and increase resilience. We held sixteen workshops to consider responses to a variety of shocks and stresses and draw on learnings from recent events.

The opportunities identified in these workshops were based on significant expertise in land-use and transport planning, fire, engagement, and project management as well as sectoral infrastructure expertise. The outputs of these workshops were then reviewed by sector specialists drawing on subject matter expertise and relevant literature, including academic literature, policy papers and guidance, case studies and expert reports. The resulting short-term and longer-term opportunities were then tested with key industry and government stakeholders from the lens of different infrastructure sectors (see **Figure 3**).

The outputs of the research were summarised into two papers (see **Section 1.3**). This paper focuses on longer-term, systemic opportunities and provides the foundation and evidence base for the companion paper, *Advisory Paper 2: Guidance for asset owners and operators in the short term.*

This paper notes the creation of the National Recovery and Resilience Agency, which is tasked with providing national leadership and coordination to reduce the impact of future disasters, and the role it will play in capturing the opportunities presented in this paper.

2 Infrastructure for resilience: a systems approach

Defining resilience

Resilience is the capacity of communities to resist, absorb, accommodate, recover, transform and thrive in response to shocks and stresses, so as to realise positive economic, social and environmental outcomes[15].

As the 2018 *NSW State Infrastructure Strategy* states, for infrastructure to be resilient it should be able to withstand disruption, operate in crisis and deal with and adapt to shocks and stresses.

2.1 Resilience: enhancing risk management

As uncertainty increases and the complexity and interdependence of our systems grow, traditional risk management approaches need to be enhanced.

Traditional risk management relies on the ability to quantify the likelihood and the impact of disruption on an asset. It also involves allocating responsibility for action to one organisation or stakeholder to avoid, accept, reduce or transfer a risk. Increasing uncertainty and complexity means that the likelihood and impact of an event is harder to predict, let alone quantify, and responsibility for action is more likely to be shared. This risk management approach can fail to consider systemic risks that emerge from compounding shocks or stresses and apply to the entire system of physical assets, organisations and communities.

With many stresses constantly at play across the Australian community, shocks can create a cascading effect – they magnify underlying stresses by disrupting service provision and supply chains. In turn, this can weaken the capacity of our assets and networks to manage future shocks and stresses.

The resilience approach is complementary to traditional risk management and can help us respond to uncertainty and complexity. Resilience focuses on the functionality or capacity of a system in which there are many parts, rather than solely on one component of the system. It also focuses on shared (rather than individual) responsibility at all levels. The relationship between the capacity of a system to withstand disruption, in relation to the shocks and underlying stresses in a place, is represented in **Figure 1**. [16]

Taking a resilience approach allows you to consider non-linear and dynamic risks, which are themselves characterised by a high degree of complexity. As demonstrated in **Figure 1,** instead of preventing risks and protecting the status quo, resilience requires a systemic increase of adaptive capacities.

Figure 1. Increasing the capacity to cope helps address systemic risks resulting from the combination of shocks and stresses (Queensland Recovery Authority, 2020)
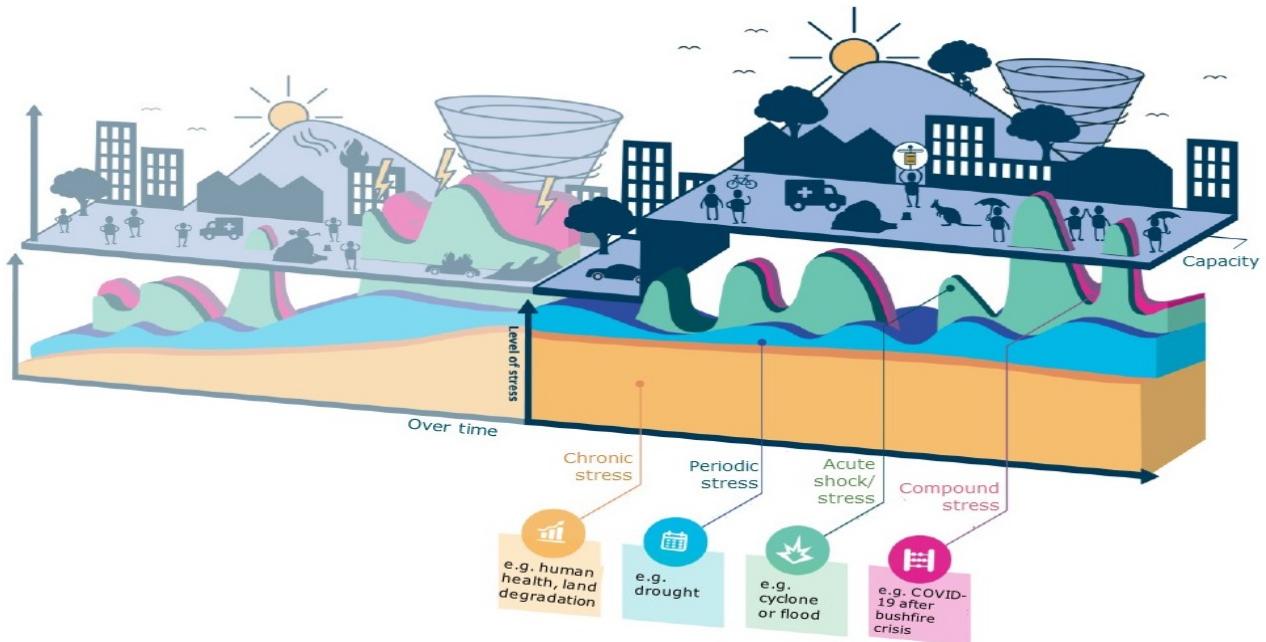
2.2 Moving to infrastructure for resilience

This emergent resilience approach necessitates a shift in focus from 'resilient infrastructure' – that is, a sole focus on the resilience of assets themselves – to 'infrastructure for resilience' – that is, the contribution of infrastructure assets and networks to the resilience of the system.

A systems-based approach is required for a resilient operating system – it asks us to look at the systems assets operate within, and how these systems interact. This approach requires us to:

- focus on the network of assets in and across sectors, in addition to the resilience of the assets themselves

- situate assets and networks in the context of their place, accounting for the unique risks and strengths of each place (thinking of place allows for a link from assets to the ultimate beneficiaries of resilience: the community)

- consider how relevant governance and coordination mechanisms interact with this place and network of assets.

Figure **2** gives an overview of the different systems relevant to *infrastructure for resilience*. **Appendix D** outlines the conditions required to achieve resilience at each level of the system.
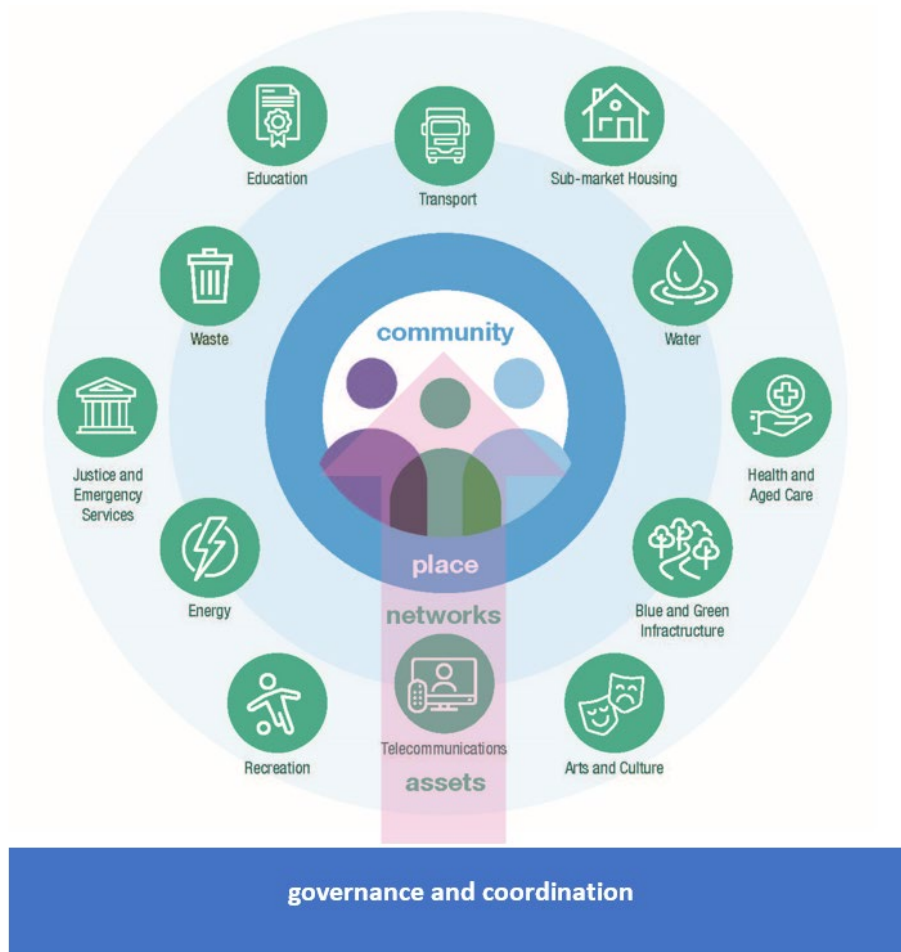
A focus on systems requires collaboration. It requires asset and network owners and operators to act collectively as well as independently, and to collaborate with the community, emergency responders, local, state, territory governments, and the Australian Government, around places and communities. This also requires them to focus on building organisational resilience and personnel capabilities, the promotion of a learning culture and a renewed focus on building resilience of communities.

This is in line with the *National Critical Infrastructure Resilience Strategy 2015*[17] and the *NSW Critical Infrastructure Resilience Strategy 2018*[18], which identifies three types of resilience:

1. *Infrastructure resilience:* the resilience planned for, designed, and built into assets, networks and systems

2. *Organisational resilience*: the resilience of the organisations, personnel and processes supporting infrastructure to supply a service

3. *Community resilience:* the role the community plays in building and maintaining its own resilience while contributing to infrastructure resilience.

Infrastructure for resilience relates to the co-ordinated actions needed to increase the ability of assets, organisations and communities to cope with the effects of multiple shocks and stresses, and how to minimise their adverse economic, social and environmental impacts. This co-ordinated approach allows us to invest in the most cost-effective mix of infrastructure and non-infrastructure responses to increase resilience.

3 Opportunities for systemic change in infrastructure planning

This section provides an overview of the 10 directions for greater transformational and systemic change in infrastructure planning identified in our research. These directions are explored in greater detail in **Sections 4-7.**

These 10 directions (**Figure 3**) are aligned to the conditions needed at the Governance and Coordination; Place; Asset; and Community levels of the system (**Figure 2**). Some directions contribute to more than one level of the system; however, they are organised by the most relevant system level.

Figure 3. Opportunities for systemic change in infrastructure planning
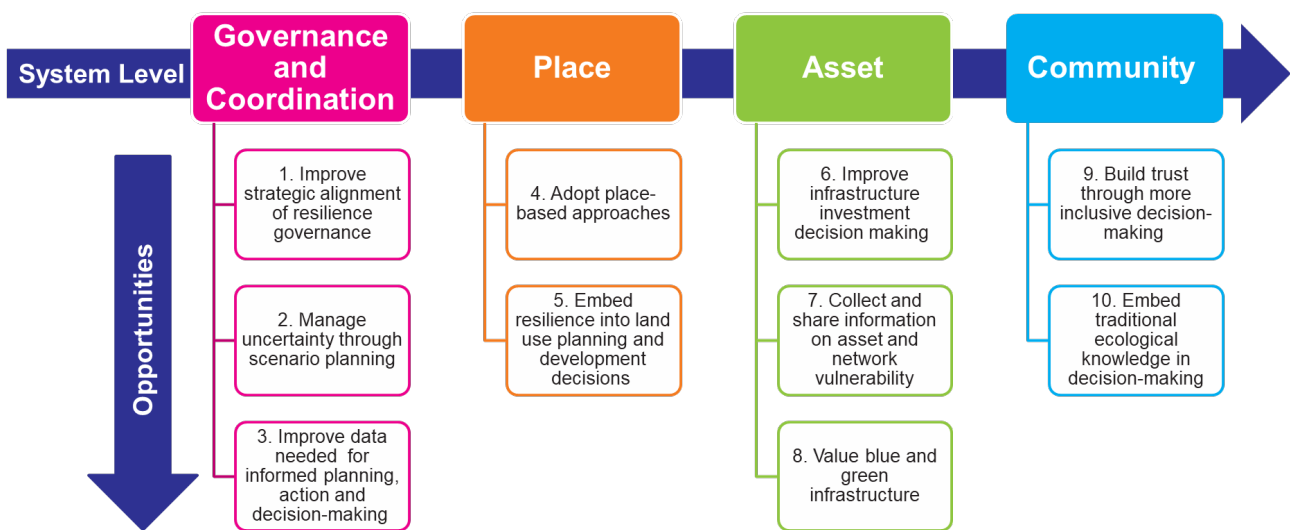
3.1 Opportunities at the Governance and Coordination level

Three key directions are identified at the Governance and Coordination level:

- **Improve strategic alignment of resilience governance** (see **Section 4.1**). Identifying, overseeing, coordinating, being accountable for and monitoring strategic resilience outcomes across sectors and jurisdictions is necessary to enable *infrastructure for resilience*. This will allow for the systemic management of resilience across infrastructure planning, climate-risk management, emergency management, community resilience and land use planning.

- **Manage uncertainty through scenario planning** (see **Section 4.2**). Enhancing resilience requires us to consider increasingly uncertain and interconnected future scenarios. Scenario planning can provide a structured approach to investigating and reviewing these interconnected and uncertain futures.

- **Improve data needed for informed planning, action and decision-making (see Section 4.3).** Critical disaster and climate data is fragmented, uncoordinated and not standardised, making it harder to respond in a crisis. Standardised information on shocks and stresses and nationally consistent data gathering and organising methods can improve data sharing and enable informed decisions**.**

3.2   Opportunities at the Place level

Two key directions are identified at the Place level:

- **Adopt place-based approaches** (see **Section 5.1**). Place-based approaches can support systemic action to achieve resilience outcomes in ways that sector-by-sector approaches cannot. There is an opportunity to build on the momentum behind place-based planning and recently established resilience bodies to drive a systemic approach to resilience planning.

- **Embed resilience into land-use planning and development decisions** (see **Section 5.2**). Land use planning could be improved by clear national policy that cascades to state and territory policies on how to treat resilience and plan for natural systems, hazards, and shocks and stresses. There is also opportunity to improve training for land use practitioners to better understand resilience and apply data to embed resilience in land use planning.

3.3   Opportunities at the Asset level

Three key directions are identified at the Asset level:

- **Improve infrastructure investment decision-making** (see **Section 6.1**). There is currently no universally agreed methodology or guidance on how to value resilience in infrastructure decision-making. Developing a nation-wide approach to quantifying risk, costs, benefits and performance of resilient assets and places would support informed decision-making. The is also opportunity to take action to develop cultures that value resilience in investment decision-making.

- **Collect and share information on asset and network vulnerability** (see **Section 6.2**). Our infrastructure assets and networks are increasingly interdependent, creating vulnerability to systemic failures. New and existing asset interdependency information systems could be brought together in an inter-jurisdictional and cross-sectoral portal to support informed decisions before, during and after shock events.

- **Value blue and green infrastructure** (see **Section 6.3**). There are opportunities to better understand, value, and build the case for investing in natural assets that provide services and outcomes that build resilience – such as ecosystem services and wellbeing.

3.4   Opportunities at the Community level

Two key directions are identified at the community level:

- **Build trust through more inclusive decision-making** (see **Section 7.1**). Effective decision-making should draw on local expertise to understand how systems interact on the ground and what communities need. To achieve this, communities need to be engaged early and throughout the project lifecycle. There are opportunities to address trust through place-based engagement and targeted measures to improve inclusiveness.

- **Embed traditional ecological knowledge in decision-making** (see **Section 7.2**). Traditional First Nations ecological knowledge is not currently being applied to land management in a systematic way, which is a missed opportunity to strengthen resilience outcomes. This knowledge could be embedded in the planning phase and throughout the entire infrastructure lifecycle with pilot programs, formal learning programs and creation of designated roles in infrastructure asset and network owner organisations.

4 Opportunities at the Governance and Coordination level

4.1 Improve strategic alignment of resilience governance

At a glance

Achieving *infrastructure for resilience* requires alignment, coordination and accountability across sectors, agencies and jurisdictions responsible for infrastructure planning, climate-risk management, emergency management, community resilience and land use planning.

Currently, actions are often uncoordinated within and across jurisdictions.

Aligning and monitoring resilience outcomes will ensure trade-offs and competing interests are better managed, and plans are active and updated as needed to achieve *infrastructure for resilience.*

There is opportunity to:

• improve strategic alignment, oversight, accountability and coordination across sectors and jurisdictions

• establish aligned outcomes for asset, network, place and community resilience across sectors and jurisdictions

• embed resilience in all types of planning

• monitor, evaluate and update resilience outcomes across all sectors and jurisdictions.

