05

Climate and disaster risks:

What they are, why they matter and how to consider them in decision making

Guidance on **Prioritisation**

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The information contained may not be representative of all audiences and appropriate to all situations. The concepts and knowledge contained in the guidance will improve as the ability to engage more comprehensively with audiences such as the Aboriginal and Torres Strait Islander populations matures and as knowledge about the underlying drivers of climate and disaster risk broadens across society. No liability is accepted for any loss or damage arising from connection with the use of information in all guidance documents.

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Foreword

The risk landscape is changing quickly, and the stability of natural, social and economic systems can no longer be taken for granted. The scale and seriousness of the momentum of change, requires genuine national collaboration, a broad range of knowledge and strategic guidance on navigating growing uncertainty.

Choices made at multiple levels by a wide range of decision makers in both government and industry interact to affect our vulnerability and resilience. Better decision making, guided by new forms of systemic risk governance, assessment and management are key to preventing and reducing climate and disaster risk.

Led by the National Resilience Taskforce and released in April 2019, the co-developed *National Disaster Risk Reduction Framework* (Framework) sets a common agenda for collective action. This new Framework is in part informed by the report *Profiling Australia's Vulnerability* that reflects a fuller understanding of systemic disaster risk and values, choices and trade-offs.

Profiling Australia's Vulnerability brings into sharp focus the reality that hazards lead to disaster where there is exposure of a vulnerable society and where the consequences exceed people's capacity to cope. The report also finds that what we value, and the choices that we make between these values, are different during periods of stability compared with disruption. Understanding this can help re-frame how we approach climate and disaster risk reduction efforts into a whole-of-society approach.

The Framework sets a foundation for action for decision makers across all sectors of the Australian economy. It seeks to raise awareness of the causes and effects of climate and disaster risks and to enable decision makers to proactively take steps within their spheres of influence and control to reduce these.

To support its implementation and encourage new conversations about climate and disaster risk, a set of inter-connected guidance documents has been developed.

This Guidance is foundational and is a first iteration. It is designed to help decision makers in the non-trivial task of contextualising the systemic physical impacts of a changing climate. In particular, it provides direction on how to call upon knowledge, capabilities and processes to apply climate and disaster risk to governance, strategic planning and investment decisions.

As you *Turn the Page*, you will be contributing to the journey from where we are now, to where we need to be.

Mark Crosweller AFSM
Head of National Resilience Taskforce
Department of Home Affairs

Turning the Page

Reducing Systemic Climate and Disaster Risk for a Resilient and Prosperous Australia

Momentum is Building

The risk landscape is changing quickly and we need to break from business as usual.

- Natural hazards are more frequent and intense
- Demand is growing to address financial impacts of a changing climate
- People, livelihoods and assets are more exposed and vulnerable
- Essential services are increasingly hyper-connected
- Disaster impacts are long-term and complex
- Costs of disasters are growing
- Stability of natural, social and economic systems can no longer be taken for granted

Where we need to be

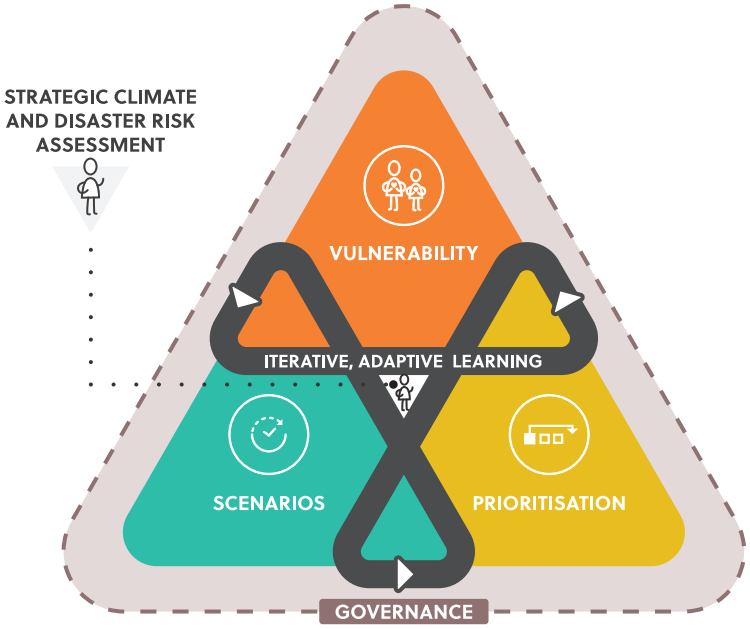
We are Aspiring Towards

A systems and values-based mindset reduces climate and disaster risks.