4.1.1 The problem

Achieving resilience requires alignment and coordination, as well as clear accountability across the various sectors, agencies and jurisdictions responsible for infrastructure planning, climate risk management, emergency management, community resilience and land use planning.

This can be challenged by the fragmented, multi-level governance arrangements around resilience that currently exist in Australia, and can mean that actions to increase infrastructure resilience are not taken with the whole-of-system approach needed to achieve infrastructure for resilience.

Multi-level governance challenges

A complex set of governance arrangements are in place to guide resilience, disaster policy and security policy.

Responsibilities for disaster risk management and climate adaptation mainly rest with emergency management organisations (EMOs) at the national and state level, as well as at a local government level (and in local government partnerships where they exist) as outlined in **Box 3** and **Box 4.** Consequently, local governments and local EMOs are often well placed to respond in a locally appropriate way. [19]

However, the outcomes that occur at the local level are often influenced and driven by the investment and operational decisions made by asset owners and service providers at other government levels and within private companies. These decisions can often occur outside the control or influence of local governments and local EMOs[20] and are generally focused on the issues related to delivery or operation of individual assets or services and/or sector or jurisdiction.[21]

Accordingly, while local governments and organisations are usually the best placed to understand local needs, they may not be the decision makers for some assets and types of infrastructure.

This fragmentation of governance means a strategic, whole-of-system perspective is not defined and embedded through national, state and territory and local levels, despite the impacts of shocks and stresses occurring across and beyond jurisdictional boundaries.

Infrastructure, goods, services and ways of living are "…interdependent systems … that are inherently reliant on interdependent risks being collectively managed".[22] Consequently, a strategic perspective and accountability is needed to manage this complexity. It is also needed to balance decisions informing public and private land use, infrastructure and emergency planning, which are otherwise made in isolation.

This can lead to sub-optimal decisions at every level of governance, including:

- unclear alignment and accountability for resilience cascading down through the governance levels
- unintended consequences in a place, sector or geography due to lack of coordination or information about decisions in another
- uncoordinated and ineffective responses in emergencies and in medium and long-term infrastructure decision-making (see also **Section 6.1**)
- the potential to repeat the same mistakes, as lessons are not transferred and information is not consolidated
- insufficient engagement can overlook necessary checks and balances and lead to erosion of community trust or poor outcomes for communities (see also **Section 7.1**)
- creation of 'blind spots' or areas of inactivity.

This is consistent with observations of the Royal Commission into National Natural Disaster Arrangements, which outlined that the coordination arrangements between critical infrastructure sectors and within government should be improved.[23] This was particularly in relation to information flows during and in response to natural disasters, between critical infrastructure operators, and between critical infrastructure operators and government.

Box 3: Governance arrangements across national resilience, security and disaster policy

Resilience context

In response to Recommendation 3.5 of the Royal Commission into National Natural Disaster Arrangements (2020), the Australian Government established a standing **National Recovery and Resilience Agency** to help Australia better prepare for future natural disasters and drive long-term resilience policy outcomes.

Security policy context

For nationally significant infrastructure, the *Security of Critical Infrastructure Act 2018* encourages coordination, information sharing, joint exercises, resilience planning between infrastructure sectors and government. The objectives and activities that arise from the Act are managed by the **Critical Infrastructure Centre**. The centre provides a cross-sector platform for information sharing, and mechanisms for monitoring and accountability through asset registers and risk assessments for nationally significant infrastructure.

While the centre and the *Security of Critical Infrastructure Act 2018* focus on risks related to foreign involvement, the Australian Government has stated its commitment to an all-hazards approach to protecting critical infrastructure.

Disaster policy context

The *Australian Emergency Management Arrangements Handbook* (2019) articulates the national governance arrangements for emergency management within Australia and its states and territories. The **Australia-New Zealand Emergency Management Committee** (ANZEMC) is the peak government committee that advocates for national policies to reduce disaster risk and prepare for emergencies. Under this governance structure, most states and territories have established a system of **regional and local emergency management committees** that lead and coordinate planning and emergency response and recovery across emergency services, government agencies, the community and stakeholders at a local level. These local emergency management committees are often coordinated by local government.

Emergency Management Australia (EMA) is responsible for 'all hazards' crisis coordination across all phases of resilience. It facilitates collaboration and information sharing across sectors and jurisdictions (for example, through the National Disaster Risk Information Services Capability pilot project). EMA is responsible for planning and coordinating physical assistance to the states and territories under the Commonwealth Government Disaster Response Plan.

Although a primary focus of the EMA is crisis response, EMA is also responsible for implementing the National Disaster Risk Reduction Framework (2018), which sets out framework priorities and guiding principles for resilience in relation to natural hazards. The Framework 'provide[s] the national direction needed to underline climate and disaster risk and improve national resilience across all sectors in Australia'.

Box 4: Governance arrangements in the NSW resilience and disaster policy context

Resilience NSW was established in May 2020 and leads whole-of-government disaster management, recovery and preparedness in New South Wales.

Disaster policy context

The NSW Government developed the NSW Critical Infrastructure Resilience Strategy 2018. It sets out how the NSW Government will work with federal sectoral groups, as well as additional state-based groups for education and government. These sectoral groups will collaborate across sectors, focusing on improving emergency management capability. The Strategy sits alongside the Critical Infrastructure Protection Program, which mitigates terrorism-related threats.

The *NSW State Emergency and Rescue Management Act 1989* and *State Emergency Management Plan* set the governance structure for how regional and local committees coordinate and lead activities. In New South Wales municipalities, the local government brings together emergency services, local government, relevant local stakeholders, and the community to prepare Local Emergency Management Plans (LEMPs).

The *NSW Public Safety Network (PSN)* was established in 1993 to provide a common platform for NSW government agencies and authorities who use mobile radio communications.

Local government policy context

In addition to local government-led LEMPs, at the city-scale, **Resilient Sydney** is a collaboration between all the councils of metropolitan Sydney, the NSW Government, business and the community. It is part of the 100 Resilient Cities Network. Resilient Sydney enables system-wide capacity building to adequately respond to all shocks and stresses. It applies a place-based lens that considers a range of inter-relationships, including land use planning. It developed the *Resilient Sydney Strategy,* and supports local government uptake of the strategy in their organisational activities and planning.

Asset management policy context

In 2019, the NSW Government introduced the Asset Management Policy for the NSW Public Sector (2019), which aims to drive better asset management through strengthening accountability, performance and capability across the public sector.

The policy mandates NSW Government agencies adopt a whole-of-government and whole-of-asset lifecycle approach to their assets. This includes developing a 'system-of-systems' approach across interconnected infrastructure networks to drive an integrated vision of infrastructure provision and management, and create value, reduce costs, manage risks and improve the resilience of assets.

4.1.2   The opportunity

A strategic approach is needed to take a systemic view, align and coordinate accountability, and to trade-off, advocate for and manage competing interests across the decision-making spheres in order to achieve infrastructure for resilience.

As our social, economic and natural systems become increasingly interconnected, dynamic and unstable, it is important to revisit and redefine governance arrangements to ensure that they are adaptive, collaborative and cross-scale in response. [24] The establishment of new agencies following the recent shocks from the summer of 2019–20 (including the National Resilience, Relief and Recovery Agency and Resilience NSW) presents an opportunity to achieve this.

These agencies, in conjunction with the existing arrangements outlined in **Box 3 and 4**, can harness the recent momentum to refocus on resilience and encourage the collaboration needed with asset owners and service providers.

Industry and local government structures should also be included, such as the industry-led, Australian Business Roundtable for Disaster Resilience & Safer Communities, and municipal alliances such as the 100 Resilient Cities Network, including Resilient Sydney and Resilient Melbourne.

Resilience considerations are currently dealt with in the realm of security and emergency management at the national, state and territory levels. The new system-wide collaboration and perspective offered by the establishment of these new agencies could move us beyond this emphasis on the crisis response and recovery phases to greater investments in prevention and adaptation.

4.1.3   The direction

For the new and established governance at state, territory and national levels to investigate opportunities to align governance, partnerships and collaboration with a system-wide consideration of infrastructure for resilience. This would involve action to:

- establish agreed resilience outcomes for assets, networks, places and communities across sectors and jurisdictions
- improve strategic oversight and coordination of resilience outcomes across sectors and jurisdictions
- set clear allocation of responsibility across actors to clarify roles and responsibilities
- embed resilience in all types of planning
- monitor and evaluate resilience outcomes across all sectors jurisdictions.

4.2   Manage uncertainty through scenario planning

At a glance

Enhancing resilience of infrastructure systems requires us to consider the impact of a broad range of uncertain and interconnected future scenarios. This is made more challenging by the very long operational lifetimes of infrastructure assets.

Scenario planning is a technique that supports the application of systems thinking. It does this by investigating and reviewing the implications of interconnected and uncertain futures in a structured way.

Developing and consistently applying a common set of futures scenarios across jurisdictions will help streamline planning and support cross-sector coordination and shared responsibility for decisions. Guidance on the use of scenarios to assess potential impacts and design for shocks and stresses will also support the uptake of scenario planning.

4.2.1　The problem

It is challenging for decision makers to adequately consider, in a systematic way, the shocks and stresses that may be faced over the very long operational lifetimes of an infrastructure asset. Different drivers of change that can occur over the lifecycle of an asset or system can affect the resilience of infrastructure in ways that may be unexpected when each driver is considered independently.

For example, infrastructure may need to provide a different role for a community that experiences shocks and stresses with increasing frequency and severity from a changing climate, when you also consider that over time, the community's socioeconomic profile may change and contribute to its adaptive capacity.

This concept is given effect by the Intergovernmental Panel on Climate Change (IPCC), which has developed five "Shared Socioeconomic Pathways" (SSPs). These represent five different feasible future scenarios that reflect varying combinations of broad climate, technological, socioeconomic and governance drivers. In their work, the IPCC apply these to create narratives of the future to explore climate change mitigation and adaption responses and inform global policy.

Scenario planning approaches like this have been developed and used across Australia, but in practice are not applied universally, or consistently. Application of these approaches has often been siloed or fragmented – for example, they have been applied by one organisation, or to one group of assets, or in one jurisdictional setting.

For infrastructure assets and networks – which operate as part of complementary and interdependent systems across different jurisdictional scales – it is important to develop and agree on consistent and fit for purpose future scenarios, that cascade to all jurisdictional levels. It is also important to provide clear guidance on which scenarios to apply and when.

This is particularly relevant for climate change scenarios, as climate change is a major driver of the shocks and stresses which assets and networks will be exposed to. Currently, climate scenarios are applied inconsistently in infrastructure planning. Different climate scenarios are often adopted for individual assets within an interdependent system. This can drive significant differences in asset, network and system performance under shocks and stresses, depending on which scenario is adopted during the planning phase for each individual asset, weakening the overall system's resilience.

4.2.2　The opportunity

To better understand the interconnected and increasingly uncertain variables used to plan for enhanced resilience, scenario planning can be used as a key input into a decision support tools for systems thinking.

Work is already underway across government, industry and academic sectors to develop scenarios and apply scenario planning as an approach. If this was progressed and universally and consistently applied, multiple stakeholders can use a common set of plausible future scenarios to analyse asset interactions and to test the resilience of plans, programs and assets to combined shocks and stresses.

Scenario planning provides a method for systems thinking

Scenario planning enables decision makers to investigate and review interconnected and increasingly uncertain variables. This helps them to plan for enhanced resilience.

Scenarios typically combine demographic, social, economic, environmental and other trends to capture a divergent range of plausible futures. These plausible futures combine the consequences of multiple shocks and stresses.

In a resilience context, scenario planning deliberately ties together socio-economic trends (as stresses) and the impact of economic, natural or human-induced threats (as shocks). These scenarios can incorporate different threats (for example, cyber-attack, extreme heat events, and heightened geo-political tensions) to enable an understanding of their broader socio-economic impact.

Consequently, they are useful to explore implications of these for institutions, governance arrangements and infrastructure networks and systems.

Common scenarios present an opportunity for resilience building

Multiple stakeholders could use a common set of futures scenarios to analyse asset interactions and to test the resilience of plans, programs and assets to combined shocks and stresses. As an example, in 2018, the NSW Government adopted Common Planning Assumptions (see **Box 5**).

Box 5: NSW Common Planning Assumptions and Group

The NSW Common Planning Assumptions and the Common Planning Assumptions Group (CPAG) are agreed information assets (for example, assumptions and parameters, data sets, models and analytical tools) used by NSW Government and others to prepare proposals, business plans and strategies.

NSW Government departments and agencies are required to use the Common Planning Assumptions in the development of plans, policies and strategies, and any deviations must be justified. The assumptions are documented in an index called the *NSW Common Assumptions Planning Book* (the CPA Book).

Data and assumptions in the CPA Book are developed by various NSW Government agencies. The Common Planning Assumptions are used to:

- provide a consistent evidence base (for example, assumptions and parameters, data sets, models and analytical tools) for NSW Government agencies to use in planning key services and infrastructure in New South Wales, from schools and hospitals to roads and transport

- leverage and bring together existing assumptions and data sets from across various NSW Government agencies to support plans, policy and strategies that serve the needs of New South Wales citizens and communities

- support the Premier's Priority for world class public service by giving NSW Government agencies easier access to a central index containing the latest datasets and assumptions for planning well-targeted services and infrastructure in NSW.

There is an opportunity to bring existing work and data together across the country to develop a series of scenarios to inform and build the resilience of community and place. The scenarios would guide network planning and infrastructure asset planning and design across Australia, leading to better consistency, improved identification of potential impacts from shocks and stresses, and more collaborative cross-sector planning.

Common scenarios that are developed at the national scale, and then adapted for use at state, territory and local scales is in line with international best practice. For example, the Netherlands has a long-established practice of developing and using climate change and socio-economic scenarios in planning. Their first efforts were published in 2006 and resulted in the Delta Scenarios in 2012 (now routinely updated). [25]

In developing and applying the scenarios, collaboration will be critical to understand the relevant trends and factors across all jurisdictions and for a diverse range of stakeholders across Australia including businesses, government, academia, Aboriginal and Torres Strait Islander groups and community representatives.

Guidance will be needed on how to use common scenarios

Consistent guidance on the use and systemic application of scenarios to assess potential impacts and design for shocks and stresses is also necessary to ensure successful adoption. This is in line with international best practice. For example, the United Kingdom Government provides some of the most comprehensive advice on using scenario planning techniques (also known as 'foresight planning') in government, including 'Tools for Futures Thinking and Foresight Across UK Government'[26]. Additionally, Policy Horizons Canada (the Canadian Government's organisation for foresight), provides training material including a *Module on scenarios and results*, which sets out their scenario development method. [27]

Work is already underway to develop scenarios

Several organisations across government, industry and academic sectors are developing scenarios across Australia. These efforts range in scale and focus on either comprehensive plausible futures scenarios or climate change.

For example, the Australian National University's National Security Hub hosts a Futures Hub (a joint initiative with the Australian Government). The Hub provides support for subject-specific scenario planning by any interested organisation. [28]

NSW has also started taking this approach. Sydney Water also produced a range of futures scenarios for Sydney in 2018. [29] Following this, NSW has started building futures scenarios into the NSW Common Planning Assumptions, which guide all New South Wales planning with common population, environmental and economic data.

The Global Infrastructure Hub produced the Infrastructure Futures Scenarios report in 2020, which also included a range of futures scenarios for infrastructure. [30]

4.2.3   The direction

An agreed, national, common set of futures scenarios that are relevant and appropriate for strategic planning, and can cascade from national to state to local government, as well as be applied by the private sector, will help streamline planning and support cross-sector coordination and shared responsibility for decisions. An agreed set of climate scenarios linked to these futures scenarios should also be developed.

In addition, guidance on the use of scenarios to assess potential impacts and design for shocks and stresses is needed to support the uptake of scenario planning.

These futures scenarios should be used by all levels of government in their strategy development processes, strategic planning and policy decisions.

4.3 Improve data needed for informed planning, action and decision-making

At a glance

Critical disaster and climate data (including data and information on shocks and stresses, the exposure of people and assets, and the vulnerability of people) are fragmented, uncoordinated and not standardised.

Decision makers need accurate, credible and timely data, along with guidance material, to coordinate their actions and make informed decisions.

There are opportunities to share and standardise information on shocks and stresses and apply nationally consistent data gathering and organising methods.

4.3.1 The problem

Critical data, including data and information on shocks and stresses, the exposure of people and assets, and the vulnerability of people, can be poor quality, not standardised, inaccessible, misapplied, fragmented and uncoordinated.

This can limit the effectiveness of coordinating responses to and recovery from crisis, and place-based and network-level planning, as well as inhibiting the ability to progress systems thinking.

Disaster and climate risk data is of variable quality

To support good decision-making, data and metadata need to be high quality, timely, best available and consistently available at the right level of granularity. Changes suggested in this paper (to land use planning, scenario modelling, valuing resilience in investment decision-making) are heavily reliant on access to consistent, reliable and robust data at all spatial scales and levels of government.

Typically, natural disaster data that are currently available is of variable quality, gathered using different methodologies and often at different geographic scales and resolutions.

Data also needs to be sufficiently precise to serve the needs of specific communities and at the right level of granularity to inform place-based planning.

In the absence of quality data, the costs and benefits associated with resilience will be challenging to quantify. This will result in advice that lacks the evidence base necessary to inform change.

States and territories have a patchwork of data standards

Data challenges can be exacerbated by each state and territory capturing data in accordance with their own standards and definitions. In practice, this can mean information on hazards, such as flood information, is not consistently treated across jurisdictions.

Consequently, combining these critical data sets across jurisdictions or different hazard types – a vital part of resilience planning – is often not feasible or useful. A key barrier related to this is the ownership and proprietorial rights to data, especially in the case of commercial in confidence and high security data.

Better standards would enable data to be more quickly and accurately collected, integrated, shared and released to consumers, industry, regulators, government and communities for effective decision-making during response, recovery, and planning.

The Royal Commission into National Natural Disaster Arrangements noted the critical need for nationally consistent reporting of data and data sharing agreements between states and territories, the private sector and communities on all hazards. This would provide a sound basis for decision-making, scenarios, place-based assessment, interdependency information and community education. [31]

Nationally significant data sets are not federated

National-level data on shocks and stresses is generally held by individual government scientific and research bodies, including those outlined in **Figure 4**. For shocks including natural hazards, data is created and held by organisations such as the Australian Bureau of Meteorology (BOM), the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and Geoscience Australia.

Figure 4. Examples of national data sources that inform resilience decisions

Data source	Data type
The Australian Exposure Information Platform (AEIP)	Nationally consistent exposure information directly accessible to key stakeholders involved in emergency management situation awareness, risk assessments, impact analysis research, and disaster management. [32] The AEIP combines work from the National Exposure Information System (NEXIS) and the National Hazard Exposure Information Framework (2018). [33]
Climate Change in Australia (CCIA), a website and suite of reports jointly authored by the BOM and CSIRO.	Data on climate change and climate change projections for Australia.
Australian Disaster Resilience Knowledge Hub, run by the Australian Institute for Disaster Resilience (AIDR)	National, open-source platform to provide data on shocks and stresses to support and inform policy, planning, and decision-making in disaster resilience. The Knowledge Hub includes a database of past disaster events, which can be accessed through an interactive map view.
The Australian National Map	Online map-based service to allow access to spatial data from government agencies. Data sets that are important for understanding shocks, stresses and vulnerability include data on some natural hazards, previous disaster events, the location of some infrastructure assets, and census data.
The National Disaster Risk Information Services Capability (NDRISC) (2020)	Pilot project delivered by the National Resilience Taskforce. The NDRISC used narrative scenarios to frame climate and disaster risk discussions for freight supply chains, and then modelled climate and disaster risks for specific case studies. [34]
Australian Bureau of Statistics	Data on Australian households on factors that impact vulnerability, such as age, income, and location.

While **Figure 4** outlines the array of different data sources available, there is no single, integrated platform for data. This fragmentation can lead to gaps and overlaps in the data that is available, making it difficult for users to select and compare data sets for specific purposes[35].

Access to data to inform decisions for communities and by communities

Access to quality data is central to the pathway to change. Data are essential for delivering the other directions outlined in this paper, including for scenario planning (see **Section 4.2**), land use planning (see **Section 5.2**), infrastructure investment decisions (see **Section 6.1**) and inclusive decision-making (see **Section 7.1**).

It is particularly important for communities to access, understand and use data. Data and the information it conveys – and the provision of support for accessing and interpreting it – empowers communities to make informed decisions that build resilient communities. Data and information (including an appreciation of the underlying assumptions, limitations, and uncertainties) allows communities to meaningfully participate in decision-making.

The inequalities experienced by Aboriginal and Torres Strait Islander peoples make them more vulnerable to shocks and stresses – and data access for these groups is vitally important. The principle of Indigenous Data Sovereignty, which seeks to give Aboriginal and Torres Strait Islander people the right to regulate, collect, use and own the data that is recorded on matters that relate to their people, communities and resources[36] can support self-determination. The *National Agreement on Closing the Gap* (2020) identified the need for shared access to data and information at a regional level.[37] Governments should support Aboriginal and Torres Strait Islander communities to build capability in collecting, interpreting and using data in a meaningful way.

Poor data can lead to decisions with unintended cross-sectoral consequences

Data collected by separate organisations and held in separate platforms introduces the risk that interdependencies between systems are not fully appreciated. This often leads to poor outcomes and unintended consequences, as a single organisation or community may not be able to fully anticipate and understand the ripple effect of their decisions on other sectors.

4.3.2   The opportunity

Coordinating accurate, timely, accessible and credible data can provide a holistic systems view of the interconnection between natural hazards, asset locations, population and impact data.

In addition, nationally standardised, transparent and consistent data gathering and organising methods will enhance capacity to share data across sectors, including the private sector.

Accessible and clear data enables good decisions at all stages

Decision makers need accurate, credible and timely data to coordinate their actions and make informed decisions.[38] For example, data on mitigation and preparedness measures for past infrastructure projects could provide lessons for future projects.[39]

As new data and information emerges, existing decisions and processes should be adapted to accommodate improved understanding, for example through adopting an 'adaptive planning' approach. Ex-post evaluation of infrastructure programs is a process to enable a feedback loop to allow for the testing and validation of new data and information.

States and territories already have a wealth of information available

Natural hazard data must play a vital role in informing decisions, education, and research across land use and strategic planning, emergency management, community education and insurance. **Figure 5** explains the types of data (mostly collected at the state and territory, and local government levels) that help to consider past, current and future risk.

Figure 5. Data types that inform decisions on past, current and future risk

Data type	Example
'Natural' hazard	Bushfire, flood and coastal inundation maps
Vulnerability data (impact)	Demographics - Economic, health and social costs
Exposure	Population, topography, asset location

The Australian Government has recognised the need for data centralisation

The Royal Commission into National Nature Disaster Arrangements made several recommendations to implement harmonised data governance and national data standards, and information platforms. [40] In response, the Australian Government has established the National Recovery and Resilience Agency. [41] This will, in the first instance, bring together the Australian Government's data for managing climate and disaster risk, including data managed by the BOM, the CSIRO, Geosciences Australia and the Australian Bureau of Statistics.

The Australian Government has invited state and territory governments to contribute their data and capability. [42] The Australian Government has also endorsed the National Disaster Risk Reduction Framework (NDRRF), which states that understanding disaster risk is critical. [43]

A national data management system could inform all levels of systems thinking

Australia would significantly benefit from a national data management system to hold and share data and information on:

- shocks and stresses (including past, current, and modelled or predicted future events)

- exposure of people and assets to hazards

- vulnerability of people.

These key data sets inform scenarios, determine risk, inform response, recovery, place-based and network-level planning, and enable systems thinking.

Central management of risk data is fundamental to understanding climate and disaster risk and making informed decisions on risk reduction options and approaches. [44]

Creating an effective national, state and territory data management system should not be driven the Australian Government alone. Collaboration in the production, access, exchange of information, knowledge and data about disaster risk will need to be sourced from all levels of government, industry, communities, Aboriginal and Torres Strait Islander peoples and the private sector.

New data standards allow nationally comparable data to be used at a localised level

Nationally consistent, transparent and comparable data sets require data standards that enhance the capacity to collect and share data. [45] Only with agreed definitions, methodologies and standards is it possible to implement a national data management system of value to infrastructure decision makers and Australian communities. To achieve this, each state and territory may require changes to licences, regulation and protocols and an appetite to carry out data reform.

In addition, consultation will be required with local governments, infrastructure asset and network owners and operators, and local communities to understand how data standards and the structure and contents of a future data management system could cater to their needs.

Consistent and interoperable data standards are the ultimate aim. However, in the short term, comparable data sets should be identified and combined.

It should be noted that sharing data can have unintended consequences, which will need to be considered during the formulation of standards. *The National Infrastructure Data Collection and Dissemination Plan* highlights concerns around:

- how data will be interpreted

- unintended consequences of sharing data

- accidental release of sensitive data

- adherence to privacy legislation. [46]

4.3.3   The direction

A national data management system - linked to similar state and territory data management systems - is needed to hold and share data and information on:

- shocks and stresses (including past, current, and modelled or predicted future events)

- exposure of people and assets to hazards

- vulnerability of people.

Risk data must be managed centrally to understand climate and disaster risk and inform decisions on risk reduction options and approaches. [47]

In the short-term, comparable data sets should be combined. In the longer-term, national data standards should be created.

5   Opportunities at the Place level

5.1   Adopt place-based approaches for resilience

At a glance

Place-based approaches provide a mechanism to consider multiple issues at once and to address resilience alongside other needs.

Risk is often overlooked when decisions about land use, infrastructure planning, environmental conservation, and emergency planning are made on a sector-by-sector basis.

Place-based approaches can support systemic actions to achieve resilience outcomes in ways that sector-by-sector approaches cannot.

The current momentum behind place-based planning represents an opportunity for new and established resilience authorities to:

- strengthen and embed resilience in existing place-based initiatives
- include place-based planning as a criterion for project approval and assurance
- strengthen capacity of local government to lead place-based planning.

5.1.1   The problem

Without place-based planning, risk can be unmanaged between decision-making silos

'Place' is where the system of land use, the infrastructure network and assets, and the broader community intersect.

Decisions that affect a place – about land use, infrastructure planning, environmental conservation, and emergency planning – are commonly made on a sector-by-sector basis. This doesn't sufficiently consider the cumulative impacts and benefits, the place-level interdependencies and vulnerabilities, or trade-offs that need to be made between them.

Silo-based approaches can transfer risk outside an individual sector to provide a solution (for example, raising a bridge to create an evacuation route). This can leave substantive, complex risks unmanaged or with no clear allocation of responsibility (for example, an evacuation centre that is now accessible due to the new evacuation route may now have insufficient capacity to respond in a crisis). Consequently, decision makers can fail to adequately consider the impact of their decisions on the broader system and its overall resilience. This can result in missed opportunities to achieve infrastructure for resilience through coordinated, place-based decision-making.

5.1.2   The opportunity

Place-based planning can address multiple issues together

A place-based approach helps us understand how shocks and stresses play out for different communities and regions, and allows government at all levels, stakeholders and communities to consider multiple issues at once. This means that planning and policy decisions can more effectively work towards building resilience in our communities, as well address other needs such as integrated transport solutions and water-sensitive urban design. It can also provide a mechanism to connect local planning to national, state and territory decisions.

As noted by the Project for Public Spaces:

> Whether the goal is improved transport, better utility networks or enhanced protection against flooding or fire … putting place, and the creation of 'place-capital' at the centre of our policy and planning frameworks can more effectively, and more cheaply, address multiple issues at once. [48]

Community-led approaches lead to places that better respond to the needs and capabilities of local communities

Engaging community and stakeholders in the planning process enables the design of community-led solutions that draw on deep community knowledge of place and provides solutions that better respond to the needs and capabilities of local communities.

Taking a place-based approach can encourage a greater consideration of Aboriginal and Torres Strait Islander culture, perspectives and needs, and as a result, support the health and wellbeing of Country and supports self-determination. [49] **Section 7.2** describes further how embedding traditional knowledge is necessary to make sure that local context is understood and solutions are appropriate and effectively contribute to community needs and objectives.

Place-based approaches are consistent with recent developments in policy and practice

Australian governments are trending towards place-based policymaking and planning. There has been a revival in understanding the social importance of great places and the need for place-management.

There is an opportunity to build on the momentum of a number of place-based initiatives already underway at national, state and local levels and ensure that resilience considerations are considered in future place-based planning. The Australian Government set an agenda for cities in 2016 with the *Smart Cities Plan* [50] (**Box 6**) and Infrastructure Australia's Reform Series paper, *Planning Liveable Cities,* in 2018. This work acknowledged the importance of all three levels of government working in partnership to support cities of all scales.

Guided by the *Smart Cities Plan,* the Australian Government has developed initiatives that contribute to the United Nations Sustainable Development Goal 11 'to make cities more inclusive, safe, resilient and sustainable'. [51]

The *National Disaster Risk Reduction Framework* identifies a key resilience strategy to 'support and enable locally-led and owned place-based disaster risk reduction efforts'. [52] This explicitly calls for a local approach, with understanding of the place-specific risks and needs and coordination requirements to deliver local measures.

Box 6: Australian Government place-based initiatives – City Deals

The 'City Deal' governance and funding structure is set out in the *Smart Cities Plan.* It is a mechanism for the three levels of government to agree objectives and commitments for places.

The approach recognises the unique challenges and attributes of a place, and need for a tailored approach to planning, investment and governance. There are currently eight city deals across Australia and a ninth has just been announced. The city deal is most commonly used to deliver economic outcomes in places that are of national interest.

'Place' has also become an increasingly important organising principle in the work and priorities of the public sector in some states and territories. For example, the NSW Department of

Planning, Industry and Environment has a team dedicated to planning for Place, Design and Public Spaces. [53] The Government Architect NSW has recently published *Better placed,* [54] *Greener places* [55] and the *Design and place state environmental planning policy* [56] as a collection of policies and frameworks that aim to promote good design and the sustainable management of places (built and natural) across New South Wales.

Increasingly, NSW Government departments and agencies have been called upon to understand how their services or investments impact on 'places', not just customers or end-users (**Box 7**). Specific examples include the NSW Premier's Priority around increasing community access to quality green public and open space, [57] and Transport for NSW and the Government Architect NSW's *Movement and Place* framework. [58]

Box 7: NSW Government place-based initiatives

A **Place Infrastructure Compact** methodology was used by the Greater Sydney Commission (established in 2016 to lead metropolitan planning for the Greater Sydney region) to facilitate infrastructure planning for the Greater Parramatta and the Olympic Peninsula, and Western Sydney. The process required collaboration across NSW Government agencies, utility providers and local councils to sequence growth and infrastructure in a way that supports liveability and resilience for local communities.

The **Greater Sydney Commission's Collaboration Area program** was initiated to help deliver *A Metropolis of Three Cities*, the Greater Sydney Region Plan. Under this program, eight collaboration areas have been identified and each of these has a Place Strategy that sets out a shared vision, priorities and actions for stakeholders. The development of the place strategy is a collaborative process between local councils, NSW Government and Australian Government agencies, and key local institutions and organisations.

The NSW Government's program of **Special Activation Precincts** across regional New South Wales requires coordination between NSW Department of Planning, Industry and Environment, Regional NSW and Regional Growth NSW Development Corporation. Through the program, state and local government stakeholders, community and industry collaborate in master planning and technical studies to understand land use, economic development opportunities, and infrastructure needs.

At the local level, Resilient Sydney (see **Box 4**) encourages member councils to apply a place-based lens that considers a range of inter-relationships, including land use planning and emergency preparedness (see **Box 8**).

Box 8: Resilient Cities strategies

Through the **100 Resilient Cities Network**, Melbourne and Sydney developed city-wide resilience strategies that respond to the challenges for each city. The Resilient Melbourne (2016) and Resilient Sydney (2018) strategies aimed to help integrate planning for land use, infrastructure and communities. Implementation of the strategies is based on consensus across metropolitan councils and infrastructure operators to translate city-wide resilience challenges to local activities.

5.1.3   The direction

Place-based planning represents an opportunity for new and established resilience authorities, in partnership with governments, asset owners and service providers, to drive a systemic approach to achieve resilience outcomes by:

- strengthening and embedding resilience in existing place-based initiatives

- including place-based planning as a criterion for project approval and assurance

- strengthening capacity, including resourcing, of local government to coordinate and lead place-based planning for resilience

- convening cross-disciplinary and multi-sector discussions at a place level to bring government agencies and communities together to better understand and respond to shock and stress scenarios at a local level.

5.2 Embed resilience into land-use planning and development decisions

At a glance

State and territory planning agencies, in some cases, make strategic land use planning decisions without the information, capability and policy levers required to enhance community resilience.

Planning systems across Australia often undervalue resilience or do not set resilience as a policy objective at all. Planning tools need to change to incorporate new and emerging data about disaster and climate risk, respond to comparable best practice and better account for place-based and localised opportunities, strengths and weaknesses.

A coherent and clear approach is needed to achieve resilient and adaptive land use planning policy. It should be applicable for the national, state and territory, regional and local planning systems. To complement this, planning practitioners require improved training to better understand resilience and apply data to embed resilience in land use planning.

5.2.1 The problem

Land use planning, regulation and development must reconcile a complex set of interests and priorities. While no state or territory is alike, planning systems across Australia do not typically establish resilience as a key policy objective, and planning tools are limited in the way they account for shocks and stresses.

This can exacerbate vulnerabilities in the built and natural environment, which weakens the capacity of communities and organisations to respond to acute shocks and stresses.

Best practice land use standards have been identified but not applied

Land use planning and regulation emerged to manage public health and environmental impacts as cities and urban populations grew, separating industrial activities from where people lived. Over time, resilience considerations have begun to be incorporated into land use planning frameworks.

In many instances, best practice has been identified, and there are a range of national and state and territory-based policy documents that aim to use land use planning to reduce natural disaster risk and build long term resilience. This includes the *National Land Use Planning Guidelines for Disaster Resilient Communities*[59] and the *Handbook on land use planning for disaster resilience communities*,[60] which set out principles of good practice in land use planning to identify risk tolerance and build disaster resilient communities, and positions community wellbeing and disaster resilience as the overarching aim for land use planning.[61]

In New South Wales, there are strategic plans that recognise the need for land use planning to enhance liveability and sustainability and manage the impact of natural hazards on communities and homes. These include Regional Plans, the Greater Sydney Commission's *A Metropolis of Three Cities,* District Plans, and Local Strategic Planning Statements.

However, there is still significant scope for improvement. [62] Progress has been mixed and implementation of best practice varies across different states and territories and between individual local governments. As a result, in some areas, development has occurred in areas with 'known and obvious risk of disaster', placing lives, livelihoods and assets at risk. [63]

The bushfire crisis of 2019–20 and coastal inundation events illustrate how homes are still being built in high-risk bushfire and coastal inundation areas, with significant implications for the security and well-being of the community. [64] In one example of this, a newly built suburb in Townsville flooded in 2019 and caused community displacement and a spike in mental health complaints. [65]

Competing priorities often cause resilience considerations to be overlooked

Land use planning decisions involve complex trade-offs between considerations such as affordability, proximity to natural areas, safety and security, and the economic prosperity of a community. [66]

An added layer of complexity is that each community is different and faces competing cross-sectoral and natural ecosystem priorities, such as vegetation or habitat protection.

Consequently, balance must be found between different trade-offs and risks at all the decision points – from the early risks of project development borne by government and industry, to ownership by individuals, businesses and other organisations.

At each of these stages, decisions made can add or avoid vulnerability. [67] However, resilience is often neglected or overlooked within the planning system due to competing economic, political, environmental or social priorities.

The increasing frequency and severity of natural hazards, pandemics and cyber threats necessitates a reconsideration of these traditional priorities.

There are inadequate tools, data and training to consider and incorporate resilience into land use and strategic planning decisions

Legislation, policy, regulatory frameworks, and standards and codes govern how planners coordinate and consider resilience across all levels of planning. They are used for risk assessment, to determine risk tolerance, to guide decision-making and appropriate responses, and to ensure that policy is aligned with national policies or international commitments. [68]

However, despite the progress made in identifying best practice, this guidance has not always cascaded to land use planning instruments and practice. As a result, the policy levers to allow for consideration of increased community resilience can be limited.

Furthermore, there are significant gaps in the simplified data available on cumulative shock and stress information that is appropriate to inform strategic land use planning. This hinders the ability of planners to understand the risks posed to assets and communities, and to balance resilience considerations against social, economic and environmental outcomes.

Finally, guidance and training is not always sufficiently provided to ensure there is capability to incorporate resilience and systems thinking into land use planning decisions.

Land use and strategic planning frameworks reviews are too static

Land use planning is often based on assumptions about urban and environmental impacts that are rarely revisited or revised. Static land use planning frameworks that do not adapt, risk authorising new assets and communities in high-risk areas.

While there are notable exceptions – such as land use planning and development systems responding flexibly in the short-term to changes like the COVID-19 pandemic – in general, many of these systems have not altered in response to changing risk profiles of longer-term shocks and stresses.

It is vital that frameworks allow flexible and adaptive responses that accord with community needs.

There is limited line of sight from national-level planning through to state and territory and regional land use planning

Policies and investments at the national level can significantly shape land use. National economic policy guides investment in regions, migration policy helps drive population growth, border policy dictates mobility inside and outside Australia and other national policies influence heritage conservation and protection, environmental management and major infrastructure development.

In practice, the influence of these national policies on land use planning and strategy varies at state, territory, regional and local levels. Best practice – where alignment cascades from national to local policy – is occurring only in a few specific locations, such as the eight City Deal and three Regional Deal locations (see **Section 5.1**). Remaining gaps can lead to an inconsistent policy focus and increase overall system vulnerabilities.

5.2.2   The opportunity

The scale of intervention required to embed resilience and systems thinking into land use and strategic planning is significant. It will require dynamic multi-scale and multi-level relationships to manage competing priorities across fast-growing cities, smaller cities and regional centres, and small towns, rural communities and remote areas.

Consequently, better data, improved capability and approaches that balance resilience against social, economic, environmental and governance considerations are vital.

Effective land use and strategic planning can mitigate impacts

State and territory governments determine how resilience is treated by planners, and local governments reflect state planning policy.

State-level planning decisions can therefore mitigate or aggravate impacts from natural systems, hazards, and shocks and stresses. For example, people and infrastructure assets are most susceptible to disasters from natural hazards when they are physically located in hazardous areas, and when the buildings and assets that are built do not address current and/or future risks. [70]

Adaptation is already occurring to reduce these risks. For example, concerns about coastal inundation have prompted the enforcement of new restrictions on the location of new housing developments and increasing attention on adaptation measures in this context. [71]

There is an opportunity to extend this thinking to all hazards and equip the planning system with the tools to strengthen and better consider Australian communities' resilience.

Better data can help land use planners to make sound resilience decisions

It is critical the best available information on risk is used in land use planning. To enhance community resilience, planning should consider data related to:

- community and place-based data (see **Section 7.1**)

- consistent and robust scenarios (see **Section 4.2**)

- hazard data (see **Section 4.3**)

- infrastructure asset and independency information (see **Section 6.2**).

The richer the detail, the more likely planners will be able to tailor their decisions to the nuances and vulnerabilities of a place, community and network. This enhances a systemic consideration of resilience.

Training and resources help to upskill planning practitioners

Better data alone may not translate into better practice. Once this information is provided, practice notes and guidance will be required to interpret and apply the data in the best interests of the community and taxpayers.

Planning practitioners will require training to understand changes such as new data, implications of resilience and how it relates to systems thinking. Professional bodies, such as the Planning Institute of Australia, have provided detail on how resilience should be considered by planners, as well as toolkits to help planners embed this knowledge. [72] Training may need to start early and extend from planning students and graduates, to training for experienced planning practitioners and their agencies.

Land use planners should also have access to guidance and training for applying scenarios and assessing the impacts of land use planning on resilience at different scales and in different locations. This may involve a review of the *Disaster Resilience Education Implementation Plan.* [73]

Land use planners should interact with inter-regional and inter-state colleagues. Collaborative and participative learning approaches that facilitate knowledge-sharing between planners and modellers will help to refine and embed best resilience practices and embed systems thinking.

National leadership can drive systems thinking and collective responses from land use planners

Resilience should be considered and addressed at every level of land use planning. This should begin, and cascade from the national level, with clear and coherent policy related to land use planning.

The Australian Government should take a systemic approach and consider any necessary governance and coordination reform, and how this will impact communities, assets and networks and places. This should cascade through state and territory, regional and local planning systems and be tailored to their own, localised needs.

Consultation with communities and emergency services improves resilience outcomes

Land use decisions alter the way communities live, where they live and their quality of life. **Communities require a say in their futures and opportunities to learn about the forces shaping them**. Modelling, assumptions, functions and outcomes that underpin land use plans should therefore be as transparent as possible.

As a minimum, land use plans should be publicly reported, and resilience assessments should be available during consultation to inform and empower communities, government agencies (including emergency services), industry and decision makers.

As part of this, collaboration between planning and emergency service agencies is necessary to improve systems thinking and ensure advice is considered in land use planning decisions. Advice of this nature would be valuable for the preparation and evaluation of land use plans, and the assessment of greenfield and brownfield projects and development applications. This partnership is critical in overcoming some of the barriers to taking a system thinking approach.

5.2.3   The direction

Coherent and clear national policy is needed for resilient and adaptive land use planning that is applicable to state and territory, regional and local planning systems and can be cascaded from national to local level.

Respective state and territory governments should determine the response to national policy at a regional scale, with local governments applying this policy and ensuring that local decisions reflect state planning policy.

Land use planning policy, at all levels, should consider and be informed by:

- a clear articulation of resilience to what, resilience of what and resilience for whom

- data, including natural hazard and interdependences information specific to the place (see **Section 4.3**)

- early, effective and ongoing consultation with communities, the Australian Government, states and territories, planning agencies and emergency services (see **Section 7.1**).

To complement this, planning practitioners require training to better understand resilience, to build relevant capacity and capability and to understand how to apply data to embed resilience in land use planning.

6   Opportunities at the Asset level

6.1   Improve infrastructure investment decision-making

At a glance

There is a need to embed resilience in infrastructure investment decision-making processes. This requires increased consideration of resilience and more guidance on how to achieve resilience outcomes.

Infrastructure is being delivered that is generally not sufficiently resilient to future events, resulting in poor social, economic and environmental outcomes for communities and taxpayers. It is imperative that projects being considered for development and delivery give regard to the long-term resilience implications of an asset's operations, location, climate risks and the shocks and stresses that are likely to impact it over the course of its lifetime.

While there are processes in place to manage risk, there is no agreed approach for quantifying the projected social, economic and financial implications of shocks and stresses.

There is a need for:

- guidance and an agreed methodology to help decision makers value resilience through the infrastructure lifecycle

- a consistent approach to quantifying risk, costs, benefits and performance of resilient assets and places to develop the business case for investment

- a culture that values the importance of resilience in investment decision-making.

6.1.1   The problem

There is a need to better consider resilience in infrastructure investment decision-making, including current business case guidelines, capital asset planning and assurance processes. However, appropriately valuing resilience in investment decision-making is difficult and complex.

The increasing severity and frequency of natural disasters and other shock events (e.g., pandemics), and the compounding and interconnected effects of climate change, globalisation and urbanisation, are leading to costly infrastructure and asset failure.

These failures, and the increasing size of the infrastructure pipeline, are exacerbating the need for better practice and culture in infrastructure investment decision-making. Without full incorporation of resilience into project appraisal, infrastructure that is not sufficiently robust will continue to be delivered. This will harm communities, disrupt people's quality of life, decrease productivity and cause significant social, economic and environmental consequences.

Not considering resilience in infrastructure decisions has significant financial cost

The 2019 *Australian Infrastructure Audit* identified a lack of comprehensive resilience strategies for Australia's assets and networks.[74] When resilience is inadequately valued in project appraisals, infrastructure asset owners and operators are increasingly incurring repair, rehabilitation and replacement costs for infrastructure damaged by natural disasters and other shocks or stresses.[75]

Given a major share of natural disaster costs arise from damage to critical infrastructure, estimates suggest $17 billion (in present value terms) may be required for the direct replacement of essential infrastructure during the period between 2015 and 2050 due to natural disaster damage. [76] This does not include costs stemming from service disruption.

As well as the capital cost, much of our infrastructure has operational costs that is funded by users and taxpayers. Infrastructure operating in sub-optimal conditions can incur significant costs for operation, repair and replacement and can weaken the integrity of the overall system.

There are barriers to incorporating resilience into investment decisions

Resilience considerations are most effective when considered at the planning phase of infrastructure delivery. A range of barriers prevent the consideration of resilience at this phase, including a lack of:

- **Data and scenarios to make resilience determinations.** As highlighted earlier (see **Sections 4.2 and 4.3**), these are not always available.

- **Consistent, robust methodologies for business cases at state and territory, and national scales.** Guidance and tools are required to provide consistency, and to incorporate risk reduction measures into project design.

- **Expertise to consider and analyse data, forecasting, and resilience costs and benefits.** Decision makers commonly do not have the expertise or resilience literacy to make determinations about risk exposure or resilience costs and benefits. Careful and complex analysis and new skill sets are required to gauge uncertainty surrounding costs, benefits and the probability of natural disasters, and achieve optimal outcomes. [78]

- **Supporting culture.** Rethinking resilience in a system requires shifting traditional patterns of thought and culture and recognising the long-term value associated with resilience.

Even where resilience has been included as a consideration in infrastructure decision-making frameworks, these barriers hinder practical application (see case study in **Box 9**).

Box 9: Case study - Infrastructure Australia Assessment Framework

The Infrastructure Australia Assessment Framework (IAAF), provides information about how infrastructure initiatives and projects are assessed for inclusion on the Infrastructure Priority List. It includes specific guidance on considering and managing climate risk. The IAAF encourages the use of scenario analysis to ensure that projects are robust to a range of plausible futures.

Since this climate scenario guidance was introduced in 2018, none of the 30 project business cases submitted by proponents to Infrastructure Australia for evaluation have fully adopted it. In response to the lack of adoption of the climate scenario guidance, a current review of the IAAF is considering how to support proponents' consideration of climate risk. This includes reviewing the clarity of the existing guidance and alignment with similar guidance provided by state and territory governments.

It will take decision makers time to apply complex practical guidance to investment decisions

The embedding of resilience into infrastructure investment processes, beyond a theoretical concept, will be challenging and will take time. Valuing resilience in investment decisions will require decision makers to:

- **Identify disaster, climate and non-natural risks**. As outlined throughout this paper, this presents numerous challenges.

- **Incorporate resilience into business cases methodologies**. This requires decision makers to formulate a common definition of resilience, best practice approaches, minimum levels of resilience, resilience benefits, risk tolerance and trade-offs.

While investment outcomes could be different, the assessment of disaster, climate and non-natural risk will not alter how business case evaluation currently occurs. Projects will still be compared to the business-as-usual base case, with resilience being considered as one of many benefits. Proponents would then assess climate and disaster risks, identify project options with greater or lesser resilience, and estimate the costs and benefits of each option before deciding on the preferred, optimal solution.

There are several different methodologies to incorporate resilience. **Box 10** provides a case study of a proposal by the World Bank. [79]

The Australian project pipeline must minimise resilience risks

Population growth, ageing existing infrastructure, political and market appetite, and COVID-19 stimulus have caused strong demand for infrastructure in Australia. Many of these investments are mega projects that will fundamentally reshape how Australia functions.

Over the four years to financial year 2023–24, $225 billion is allocated for general government-sector infrastructure funding. **Figure 7** demonstrates the state and territory per capita infrastructure funding. [80]

Figure 6. State and territory per capita infrastructure funding, based on 2020-21 and 2019-20 Budgets
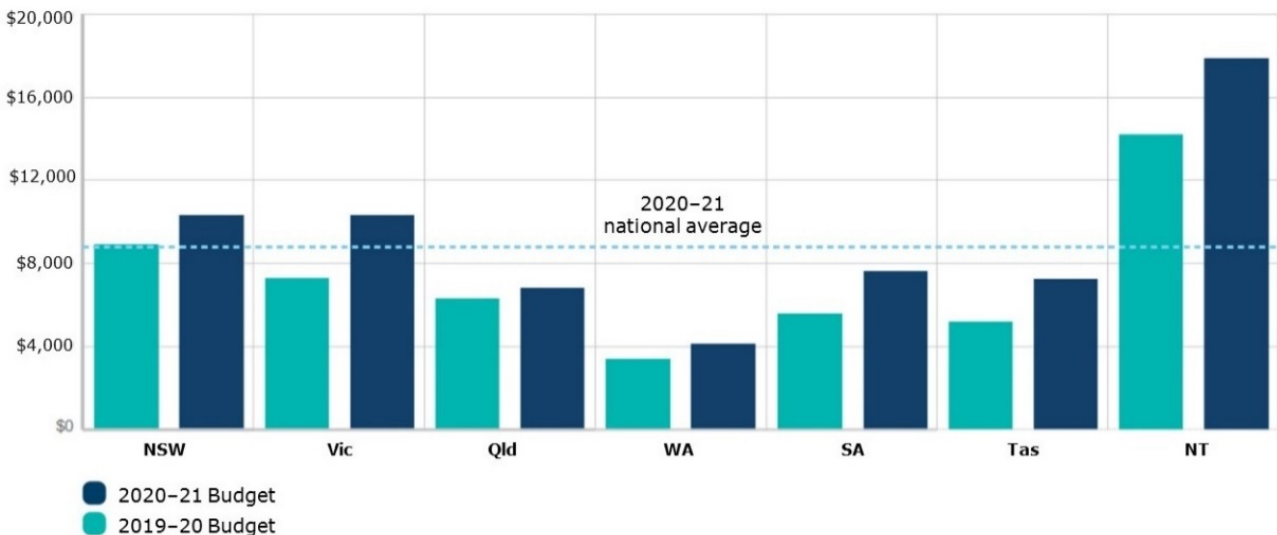
Source: Infrastructure Partnerships Australia, 2021

It is imperative that the projects being considered for development and delivery give regard to the long-term resilience implications of an asset's operations, location, climate risks and the shocks and stresses that are likely to impact it over the course of its lifetime.

Without sufficiently considering resilience in the investment decision-making process, asset decisions are being made that may conflict with emerging natural hazard risks. In a fiscally constrained environment, governments and taxpayers can't afford to fund infrastructure that will be redundant, inefficient or unable to operate.

Box 10: Case study – the World Bank's Resilience Rating System

The World Bank has outlined a Resilience Rating System as a methodology for building and tracking resilience to climate change.

The rating system (**Figure 6**) ranks different methodologies for assessing:
1) Resilience *of* the project.

2) Resilience *through* the project.

Figure 7 Resilience Rating System (World Bank, 2021).

resilience *of* the project

C — The project has conducted a basic climate and disaster risk screening and provides a qualitative estimate of residual risks and a justification for the level of risk.

B — The project has conducted a multi-model risk assessment and considered adaptation options for identified risks.

A — The project has conducted a quantitative stress test to ensure that plausible risks do not make it economically unviable.

Rating +
The project explicitly discusses the possibility of unexpected impacts and performs a systematic analysis of uncertainties that informs contingent planning in case of unanticipated changes.

resilience *through* the project

C — The project is a development project that increases local incomes, reduces poverty, or provides beneficiaries with improved infrastructure or financial services.

B — The project includes resilience-building activities and reduces identified vulnerabilities (adaptation co-benefits).

A — The project is transformational in improving resilience, with impacts beyond direct outputs through improved institutions, policies, incentives, technologies, or capacities.

Rating +
The project monitors and tracks the progress of resilience-building activities through at least one climate indicator that is embedded in the project's monitoring and evaluation strategy.

The impact of resilience on the welfare of vulnerable people is not being captured in decision-making

A specific area of focus for resilience and investment decision-making is how resilience enhances the welfare of vulnerable groups. Shocks and stresses have significant impacts on the wellbeing of our communities and some groups are more vulnerable to the impact of these shocks and stresses than others, such as those with specific health needs or those experiencing economic or housing insecurity. For example, emotional stress, trauma and anxiety can occur when older people or residents at health facilities are reliant on electrical medical equipment or air conditioners that may fail in energy supply interruptions. [81] As the damaging effects of

climate change increasingly impact upon our infrastructure, these vulnerabilities will continue to be exposed.[82]

Infrastructure failure also has indirect social and economic impacts on business, livelihoods and community structure. Small and medium enterprises are vital to local and regional economies, but often lack the social and financial resources to recover quickly. This can have lasting economic impacts on local communities.[83]

Private capital is increasingly demanding assurances and consideration of resilience

Like governments, the financial sustainability of private investment is reliant on ongoing and efficient operation. Accordingly, the private sector has an incentive to make decisions that align with the best disaster and climate risk guidance and data.

The private sector has been leading efforts to forecast climate and disaster risk through collaborative programs like the Climate Measurement Standards Initiative.

Industry collaborations are similarly seeking to influence more sustainable and resilient investment. Responsible Investment Association Australasia brings together most major infrastructure investors, delivering tools, education and advocacy for long-term, responsible investment and sustainable capital markets.[84]

Insurers similarly recognise that often 'prevention is better than cure' and are seeking to influence a more resilient built environment for safer communities.[85]

A consistent approach to valuing resilience would enable governments and agencies to align and better leverage the significant private capital pursuing good-quality infrastructure investments. Governments that do not incorporate resilience risks into their investment assessments may deter significant private capital investments, and private partnership opportunities.

6.1.2   The opportunity

There is an increasing appetite for change

There is an appetite and momentum for changes to investment decision-making processes. The Australian Government and state and territory governments have indicated policy support for embedding resilience into investment decisions but have not yet developed standards and methodologies to do so. They are at differing points in embedding resilience into their frameworks and there are varying degrees of maturity across infrastructure bodies' guidance and assurance processes.

Some examples of momentum building at a state-level include:

- The NSW *State Infrastructure Strategy 2018–2038* identifies approaches to natural hazard and climate change risk and recommends embedding consideration of risk and resilience in business case guidelines, capital asset planning and assurance processes.[86] Infrastructure NSW and NSW Treasury provide *Guidelines for Resilience in Infrastructure Planning; Natural Hazards.*[87] With a focus on natural hazards, it points to sources including the *Common Planning Assumptions Book* and identifies methods of valuing benefits and costs of potential interventions ranging from sensitivity analysis to real options analysis.[88]

- The Infrastructure Australia Assessment Framework, released in July 2021, provides new, practical guidance for considering resilience in project development processes. It encourages proponents to embed resilience considerations from planning through to implementation, with the aim of improving resilience outcomes by considering shocks and stresses during each of the Assessment Framework stages.

- The Queensland Government's *Business Case Development Framework* outlines requirements for considering resilience at assessment stages throughout business case development. [89] Project proponents are required to consider broader resilience issues in cost-benefit analysis (via sensitivity and scenario testing) and qualitatively in socio-economic and sustainability appraisals.

- The Victorian Department of Treasury and Finance's business case framework provides high-level guidance for the consideration of climate and resilience impacts as part of project evaluation. [90] The *Climate Change Act 2017* (Vic) requires any decision, policy, program or process made, developed or implemented by the Victorian Government to take account of climate change by having regard to the policy objectives and the guiding principles of the Act.[93] [91]

- The *Climate Risk Ready NSW Guide* (2021) provides practical guidance for the NSW Government sector to assess and manage climate change risks. The Guide sits alongside the objective of the NSW Government to reach net zero emissions by 2050 as outlined in the Net Zero Plan Stage 1: 2020–2030.

Box 11 provides an example of work led by Infrastructure Australia which has led to a collaborative piece of work with the Queensland Government and Infrastructure NSW. It maps the breadth of work occurring in the sector by governments, states and territories and the private sector to advance the consideration of climate and disaster risk. The aim is to incorporate these findings into strategic planning, decision-making and assessment frameworks. This work showed that government agencies and the private sector are dedicating significant resources to achieve this goal.

Momentum is also building in the private sector in Australia and globally, with initiatives such as the Task Force on Climate-related Financial Disclosures, Resilience Valuation Initiative, and the Australian Sustainable Finance Initiative. Advanced industry guidance is continuously being improved, including the development of standards for resilience and adaptation from the Infrastructure Sustainability Council of Australia, Green Building Council of Australia and the Australian Business Roundtable. These developments should also be harnessed for application to the public sector.

Box 11: Case Study – Infrastructure Bodies' climate risk workshop

In June 2020, 40 people representing 19 organisations from the Australian Government, state and territory governments, academia and industry participated in an online collaborative workshop to map current climate risk research associated with infrastructure planning and decision-making.

The aim of the workshop was to:

- advocate for coherency and consistency in climate risk assessment and appraisal, while recognising that these are evolving processes based on new evidence and international guidance
- share information about project overlaps, information sharing barriers, best practice, and new assessment guidance and decision-making tools
- identify opportunities for collaboration and information sharing between the public and private sector, cross sectoral and inter-jurisdictional projects
- identify owners and partners for further research on climate risk, to facilitate the embedding of best practice climate risk in strategic planning, decision-making and assessment frameworks.

The workshop is part of the partnership between Infrastructure Australia, Infrastructure NSW and Building Queensland, which is seeking to take a system-wide view to embedding climate risk in infrastructure planning and decision-making. Participants identified 72 projects relevant to current climate risk research associated with infrastructure planning and decision-making.

Projects include:

- CSIRO/Value Advisory Partners Integrating Systemic Risk into Investment Decisions
- Resilient Investment Vehicle project (a collaboration of IAG, NAB, Emergency Management Australia, Queensland Reconstruction Authority, and Resilience NSW and CSIRO)
- Coalition for Climate Resilient Investment
- Minderoo Foundation Resilient Communities Initiative
- Climate Measurement Standards Initiative
- Climate-KIC Adaptation Finance Project
- Australian Sustainable Finance Initiative Roadmap.

Agreement is needed on how to value resilience in decision-making

An agreed methodology and guidance on how to value resilience in decision-making through the infrastructure lifecycle is critical. There is a need for a nation-wide approach to quantifying risk, costs, benefits and performance of resilient assets and places, to develop the business case for investment. This work should be aligned across jurisdictions, referenced in policies, and embedded in assessment frameworks and processes.

To be effective, infrastructure assessment frameworks across the country should require projects to demonstrate how they address risks in their designs to ensure infrastructure contributes to community resilience. At a minimum, assessment frameworks will need to incorporate the elements set out in **Figure 8**.

Figure 8. Considerations for infrastructure assessment frameworks

Gather and consolidate data on disaster and climate risks, and plausible scenarios and infrastructure dependencies → Incorporate resilience into business cases methodologies → Develop and incorporate supporting information → Outline resilience monitoring of goals and objectives → Create adaptive methodologies
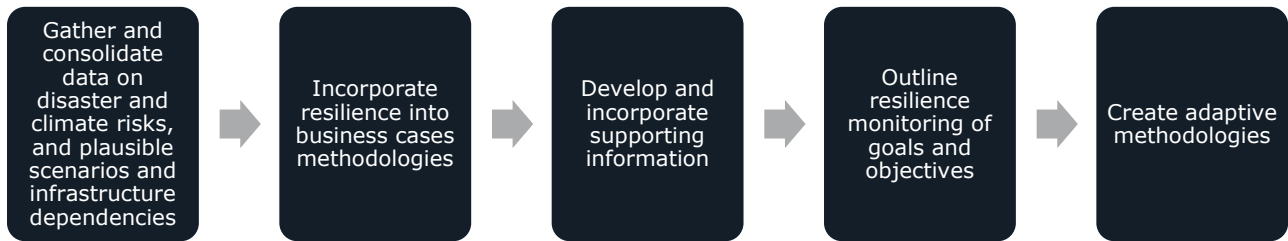
Integrating resilience into infrastructure decision-making will require a process of continuous improvement and refinement. As our understanding of resilience evolves, ongoing investment will be needed to develop detailed advice on appraisal methodologies for different infrastructure sectors and approaches to quantifying different types of costs and benefits.

6.1.3   The direction

An agreed methodology and guidance on how to value resilience in decision-making through the infrastructure lifecycle and the development of a nation-wide approach to quantifying risk, costs, benefits and performance of resilient assets and places is critical. This work should be aligned across jurisdictions, referenced in policies, and embedded in assessment frameworks and processes.

All sectors, governments, asset owners and operators and communities will need to cooperate and coordinate. This will necessitate formal governance arrangements, resourcing and convening national authorities, and state and territory and local agencies who lead the work within jurisdictions. A cross-jurisdictional community of practice would share information, best practice, develop connections and networks and facilitate a culture that encourages valuation of resilience in infrastructure investment.

6.2   Collect and share information on asset and network vulnerability

At a glance

Information on the interdependency of infrastructure assets is typically not available, partly because of governance and data sharing arrangements.

Failure to understand and manage asset interdependencies can lead to cascading impacts.

Governance and data sharing arrangements should be reviewed to enable sharing of interdependency asset information across all levels of government and the private sector.

There is opportunity to build on existing asset interdependency information systems and integrate them with new developments (such as 'digital twins') to create a portal that enables decision makers to make informed decisions about service delivery and network operation before, during and after shock and stress events. This effort would require inter-jurisdictional collaboration.

6.2.1   The problem

No infrastructure asset exists in isolation, and there is a high and growing degree of interdependency and vulnerabilities in the infrastructure system. Failure to understand and manage these interdependencies can lead to cascading impacts. [92]

Interdependencies exist between sectors and failures lead to cascading effects

While infrastructure networks are interconnected, assets are typically operated individually within sector silos and asset-class silos. This is a result of current governance arrangements, legacy systems for communication and operational control, and privacy, commercial and security concerns related to sharing asset information.

Within each sector, multiple asset owners and operators work together and rely on each other to deliver services to the community. For example, road networks include state-owned roads, locally owned roads and privately owned roads.

Multiple interdependencies also exist between sectors. The delivery of one service is critical for the continuity and performance of another sector. For example, electricity is required for communities to receive telecommunication services. **Figure 9** displays the already complex interrelationship between the electricity sector and other infrastructure sectors.

Figure 9. Sample electricity supply interdependency model [93]
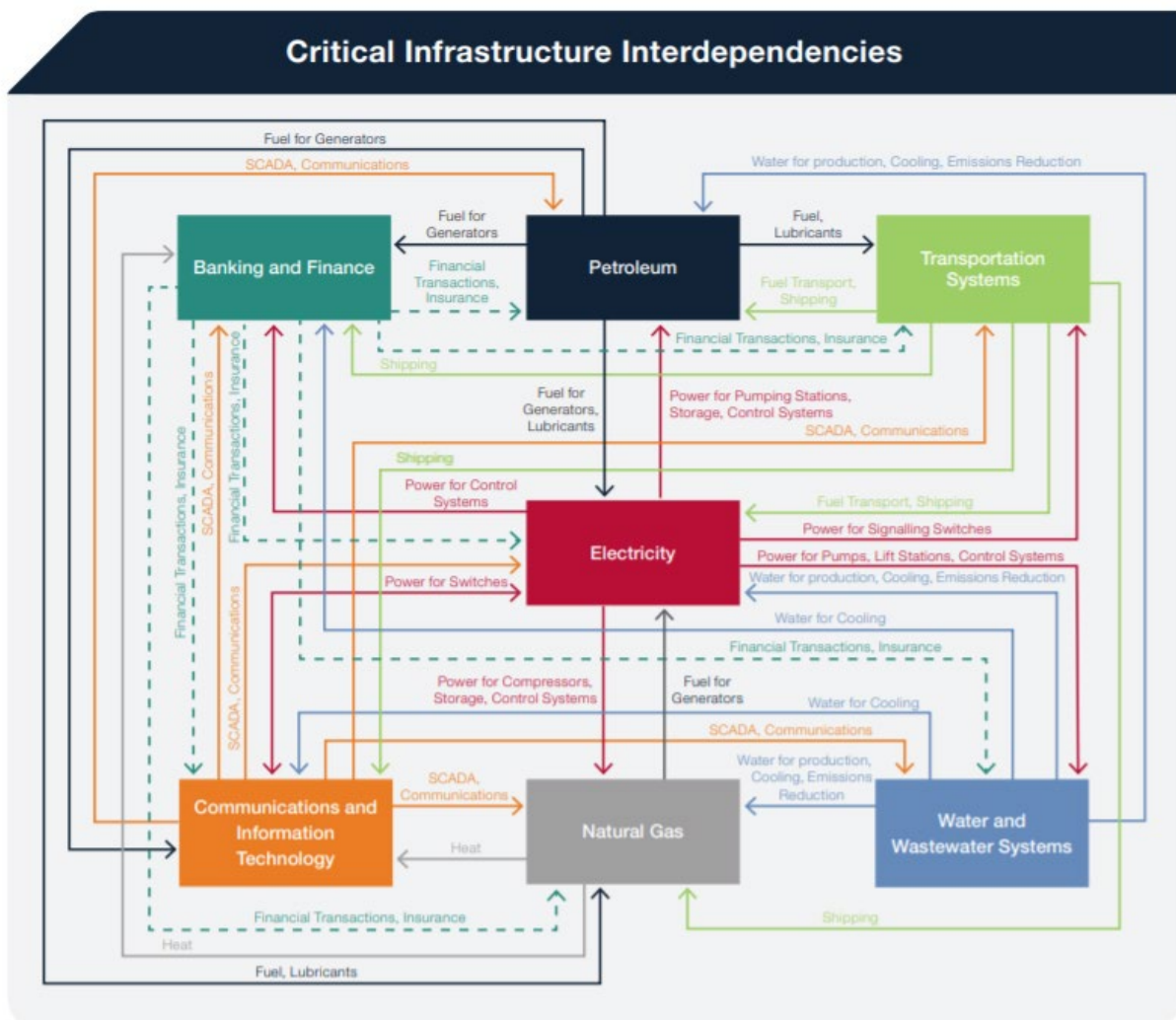
In addition, the increasing interdependencies between physical and digital assets can expose the system to cyber-attacks, leading to compounding impacts. The need to identify and manage cyber risks is a key resilience consideration.

During the Victorian COVID-19 lockdown, there were cascading impacts between transport, social infrastructure and waste sectors. For example, a medical waste incinerator in Victoria could not operate because staff were in Queensland and not permitted to return due to border restrictions.

During the 2019–20 bushfires these interdependencies were clear. Damaged powerlines caused power outages to mobile telecommunications towers, which then disrupted mobile telephone coverage (of 888 telecommunication outages between December 2019 and January 2020, 779 (88%) were caused by mains power outages[94]).[95] These in turn affected ATMs and EFTPOS machines, which became disconnected from the internet, meaning people could not pay for the fuel they needed to be able to evacuate.[96]

The City of Sydney has identified interdependencies on the city's rail corridor, which runs through the city from the north to the south. If Green Square station were disrupted – for example, by flooding or fire – it could stop 70% of trains from running on the line. If this were to occur, there could be unknown cascading impacts to services on the motorway, airport, substations, broader rail network and road network.[97]

The implications of cascading impacts can be even more severe. Cascading impacts could jeopardise the ongoing operation of critical assets, supply chains, evacuation routes, telecommunication methods and technology on a temporary or permanent basis. As a result, communities and business owners could encounter significant social and economic issues, leading to broader potential concerns about Australia's national security.

Interdependencies will increase

As our reliance on technology grows, our infrastructure sector will become more interconnected. Electrification of assets (such as electric vehicles) will forge new links between the energy and transport sector. Hydrogen production and export, if realised, will place increased pressure on our ports.

Interconnectivity has benefits for communities' quality of life, access to services and affordability. However, increasing connectivity and interdependency of systems creates a corresponding and growing networked vulnerability.[98]

Information on interdependencies is limited and rarely shared

Interdependencies both within and between sectors are often not well understood, which increases vulnerabilities. During our workshops, stakeholders highlighted this challenge:

> As a country, we don't have a good understanding of how X depends on Y. Specifically, if a certain element of the banking system was damaged [by any hazard], we don't really know what that would mean for buying food or a train ticket.[99]

Compounding the problem is that different sectors use different methods to interpret and measure risk. Shared understanding of potential impacts to interconnected systems, where it exists, is typically limited to high-level generalised information.

While there have been simulation exercises to increase awareness and understanding of the consequences of service disruption, stakeholders note that 'improving sharing of information of these cross-sector exercises and silos need to be addressed.'[100]

Asset dependency information and communication of this information is key to creating resilient critical infrastructure.[101]

Sharing of real-time service disruption information between sectors can be improved

Better sharing of information on real-time service disruption is needed to improve cross-sectoral planning, enable infrastructure networks to respond together in a crisis and identify alternative service delivery mechanisms.

For example, telecommunication providers currently rely on publicly accessible information to ascertain power status, time estimated to complete remedial works and priorities for fixing the electricity network. [102] Conversely, energy providers have struggled to identify which telecommunication providers own particular assets, causing issues with notifying the correct party before a scheduled or forced power outage. [103]

Shocks and stresses do not account for borders. Stakeholders who operate assets and networks near state or territory borders had difficulty accessing information on the other side of the border. During the 2019–20 bushfires asset owners did not have complete information on cross-jurisdictional transport networks. As a result, communities were not able to make informed decisions about how to evacuate.

6.2.2   The opportunity

Programs already in place have formed a comprehensive and engaged network of infrastructure asset owners across government and the private sector. There is opportunity to build on existing asset interdependency information systems and integrate them with new developments such as 'digital twins' (digital replicas of infrastructure assets) to create a portal that enables decision makers to make informed decisions about service delivery and network operation.

The ideal resilience asset information portal

A portal that shares information on asset interdependency would allow decision makers to plan and anticipate the effect of their decisions on the resilience of any place, network or asset across Australia, and fluidly communicate with industry, all governments and communities before, during and after a disaster.

Rather than a single system, the portal would draw on an ecosystem of existing asset information systems and ensure they are able to exchange information and 'talk to each other'. The platform would also enable stakeholders across states, territories and private industry to come together to map interdependencies, which would have the added benefit of contributing to organisational and systemic resilience.

A data portal should be intuitive and quickly accessible through mobile technology and during telecommunication disruptions. Platforms should be interoperable, both intra-jurisdictionally and inter-jurisdictionally.

The data management portal should be accompanied by interactive visualisations, examples of how the data can be used, and documentation of sources and underlying assumptions. This can support decision makers and the public to interpret the data. Data visualisations should be consistent and comparable across all jurisdictions.

The portal could consider the use of and linkage to digital twins. NSW Spatial Services is already developing the NSW Spatial Digital Twin, upgrading two-dimensional maps of infrastructure assets into four-dimensional models (3D plus time). The portal could also consider linkage to live data feeds using remote sensing technologies, and tracking systems to report on assets, environments and communities.

The portal could benefit from use of artificial intelligence and fuzzy logic to support processing and interpreting data from many data sources.

Building on existing efforts

Substantial national, state and territory efforts have been made to identify and share interdependency information on critical infrastructure. National projects include the Trusted Information Sharing Network (TISN) and the Critical Infrastructure Program for Modelling and Analysis. Various state and territory and local governments also have emergency asset databases, or asset databases across different infrastructure sectors. The ideal platform would draw on these databases and bring them together.

TISN's information helps to prepare for natural disaster, however, it lacks the ability to coordinate response and facilitate information sharing during a disaster. [105] The Department of Home Affairs is updating the TISN to provide better coordination between assets owners and operators during shocks and stresses.

Strong governance is the key to overcoming concerns about data sharing

Consideration and management of privacy, data security, national security, and commercial-in-confidence data concerns will be needed to overcome key barriers to sharing of information.

Reform of governance and coordination arrangements for sharing information between critical infrastructure operators and governments will need to be cognisant of overlap and duplication with existing emergency management arrangements. This will require consolidation into a framework for cross-sectoral and inter-jurisdictional coordination. [106]

6.2.3   The direction

A new portal is needed that draws on existing asset interdependency information systems and integrates them with new developments (such as digital twins). This portal should enable information sharing, communication and coordination before, as well as during, disasters for any asset across Australia. An inter-jurisdictional review should be completed into the governance and data sharing arrangements needed to enable such a system.

6.3   Value blue and green infrastructure

At a glance

Blue and green infrastructure (that is, waterways and greenspace) is often overlooked and undervalued as infrastructure. However, the ecosystem services it delivers such as water purification, air quality, soil formation, food production, space for recreation, and climate mitigation and adaptation are vital for resilience.

These potential resilience benefits are often not realised because this type of infrastructure is often not adequately valued for its contribution to reducing risk. Other barriers include lack of coordination across levels of government, as well as challenges in determining how to share the costs and benefits of blue and green infrastructure across 'owners' and 'users'.

There are opportunities to realise the resilience benefits of blue and green infrastructure by:

- improving strategic planning and setting overall objectives for blue and green infrastructure as an asset class
- developing a standardised, agreed methodology for valuation of the benefits, including mapping and quantification of ecosystem services
- embedding traditional Aboriginal and Torres Strait Islander land management processes in infrastructure planning to enhance the quality of natural environments.

6.3.1   The problem

The current scale of biodiversity decline and habitat loss in Australia runs counter to the objectives of national plans (such as Australia's Strategy for Nature) and obligations under international agreements like the UN Convention on Biological Diversity. Current approaches to conservation planning in Australia, including biodiversity offsetting, have limited effect in meeting these goals and obligations.

Blue and green infrastructure is not adequately valued for its contribution to reducing risk and so potential resilience benefits are not realised. A lack of coordination across levels of government, as well as challenges in determining how to share the costs and benefits of blue and green infrastructure across 'owners' and 'users' exacerbates this.

Blue and green infrastructure is not adequately valued for its contribution to resilience outcomes

Blue and green infrastructure provides multiple benefits, including:

- reducing a community's vulnerability and exposure to an extreme weather event [107]

- mitigating the impacts of climate change and providing adaptation benefits

- improving the overall quality of urban and rural environments. [108]

Natural assets provide ecosystem services that can complement traditional infrastructure-related services or offset the need for physical investment. Trees and green cover can promote urban cooling effects, carbon capture, stormwater mitigation, healthy waterways and surrounding environments can assist in water filtration – both instances that could offset traditional physical infrastructure investments. In the regional context, farmlands can contribute to resilience and ecosystem services through water filtration, aquifer recharge areas, carbon sinks, and the provision of food and fibre.

In the context of a changing climate, it is projected that in NSW, by 2061, between 700,000 and 2.7 million additional days of work will be lost every year due to the higher frequency and intensity of heatwaves [109]. As such, the urban cooling benefits of trees and green cover in urban areas can offset the physical infrastructure that will otherwise be needed to support communities.

Green and open space (including beaches and parks) along with other public space (libraries and community centres) play a significant role in the emergency response and recovery. For example, these spaces have built community resilience through providing spaces to connect during the pandemic and through multi-purpose places of refuge during natural disaster events.

Quality and accessible public open space plays an integral role in addressing underlying stresses, such as low levels of social cohesion, that in turn build community resilience. Well-designed public open spaces can build a sense of belonging, encouraging greater social interaction, enjoyment and positive behaviours by providing welcoming, safe and inclusive settings that can be enjoyed by all.

Infrastructure decisions can preserve biodiversity, create green space and enhance and enable ecological connectivity. As a result, the vulnerability and exposure of communities to extreme weather events, in many cases, can be reduced.

Despite the many social, economic and environmental benefits of blue and green infrastructure, the value is not well quantified or documented in decision-making processes in a similar way to other types of infrastructure. [110] This results in challenges to funding blue and green infrastructure when it is treated in isolation in decision-making processes. [111]

Consequently, the services that blue and green infrastructure provides, and the related resilience benefits, are not often considered as part of a resilience response.

The importance of valuing this kind of infrastructure has been in part acknowledged in the New South Wales context, with the NSW *Greener Places* framework stating that green infrastructure "…is essential and needs to be considered as an asset in its own right".[112]

Accurately valuing blue and green infrastructure, in addition to nature-based assets, will enable the protection of existing natural environments and enable the inclusion of blue and green infrastructure in new infrastructure.

There is a lack of coordination across levels of government

The 2019 *Australian Infrastructure Audit* notes that there is a lack of coordination across levels of government for the effective planning, delivery and maintenance of blue and green infrastructure.[113] All levels of government and private landowners have a role to play in the provision of blue and green infrastructure – however, there is significant difference in responsibilities, resourcing and capabilities between stakeholders. This often results in ad-hoc outcomes.[114]

As a result of this lack of coordination, there is limited strategic direction for blue and green infrastructure. Despite recent progress (see **Box 12** for the national context and **Box 13** for the New South Wales context), further work is needed to articulate a clear objective and strategic direction from government in some jurisdictions for the blue and green and nature-based assets as part of our infrastructure networks. Current approaches differ across jurisdictions and are at different levels of maturity.

Box 12: National policy context for blue and green infrastructure

The protection and enhancement of blue and green infrastructure and the biodiversity it supports is reflected in Australian and state-based policies.

These include for example:

- Australia's commitments under the UN *Convention on Biological Diversity*
- *Environmental Protection and Biodiversity Conservation Act 1999* (Cth)
- Australia's Strategy for Nature (2019–2030).
- Smart Cities Plan, City Deals, and the Smarts Cities and Suburbs Program, which all envision productive, liveable and green cities.[1]

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Box 13: NSW policy context for blue and green infrastructure

Greener Places was developed by the NSW Government Architect as a best-practice guide for the planning, design and management of green infrastructure, to contribute to better places. The design framework and design guide will be incorporated into the new **Design and Place State Environment Planning Policy** to provide direction for planning and development at state and local government levels.

With a particular focus on open space for recreation, urban tree canopy and bushland and waterways, the *Greener Places* design guide bolsters the Urban Green Cover in NSW Technical Guidelines[1] with a view to optimising green infrastructure for people, adaptation and resilience, and habitat and ecological health.[1]

The ***Practitioner's Guide to Movement and Place*** sets out a process and evaluation method to achieve a well-designed built environment. Blue and green infrastructure should be considered to deliver improved biodiversity, environmental protection, vegetation cover, tree canopy and access to waterways.

Both *Greener Place* and the *Practitioner's Guide to Movement and Place* support the **Premier's Priorities for a Better Environment**:
- Greener public spaces: Increase the proportion of homes in urban areas within 10 minutes' walk of quality green, open and public space by 10%by 2023
- Greening our city: Increase the tree canopy and green cover across Greater Sydney by planting one million trees by 2022.

The **Sydney Green Grid** is an integral part of the Greater Sydney Region Plan and District Plans, offering an interconnected network of green spaces to keep the city cool, promote good health and well-being, enhance biodiversity and ensure ecological resilience in the face of climate change and urbanisation.

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There is limited balancing of the costs, benefits and risks of blue and green infrastructure

The fragmented ownership of the costs, benefits and risks is a barrier to protecting the existing blue–green infrastructure network and investing in new blue and green infrastructure assets. While landowners bear costs of blue and green infrastructure (such as water and maintenance), the community receives the resulting benefits in health, productivity, cultural significance, biodiversity and property value.

There is no clear policy framework set by governments that enable decision makers to make planning decisions that balance and allocate the benefits of enhanced urban amenity, against the additional costs (and responsibility for them) that may be incurred, and at the temporal and spatial scales they may occur.[115] Some policies focus on the benefit, while others focus on the cost, which increases barriers to achieving the best overall outcome. For example, the effective use of planting masterplans and tree corridors with careful species selection can reduce bushfire hazard, as well as provide ecological and social values.[116] However, in some bushfire hazard management policies, trees are classified as 'elevated fuel' for fires and are classified as a liability.[117]

6.3.2   The opportunity

There are opportunities to realise the resilience benefits of blue and green infrastructure by developing a standardised, agreed methodology for valuation of the benefits and embedding traditional Aboriginal and Torres Strait Islander land management processes to enhance the quality of natural environments.

A standardised valuation mechanism is needed

A standardised approach to valuing blue and green infrastructure would enable its value to be weighed against other alternative priorities. Efforts to develop a standardised valuation mechanism should ensure alignment between national, state and territory governments.

It *is* possible to demonstrate and even quantify the value of blue and green infrastructure. By way of example, studies have shown that a 10% increase in tree cover over a single dwelling can save $50 per year due to the reduced need for air-conditioning. [118] Additionally, the estimated economic value of Victoria's parks network provides $46 million per year in flood protection benefits from avoided infrastructure costs alone. [119]

A step forward would be to:

- recognise the value of blue and green infrastructure (for example, through recognising it as an asset class)
- establish an agreed methodology for valuation of the benefits.

This would unlock the potential for investment in blue and green infrastructure options that could complement traditional infrastructure-related services or offset the need for physical investment.

Improved valuation mechanisms would also reduce the risks related to fragmented ownership of the costs and benefits.

A valuation mechanism may require the mapping and quantification of ecosystem services (such as water purification, food production and climate mitigation) provided by blue and green infrastructure across Australia as well as calculation of the value of those ecosystem services. In undertaking this work, ecosystem services could be mapped, quantified and valued at a granularity that enables the data to be used to inform planning and decision-making at a national, state and territory, regional (subregional) and local scale.

In addition, there is the opportunity to gain lessons through consistent and coordinated monitoring, evaluation and reporting of the performance of Australia's blue and green infrastructure and its contribution to ecosystem services or broader benefits. The community could draw on this data to inform decisions (see **Box 14**). Another data gap to address is the limited understanding of where communities and livelihoods are most at risk as a result of natural capital loss.

> ## Box 13: Example methodology for valuing natural capital assets
>
> ### NSW Natural Capital Assessment Methodology
>
> The emerging Natural Capital Assessment Methodology seeks to enable natural capital to be measured and valued in an economic accounting context. The program aims to develop practical guidance, and decision-support tools and processes to help private and public-sector parties fully integrate natural capital thinking in their activities.
>
> ## Example of monitoring green infrastructure values
>
> ### NSW Forest Monitoring and Improvement Program
>
> Under the NSW Forest Monitoring and Improvement Program, work is currently underway to define baselines, trends and drivers that will provide a better understanding of factors influencing change in New South Wales forests (both private and publicly owned).
>
> These will be based on a range of scenarios for the future of New South Wales forests. These will include alternative futures that emphasise different forest values and community expectations from the short to long term. Projected changes in climate will be incorporated into all scenarios.

Traditional land management can be used to enhance the quality of the natural environment

There is opportunity to embed traditional Aboriginal and Torres Strait Islander land management processes to enhance the quality of natural environments. Strong natural environments can reduce community vulnerabilities to natural hazard events (for example, mitigating extreme heat) and reduce underlying stresses in communities.

Section 7.2 outlines opportunities for better collaboration with Aboriginal and Torres Strait Islander peoples.

6.3.3   The direction

Protecting and enhancing blue and green infrastructure can improve resilience outcomes. This can be achieved by:

- improving strategic planning and setting overall objectives for blue and green infrastructure as an asset class

- developing a standardised, agreed methodology for valuation of the benefits, including mapping and quantification of ecosystem services (such as water purification, food production and climate mitigation) provided by blue and green infrastructure across Australia

- embedding traditional Aboriginal and Torres Strait Islander land management processes in infrastructure planning to enhance the quality of natural environments.

7 Opportunities at the Community level

7.1 Build trust through more inclusive decision-making

At a glance

Engagement processes undertaken in the development of infrastructure do not effectively capture communities' views on resilience, experiences of shocks and stresses and community knowledge on effective solutions. Where engagement processes do exist, they can be inadequate and poorly structured or resourced, eroding trust in decisions and planning.

Communities need to be included and informed about risk and uncertainty as it relates to infrastructure services and their livelihoods. This will allow active participation in determining a range of possible outcomes and the required trade-offs to achieve them.

Infrastructure investment policies need to facilitate inclusive, accessible practices to increase community participation and buy-in to infrastructure decisions. There are opportunities to increase trust by reducing siloed efforts through place-based engagement and targeted measures to improve inclusiveness.

7.1.1 The problem

Limited involvement of communities in infrastructure decision-making processes can lead to poor resilience outcomes.

These outcomes occur when:

- there is mistrust between government and communities

- communities' lived experiences and knowledge of shocks and stresses are overlooked

- community awareness of risks is limited.

The difficulty for governments is resourcing and coordinating effective engagement.

Lack of trust in institutions is a barrier to addressing resilience challenges

Mistrust between government and communities prevents governments from understanding the needs of communities and gaining community buy-in. This acts as a barrier to effective delivery of the measures required to build resilience.

Currently, land use, infrastructure and emergency planning decision-making, and assurance processes across government, infrastructure asset and network owners and operators do not typically effectively engage those affected or interested in ways that enhance resilience. [120]

Strong relationships are increasingly important as resilience challenges worsen, and yet the trend for increasing complexity has coincided with declining levels of trust in governments across the world. [121] For example, mistrust caused diverse global reactions and outcomes to COVID-19. Health advice was dismissed due to community members ignoring advice given or the authority of those providing it. [122] In Australia, people ignoring, or distrusting government advice hindered rescue efforts during the 2019–20 bushfires.

Low levels of trust and social licence translate into costly community opposition. The estimated cost of community opposition to infrastructure projects on the east coast of Australia over the past decade is $20 billion, due to projects being delayed, cancelled or completed differently to

how they were originally intended.[124] Research by Western Sydney University found that two of the factors most strongly correlated with community resilience were 'community decision-making and trust' and 'trust in industry decision-making'.[125]

In the future, in extreme circumstances, entire communities may need to be relocated to avoid harm from extreme weather or coastal inundation – trust will be required to achieve this. These are hard realities for communities to bear and uncomfortable truths to face for decision makers. However, if based on the right information and systems thinking, it will be in the best interests of the community. **In a climate of unavoidably difficult and unpalatable decisions, communities need to be included and informed**.

Communities tend to be supportive of the projects or plans they design and influence.[126] Engagement can improve trust and social licence to operate, produce higher levels of satisfaction with decision-making processes, and build stronger trust between communities and governments.[127]

Community's lived experience of shocks and stresses are not adequately valued in decision-making

There is a tendency to inform rather than consult communities and governments often fail to capture deep community knowledge about local problems and possible solutions.[128] Rather than using local expertise to find the best solutions, engagement is frequently seen as a way of getting buy-in to a decision and minimising opposition.[129]

Communities have lived experiences of the stresses and shocks in their local area (their 'place') and are often experts in the way things 'work on the ground', and how this aligns with community values and priorities. This is invaluable for answering critical questions for effective decision-making. While a potential policy or project may be possible, the community can help decide whether it is desirable, makes sense, will work in practice, should be trusted and if it will meet their needs.[130] Only communities possess this valuable knowledge.[131]

Community participation is also useful in addressing complex problems where there is technical disagreement about goals and management options and a complicated, interacting set of challenges that cannot be addressed in isolation from one another.[132] For example, climate change, the risk posed by natural hazards and the desire to safeguard communities' quality of life are often in conflict. Studies have found processes that seek a wide spectrum of views, enabling participants to understand both technical issues and the range of values and interests at play are successful in these situations.[133]

Communities need support to understand risk and uncertainty as it relates to infrastructure services so that they can actively participate in determining best possible outcomes and any required trade-offs to achieve them.

Limited community involvement in decision-making limits understanding of risks

Limited involvement of community in decision-making is a missed opportunity to build the community's understanding of key risks and resilience challenges. This in turn influences how communities react to shocks and stresses and respond to government advice.

Community understanding of hazards and risk is often low and communities need more information to understand what is expected of them during a shock or stress event. Local behaviour is critically important to disaster management and response.[134] Stakeholders commonly described a locally led response as one of the strengths of the disaster management system and a foundational principle.

Good engagement is resource intensive

Building trust through sustained engagement is challenging. It is resource-intensive and requires collaboration with other organisations engaging with the same communities. Finding community members willing to be involved in long-term engagements is difficult, but the benefits are significant. Building trust enables infrastructure asset and network owners and operators to provide far deeper insight into community needs than might otherwise be gained. It builds adaptive capacity and increases resilience. [135]

The more sophisticated and truly participatory the approaches are, the more complex and resource-intensive they become. With limited budgets and compressed timeframes, engagement that does justice to this can be challenging.

7.1.2   The opportunity

Improving resilience and achieving the vision in **section 1.5** can be achieved through effective and meaningful engagement with the communities and businesses affected by the infrastructure decisions being made. Engagement that is more effective in meeting communities' needs can be achieved through:

- improved governance and coordination
- place-based engagement across strategic infrastructure planning agencies and at each stage of the infrastructure lifecycle.

Effective engagement occurs when communities are given the necessary tools and appropriate environments to participate. This includes tailoring engagement processes to be inclusive and representative and providing communities with good data and information to make sound decisions. There is an opportunity for government to build on the high levels of trust gained through the response to the COVID-19 pandemic.

Improving governance and coordination across infrastructure strategic planning

To achieve meaningful place-based engagement, participation needs to be heightened at the strategic planning phase, where the place-based, asset and network needs of projects are identified, and then throughout the infrastructure lifecycle.

Communities are not always involved during early decision-making phases where strategic directions and intent is established. [136] Instead, communities are mostly engaged at the design and delivery stages of infrastructure projects. This can lead to opposition to changes that reflect broader strategic decisions communities have not been part of, impacting relationships between communities and decision makers and lowering levels of trust. [137]

Improving governance and coordination across infrastructure planning and strategy can help address the challenges of fragmented governance, such as how governments communicate with communities, including: under and over communication and engagement; siloed communication; and confused messaging.

Research has found strategic policy settings are important for embedding effective community engagement in decision-making. This is because they set a consistent understanding and expectation of engagement both for organisations and the public until such time as good practice is accepted as business as usual. [138]

Transparent commitment to engagement is needed, both for organisations making strategic plans for infrastructure delivery (including land use, strategic infrastructure and sectoral line agencies, such as state transport or school infrastructure departments) as well as those designing, delivering and operating individual projects.

Incorporating place and asset interdependency into engagement

Collaborative place-based strategic planning will enable infrastructure to play its part in meeting the needs of local communities and creating resilience (see **Section 5.1**). For example, in addition to engaging about a road upgrade, transport asset owners and operators could gather community input into place-based transport solutions more broadly and discuss cross-sectoral benefits. Opportunities should be identified in existing engagements to incorporate systems thinking and more holistic elements that speak to the resilience productivity, growth and quality of life of the community, and not only to those projects currently underway.

Engagement will only be effective with community trust. To support a community's readiness for change, the project needs to be communicated in a way that builds ongoing trust with the community and is not viewed as a distraction or burden.

Project assessments should set engagement requirements throughout the project lifecycle

Governments and proponents should undertake meaningful stakeholder engagement at each stage of the project development process – from identifying the problem, developing options, project delivery to post-completion review.

While most authorities and asset owners have engagement strategies in place, their effectiveness is not often assessed over the longer term. Engagement is frequently a one-off activity, focused around a project or initiative and not linked or connected to other activities within a community.

Assurance process owners (that is, those who assess infrastructure projects to grant funding and development approval) should provide clarity around what they expect from proponents. Engagement requirements should be clearly expressed in requirements for environmental and social impact assessments and infrastructure assessment frameworks.

Engagement should not end once a project is delivered or completed. Governments should commit to, develop and release post-completion reviews to evaluate whether the intended outcomes have been delivered for the community.

A one size fits all approach reduces inclusivity

A genuine commitment to accessibility and inclusivity acknowledges one size does not fit all. Engagement is most effective when it is tailored to the kind of decision being made and the capacities and needs of the target community.

Shocks and stresses affect communities and individuals in different ways. Often the most vulnerable and disadvantaged are also the most impacted. It is important that engagement reflects this reality.

Engagement processes are not as inclusive as they should be. [139] Some groups can be under-represented in engagement activities – particularly those who speak different languages or lack the time and money required for participation because of socio-economic vulnerability. [140] The quality of citizen engagement improves when processes value fairness and equity, encourage people from diverse backgrounds to participate, and make it easy for them to be involved. [141]

Effective engagement may need to be tailored for different groups, for example, to provide culturally appropriate engagement with Aboriginal and Torres Strait Islander communities. It has also been suggested that there is a need to move beyond passive terms such as 'engagement' and 'consultation', to active terms such as 'involvement' and 'participation' of the community in decision-making. [142] Using this kind of language could set clear expectations for both parties.

The importance of this is acknowledged by the Australian Government's *Multicultural Access and Equity Policy Guide.* [143] This guide suggests the need to establish forums for engaging with multicultural groups and including people from diverse cultural and linguistic backgrounds on advisory and review bodies to ensure the diversity of the Australian population is reflected in decision-making. [144] Other programs, such as the *National Emergency Management Strategy for Remote Indigenous Communities: Keeping Our Mob Safe*, have been designed specifically to meet the needs of Aboriginal and Torres Strait Islander communities.

Inclusivity is a foundation for effective engagement. A good example of this is the CSIRO-facilitated research that created the *Our Knowledge, Our Way 2020* best practice guidelines, which outline Aboriginal and Torres Strait Islander-led approaches to strengthening and sharing knowledge of land and sea management. [145] It focuses on co-creation, on building relationships through shared understanding, and on the opportunities for innovation and transformation. [146]

Communities need access to data and tools to make decisions in their best interests

Communities, just as much as governments, require good data and information to make sound decisions. Communities with an incomplete picture of their environment and its challenges, their exposure to climate change and other hazards, will not make decisions in their best interests. When people choose to live in high-risk communities, it is up to governments to ensure that this decision is formed with the clearest view of its consequences. Otherwise, this can lead to an erosion of institutional trust, especially in circumstances where community relocation may be the only viable option.

Using opportunities presented by COVID-19

The value of public trust has been demonstrated during the pandemic. Trust has enabled the changes to public behaviour necessary to contain and stop the spread of infection. In the face of an uncertain future, it is vital we do not return to the levels of trust that existed before the pandemic.

The COVID-19 pandemic presents the opportunities to maintain and build on the high levels of trust in government and public service and to strengthen systems thinking through engagement. Government can build on the high levels of trust in institutions and increase community influence in the design and origination of infrastructure solutions. [147] It is an opportunity for infrastructure asset and network owners and operators to become more transparent, better share information with stakeholders, and become open to collaboration that will create better long-term outcomes.

7.1.3   The direction

There is opportunity to improve resilience outcomes through effective and meaningful engagement with the communities affected by the decisions at all stages of the infrastructure lifecycle. The engagement should include place-based engagement coordinated between strategic infrastructure planning agencies.

A commitment to transparency is needed both for organisations making strategic plans for infrastructure delivery as well as those designing, delivering and operating individual projects.

These organisations should tailor engagement processes to be inclusive and representative and provide communities with good data and information to make sound decisions.

7.2 Embed traditional ecological knowledge in decision-making

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At a glance

Decision makers are not systematically drawing on traditional ecological knowledge to manage land and natural resources. This is an unrealised opportunity to strengthen the resilience of places and people. It is also inconsistent with the principles of self-determination and co-design.

The application of traditional ecological knowledge can contribute to the reduction of hazard risk to infrastructure and communities. It can also address some of the underlying stresses in an individual or community, resulting in increased community resilience.

There is an opportunity to embed traditional knowledge in a way that supports infrastructure planning by:

- developing accreditation of formal learning programs
- creating designated roles in infrastructure, land-use and other planning organisations for qualified Aboriginal and Torres Strait Islander people to embed traditional management practices
- piloting a place-based program that builds on existing guidance and initiatives to measure, evaluate and learn from the impacts of embedding knowledge practices in high-risk locations.

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7.2.1 The problem

Traditional First Nations practices are founded on a deep understanding of place as a complex network of interconnected and interdependent systems, of which people are an integral part. The application of traditional ecological knowledge benefits the entire system, not just the environment – for example, by reducing the severity of bushfires.

The systematic application of traditional ecological knowledge and practices is limited by the capacity and capability of stakeholder groups – both those delivering traditional practices and those receiving them. To build this capacity and capability, adequate funding and support are needed, alongside formal accredited learning programs.

Ineffective land management can increase the risk of natural hazards

Ineffective land and resource management can increase the risk of natural hazards to infrastructure assets and communities. However, Aboriginal and Torres Strait Islander land management processes can enhance the resilience of the Australian environment, using elements such as fire to protect and renew the environment. [148]

To date, embedding traditional ecological knowledge in infrastructure planning, land and natural resource management is not common practice. It has been limited by a focus on the risks and costs associated with traditional practices (such as the risks and insurance costs of cultural burning), rather than on the benefits for the health of the ecosystem, and the flow-on implications to infrastructure and communities.

This is supported by the findings of the NSW Bushfire Inquiry into the 2019–20 bushfires, which recommended:

that Government adopt the principle that **cultural burning is one component of a broader practice of traditional Aboriginal land management and is an important cultural practice, not simply another technique of hazard reduction burning** [and that] Government commit to pursuing greater application of Aboriginal land management, including cultural burning… [149]

The systematic application of traditional practices is limited by the capacity and capability of stakeholder groups

The application of traditional ecological knowledge is currently limited by the capacity and capability of existing organisations delivering and receiving this knowledge. These organisations are unable to meet demand for services.

Organisations specialising in traditional burning, such as Firesticks Alliance Indigenous Corporation, were inundated with requests for services since the 2019–20 bushfire season. In October 2020, Firesticks – "an Indigenous led network" that "aims to re-invigorate the use of cultural burning by facilitating cultural learning pathways to fire and land management" [150] – reported it had received 400 requests for assistance from across Australia. [151]

In order to respond to just some of these requests, Firesticks estimated it needed to recruit four individuals to work with those delivering the services (Aboriginal and Torres Strait Islander communities and community-controlled organisations) and those receiving the services (professional and volunteer fire services and government agencies, like National Parks and Wildlife Services and natural resource management agencies) to fill capability gaps in both.

Without trained facilitators supplementing stakeholder capacity and capability, demand for services is unlikely to be met in the short to medium term.

7.2.2   The opportunity

The proactive management of the land using fire and other traditional ecological knowledge improves the health of the ecosystems. This in turn protects communities and infrastructure from shock events. There are also opportunities – for example, educational and employment pathways and greater representation – to address some of the underlying stresses in an individual or community, resulting in increased community resilience.

This can be enabled through accredited learning programs and creating designated roles for qualified Aboriginal and Torres Strait Islander peoples within National Parks and other organisations to enable the embedding of traditional knowledge processes.

There is the opportunity to leverage existing guidance and programs to strengthen knowledge and partnerships and build on principles of self-determination and co-design. Taking this approach to embed traditional knowledge can improve outcomes for Aboriginal and Torres Strait Islander communities, as well as enhancing resilience.

Embedding traditional knowledge improves social outcomes and can address underlying stresses

Embedding processes that value traditional knowledge (for example, greater representation of Aboriginal and Torres Strait Islander peoples in decision-making, employment and educational pathways) leads to improved social outcomes. These outcomes can address some of the underlying stresses in an individual or community, resulting in increased community resilience.

Stresses experienced by some Aboriginal and Torres Strait Islander communities can in part be addressed by increased participation and representation in land management, the visibility of Aboriginal and Torres Strait Islander history and culture, access to and control of land, further education pathways and increased employment.

The potential social benefits of the application of traditional knowledge include:

- access of Aboriginal and Torres Strait Islander peoples to new economic opportunities, both direct (such as employment to undertake cultural burning) and indirect
- the regeneration of native plants through burning and their harvesting for commercial purposes
- the revival and advancement of Aboriginal and Torres Strait Islander peoples' knowledge of the land and waters
- recognition of the importance of connection to Country to the social and emotional well-being of Aboriginal communities
- the intergenerational sharing of living knowledge within communities and with non-Indigenous people, deepening understanding and broadening connections.

Leveraging traditional ecological knowledge is an opportunity for Australian governments to contribute to progress towards achieving those outcomes identified in the *Partnership Agreement on Closing the Gap 2019-2029.*[152]

Accredited learning programs and educational programs can help embed traditional ecological knowledge

Accredited and experienced Aboriginal and Torres Strait Islander practitioners are required to fill gaps in traditional ecological knowledge within the fire services and government agencies and in the design and delivery of policy and programs.

For traditional ecological knowledge to be embedded in existing policy and processes, formal accredited learning programs are needed. These programs do not yet exist and it will take time to develop and apply them through practice.

In addition, the expansion of existing primary and secondary school educational programs with a focus on the sharing of living knowledge (including, but not limited to traditional ecological knowledge) by local knowledge holders, would activate and equip the next generation (and the next) with knowledge to contribute to community resilience.

Designated roles for qualified Aboriginal and Torres Strait Islander peoples can help embed traditional knowledge

There is the opportunity to create designated roles for qualified Aboriginal and Torres Strait Islander peoples across government to embed traditional knowledge practices. This includes roles in National Parks, state and territory government natural resource management agencies, metropolitan, regional and rural fire agencies, and with infrastructure asset and network owners and managers.

In addition, identifying and training facilitators to 'match' Aboriginal and Torres Strait Islander communities with people and organisations wishing to benefit from traditional ecological knowledge (in particular, cultural burning and water management practices), can enable improved land management outcomes.

Pilot projects and programs can demonstrate benefits and inform future work

Our Knowledge, Our Way 2020, is best practice guidance for working with Indigenous knowledge in land and sea management. It was developed by the North Australia Indigenous Land and Sea Management Alliance (NAILSMA) and CSIRO. [153]

There is an opportunity to leverage such guidance to strengthen knowledge and partnerships and apply holistic traditional ecological knowledge in land management. There are also opportunities to leverage existing initiatives such as Firesticks, the Australian Government's

Land and Sea Ranger program, and a similar range of programs across the country, including Queensland's Indigenous Land and Sea Ranger program.

The greatest benefits come from initiatives that cover entire landscapes. As a result, the

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Box 15: NSW Government – Our Place on Country Aboriginal Outcomes Strategy 2020–23

In the New South Wales context, *Our Place on Country – Aboriginal Outcomes Strategy 2020-23* is focused on delivering improved outcomes for Aboriginal and Torres Strait Islander peoples. The Strategy sets the underlying principles of self-determination and co-design in the work of the NSW Department of Planning, Industry and Environment and Regional NSW.

Among many outcomes identified in the Strategy, it is now expected that Aboriginal people and communities determine the Aboriginal culture and stories that are reflected in the built and natural environment across NSW. Relevant priority actions include:

- The development of an NSW Department of Planning, Industry and Environment Water strategy to improve Aboriginal people's access to water for cultural and economic uses.
- Joint Management Agreements. These are negotiated agreements with Aboriginal peoples and communities to cooperatively manage and protect national parks and reserves.
- A climate adaptation planning pilot. This will provide strategic planning for climate adaptation through a pilot program with Aboriginal landholders and their communities.

Target outcomes of the Strategy:
- The NSW Government approach to working with Aboriginal people in New South Wales is consistent with the principles of self-determination and co-design.
- Aboriginal people and communities have greater choice, access and control over land and water, housing and resources.
- Aboriginal organisations and businesses are supported to succeed and grow New South Wales' first economy.
- Aboriginal people and communities determine the Aboriginal culture and stories that are reflected in the built and natural environment across New South Wales.
- The Aboriginal workforce increases across all areas and levels of the NSW Government until they become an employer of first choice for Aboriginal people.
- Residents and visitors to New South Wales gain a deeper understanding of Aboriginal history and culture through tangible and intangible heritage,
- The continuum of Aboriginal history and culture is a visible part of New South Wales's built and natural environment.

Source: NSW Department of Planning, Industry & Environment

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greatest opportunity exists in applying existing guidance and programs at scale. To this end, two NSW Government agencies have committed to embedding Aboriginal and Torres Strait Islander cultural knowledge within government through the *Our Place on Country – Aboriginal Outcomes Strategy 2020-23* (see **Box 15**). [154]

Building on the existing guidance and initiatives outlined above, there are opportunities to undertake pilot projects to demonstrate the value of traditional ecological knowledge. These pilot projects could:

- identify areas of high environmental and cultural value at risk to large-scale bushfire or other risks

- work with Aboriginal and Torres Strait Islander communities to apply traditional practices

- measure, evaluate and learn from the impacts of these practices (including social and emotional, environmental and economic benefits to the community at large)

- help demonstrate the value of community resilience and inform future investment decision-making, which relies on the assessment of costs and benefits.

7.2.3   The direction

The embedding of Aboriginal and Torres Strait Islander cultural knowledge as a 'business as usual' approach, presents an opportunity to gain lessons from Aboriginal and Torres Strait Islander peoples on caring for Country in a sustainable way.

There is an opportunity when taking a place-based approach (see **Section 5.1**) for government to engage with Aboriginal and Torres Strait Islander people in a way that is consistent with the principles of self-determination and co-design. In doing so, traditional knowledge, including traditional ecological knowledge, can be embedded in the planning phase and throughout the entire infrastructure lifecycle. This could include piloting a place-based program that builds on existing guidance and initiatives to measure, evaluate and learn from the impacts of embedding knowledge practices in high-risk locations.

There is also opportunity to:

- develop accreditation of formal learning programs

- create designated roles in various government agencies and infrastructure asset and network owners for qualified Aboriginal and Torres Strait Islander people to embed traditional management practices.

8   Conclusion

Infrastructure needs to be planned, delivered and operated in a way that supports continuity of service delivery, supports community resilience, and ensures that we increase our collective capacity to cope.

Infrastructure Australia and Infrastructure NSW partnered in this *Pathway to Infrastructure Resilience* research to identify opportunities to improve how infrastructure is planned. The methodological approach taken to draw on a broad range of expert opinions in a cross-government collaboration has resulted in an understanding of resilience that goes beyond a risk-based approach, to systemic resilience.

This partnership was founded on a shared vision for a resilient future where Australian communities are able to recover, transform and thrive in response to shocks and stresses, and to realise positive social, economic and environmental outcomes. The aim of this work was to build expertise and momentum for change and to set a strategic direction for how we plan infrastructure to respond to these natural and non-natural threats.

Advisory Paper 1: Opportunities for systemic change, identifies 10 directions for transformational and systemic change in infrastructure planning across four system levels. Acting on these directions will result in transformational change in the capacity of communities, government and industry to better respond to resilience risks, as well as alleviating the underlying vulnerabilities that lead to these risks.

The most significant opportunity to consider and achieve resilience is in the infrastructure planning phase. The decisions made at this stage establish the trajectory of all the dimensions of the infrastructure lifecycle.

A major finding of this research is that achieving resilience requires a shift in focus from the resilience of assets themselves, to the contribution of assets to the resilience of the system – or infrastructure for resilience. This new approach requires consideration not only of strengthening the asset, network and sector, but also strengthening of the place, precinct, city, and region that the infrastructure operates within (**Figure 2**).

To achieve infrastructure for resilience, asset and network owners and operators must act collectively as well as independently. They must collaborate with the community, emergency responders, local, state and territory governments, and the Australian Government.

While this approach will be more complex and undoubtedly more challenging, it will lead greater resilience and most likely also deliver a range of previously unrealised positive outcomes. We encourage all levels of government, communities, industry and academia to build on and make use of this research and look forward to partnering with all stakeholders towards a more resilient Australia.

Appendix A – Selected shocks and stresses in the Australian context

Pandemic *Shock*	Governments have become more important in the Covid-19 pandemic, following on in Australia from the advanced role played by the public sector in ensuring communities are safe from or recover from fires and flooding, as we saw in late 2019, early 2020. Demand for government support, services including health infrastructure, has reached a new high and expectations of government have risen accordingly.
Cyber risk *Shock*	Australia's increasing reliance on technology to support our systems and way of life exposes the community and infrastructure in the event of cyber-attack. Cyber-attacks on energy, water and telecommunications are no longer theoretical threats. Australia's systems have been able to resist actions to date, but they must continue to innovate in order to keep ahead, particularly in the face of growing geopolitical instability.
Bushfire *Shock*	The 2019–20 bushfires caused nearly $1 billion of damage to NSW Government owned infrastructure across a range of asset classes and locations. This represents damage to approximately 0.33% of the entire NSW infrastructure stock and equates to nearly 5% of the average annual NSW Government capital spend over the next four years. The 2019/2020 Black Summer Bushfire season triggered a reckoning. In January 2020, the Australian Government established the National Bushfire Recovery Agency to lead and coordinate a national response to rebuilding communities affected by bushfires across the country. The Royal Commission into National Nature Disaster Arrangements was launched in February 2020 to examine how Australia is prepared and coordinated to respond to bushfires and other natural disasters. In NSW, there has been a Bushfire Public Inquiry and the establishment of Resilience NSW.
Extreme weather and climate disruptions *Shock*	Extreme weather events and climate disruptions greatly impact the vulnerability of our environment, economy and society. Changes that are currently occurring across Australia include warming temperatures, changing rainfall patterns, longer and more intense heatwaves, extreme fire weather and rising sea levels. Temperature will continue to increase, with more hot extremes across the country. Duration and severity of drought will increase over southern Australia, combined with projected harsher fire weather across southern and eastern regions. Average snow depths have already decreased since the 1950s, with snowfall expected to decrease further. Intense short duration rainfall and associated flooding is expected to increase across Australia. Rising sea levels and increasing single event rainfalls will heighten the intensity of cyclones in south-east Queensland and north-east NSW regions.
Financial system failure	The banking system underpins all economic activity by creating, storing and transferring money. As observed during the Global Financial Crisis, a failure in the banking system can cause the destruction of wealth and the erosion of confidence. During this current pandemic, governments have actively suppressed business activity for reasons of public health. So far,

Shock	global banking regulation and systems have held up well in this crisis but there is a long way to go.
Terrorism *Shock*	Terrorism is the use of violence and intimidation, especially against civilians, in the pursuit of political or ideological aims. The target of a terrorist attack is typically people, but attacks play out in the context of infrastructure, e.g. within iconic buildings or on public transport. Terrorism shatters the normal conception of safety. People extrapolate the relatable – the location of an attack could have been their own bus, local café, or place of worship. This fear can then turn into a societal stressor and impact people's behaviour of how they view and ultimately use a space and the infrastructure within it.
Community violence and public safety *Stress*	Community violence is the exposure to intentional acts of interpersonal violence committed in public areas or in domestic settings. Community violence is recognized as a major public health problem. Chronic exposure to community violence can have detrimental effects on academic achievement and correlates with anxiety, depression, disruptive and aggressive behaviour, and substance use – which has a significant negative impact on wider community infrastructure.
Species extinction *Stress*	Australia's natural environment is under severe pressure. The country is facing an extinction crisis with 100 species extinct since 1788 (compared with 4 in the United States) and 1,892 listed threatened species. The accompanying decline in ecosystem services provided by the natural environment is likely to have a growing impact on community well-being and biodiversity as our climate changes and threats to our natural environment intensify.

Appendix B – Infrastructure and other considerations covered by this paper

- **Telecommunications infrastructure** generally refers to the mobile phone network, the fixed broadband network and the digital network

- **Energy infrastructure** refers to electricity generation, transmission, distribution infrastructure, forms of electricity storage, in addition to gas transmission and distribution infrastructure.

- **Water infrastructure** refers to infrastructure involved in water supply and treatment, wastewater removal and treatment, stormwater management, flood management and coastal protection.

- **Waste infrastructure** refers to infrastructure involved in waste collection, waste disposal and resource recovery.

- **Blue and green infrastructure** refers to the network of natural and semi-natural spaces that exist within our urban and rural landscapes. This network includes world heritage areas, national parks, state forests and reserves, remnant habitats, species and ecosystems on publicly and privately-owned land, waterways, lakes, wetlands, artesian water and marine environments as well as agricultural land.

- **Social infrastructure** generally refers to infrastructure associated with arts and culture, health and aged care, sub-market housing, education and recreation as well as justice infrastructure including police stations, local, district, supreme and federal courts, adult and juvenile correctional facilities, and forensic health facilities.

- **Emergency services infrastructure** refers to fire and ambulance stations, other state, territory and local emergency response facilities, state emergency services and the Australian Defence Force in their role providing emergency response support.

- **Transport infrastructure** refers to pedestrian, cycle, public transport, road and freight networks as well as ports and airports.

- **Land use planning** refers to the systems of strategic and statutory planning that set the policy framework and processes which guide and facilitate development.

- **Land management** refers to the planning and implementation of land management practices and process.

Appendix C – Geographies covered by this paper

- **National:** Australia-wide.

- **Fast-growing cities**: Sydney, Melbourne, Brisbane and Perth.

- **Smaller cities and regional centres**: Smaller capital cities, satellite cities and regional centres home to more than 10,000 people.

- **Small towns, rural communities and remote areas**: Small towns with populations of fewer than 10,000 people and more than 200 people, rural communities with fewer than 200 people, and all remote areas outside of recognised settlements.

- **Developing regions and northern Australia**: Developing regions with strong growth prospects and where industry composition is changing, and northern Australia, including a mix of regions across the Northern Territory, and the northern parts of Queensland and Western Australia.

Appendix D - Conditions needed to achieve infrastructure for resilience

System levels	Conditions required for resilience
Governance and coordination	• Relevant information on the impacts of shocks and stresses is collated with best practice approaches shared across jurisdictions. • People and organisations are accountable for reduction risks within their control, with shared but defined responsibilities • Decision-making is informed, inclusive and transparent, and decisions are influenced by those impacted • Decision-making is integrated, considers infrastructure and non-infrastructure solutions, and is based on understanding the impacts • Governance structures are equitable, and equity is embedded in decision-making • Governance structures facilitate collaboration and enable effective implementation of decisions • Community members have access to independent avenues to ensure rights and welfare are protected
Place	• Planning and design is robust, integrated, place- and network-based • Place and network information and understanding is comprehensive • Collaborative working and decision-making is incentivised • Ongoing monitoring and evaluation is undertaken and plans are reviewed and updated at an appropriate frequency • Preparedness is prioritised; disaster risk managed and redundancy built in • Response planning at a place-level is undertaken with recovery and future performance in mind • Flexibility and adaptability are designed in at a place-level and there is a culture of safety and security • Demand is managed
Asset	• Asset planning and design is robust and integrated, with failure and recovery in mind and redundancy built in • Information management is prioritised, including information on impacts • Collaborative working and decision-making is incentivised

	• Response planning is undertaken with recovery and future performance of the asset in mind • Flexibility and adaptability of the asset are designed in and there is a culture of safety and security • Ecosystem services are valued, regenerated, maintained and enhanced
Community	• Institutions are trusted; democracy is strong; and decisions realise benefits for people and the environment • The health of the environment is protected, including human health • All people are physically, socially and emotionally safe and cultural and social assets are valued and protected • A diverse economy meets the community's needs for social goods and services and prosperity within environmental limits.

Appendix E – Glossary of terms

Term	Definition
Asset	Assets include, but not limited to, land and buildings, plant and equipment, infrastructure systems, leased assets, works in progress, cultural and heritage collections, ICT systems, and digital services.
Critical Infrastructure	The Australian Government defines critical infrastructure as 'those physical facilities, supply chains, information technologies and communication networks which, if destroyed, degraded or rendered unavailable for an extended period, would significantly impact the social or economic well-being of the nation or affect Australia's ability to conduct national defence and ensure national security.'[155]
Exposure	The elements within a given area that are, or could be, subject to the impact of a hazard.
Governance	Governance is the system that sets direction, establishes accountability and resources for activities that progress that direction, then monitors and regulates those that are accountable. It includes organisations and policy.
Green infrastructure	Green infrastructure is the network of green spaces, natural systems and semi-natural systems that support sustainable communities. It has connected elements: waterways; urban bushland; urban tree canopy and green ground cover; parks and open spaces.
Infrastructure investment decisions	Infrastructure investment decisions involve strategic assessment and prioritisation, business cases, design, funding and financing, procurement, delivery, operation, asset management, renewal, and program evaluation. They span the full investment lifecycle, prioritising and committing both public and private capital.
Land-use planning	Land use planning refers to both strategic and statutory planning and involves the setting of policy, development of frameworks and processes which collectively guide and enable development, settlement and regional growth. This includes physical layout, design and location of the built environment, parks, businesses and homes. Decisions can range from restricting new development, to approving asset use, to determining a communities' masterplan.
Network	A group or system of interconnected infrastructure.
Place	Place is where the systems of land use, the infrastructure network and assets and the broader community intersect.
Public open spaces	Public open spaces refers to land that has been set aside from development to accommodate recreation or relief from the built environment. Open space can be used for purposes such as personal and social recreation, sport and physical activity, active transport corridors, waterway and riparian corridors, biodiversity and fauna conservation, and

	visual and landscape amenity. Such settings include natural areas and linkages, foreshore areas, informal parkland, sports grounds and courts, children's playgrounds, historical sites, formal gardens, and linear walking, cycling, and equestrian tracks.
Public facilities	Public facilities are public libraries, museums, galleries, civic/community centres, showgrounds and indoor public sports facilities.
Scenario	A scenario is a coherent, internally consistent and plausible description of a possible future state of the world.
Shocks	Shocks are sudden, sharp events that have the potential to disrupt the services supplied via infrastructure.
Stresses	Stresses are longer-term, chronic conditions that impact physical assets, organisations or communities. Stresses also include the increasing interdependencies between critical infrastructure that can exacerbate the impact of shock events.
Vulnerability	The characteristics of a community, system or asset that make it susceptible to effects of a hazard.

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