- Risk-informed sustainable development
- Substantial reduction in loss and harm
- Successfully living with natural hazards and a changing climate
- Reduced intergenerational vulnerability
- Wellbeing, trust and confidence

Guidance on Prioritisation

The document is one of a set of interconnected Guidance documents on *governance, vulnerability, scenarios and prioritisisation* for enabling climate and disaster risk reduction.



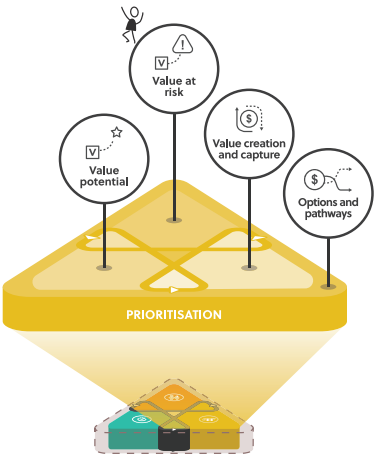
The set of Guidance documents has been developed to help you:

- more holistically understand the systemic nature of climate and disaster risk, particularly the causes and effects of societal vulnerability, using a systems- and values-based approach to assessment and collaboration;
- explicitly revisit the vision, goals, objectives and decision criteria of relevant stakeholders in the context of changing climate and disaster risk;
- recognise which aspects of uncertainty matter when making strategic long-term decisions and how to apply techniques to make robust decisions in lieu of complete knowledge; and
- understand what types of knowledge and information are important for different stages of a strategic risk assessment.

The Guidance on Prioritisation can be read and applied in parts, independently or as an integrated set with the Guidance on Governance, the Guidance on Vulnerability and the Guidance on Scenarios. It should be read in conjunction with the Introduction and the supporting Terms and Concepts.

The Guidance on Prioritisation encourages users to re-visit, programme and project investment objectives by shifting the focus from 'assets' (economics) to 'services and communities' (vulnerability). It contains a Prioritisation Framework for climate and disaster risk reduction developed with two novel capabilities critical for informing the prioritisation of investments to reduce climate and disaster risk. The Prioritisation Framework:

- allows users to evaluate interventions ('options and pathways') based on how much they reduce vulnerability ('value at risk') and the economic net benefits created ('value potential');
- is scenario-based. Users calibrate the framework to explore various possible combinations of future hazards, exposure, vulnerability and intervention options. They can apply different assumptions about changes in climate, population and socio-economic development; and
- provides a rapid assessment process of opportunities for value creation and capture.



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Approach to developing the guidance

The Guidance on Prioritisation has been developed on the principles and practices of inclusive and participatory stakeholder engagement with the private sector, federal, state and local governments, community groups and research/academic agencies. This consultation involved a national survey, meetings, workshops and focus groups, along with extensive review of published reports, other guidance, journal articles and leading best practice.

It has been constructed on the principles of building on and drawing from existing capabilities, resources, decision processes and initiatives in order to complement existing practices and enable the implementation of the National Disaster Risk Reduction Framework.

1. Introduction

There is a need to shift the focus of climate and disaster risk management from a predominantly reactive to a more proactive approach with an emphasis on reducing the causes and effects of societal vulnerability[1]. In doing so we can place a greater emphasis on investments that reduce vulnerability and clearly recognise the cross-scale and interconnected nature of these risks. This Guidance on Prioritisation has been developed to do just this; to encourage and enable strategic thinking and inclusion of wider sets of stakeholders in the framing and reframing of objectives and to identify broader sets of options for reducing the systemic causes and effects of these risks.

There are few legislative or regulatory requirements, incentives or standards currently promoting consistent consideration of climate and disaster risk reduction in investments.

Additionally, current arrangements for assessing initiatives for climate and disaster risk reduction are generally limited to local contexts, focused on hazard management or community resilience, and based on historical climate.

This Guidance and an underpinning Prioritisation Framework have been developed to:

- align with and feed into existing decision and risk assessment processes; and
- expand the focus and intent of these approaches to consider the cross-scale, uncertain, and systemic nature of the causes and effects of societal vulnerability in the context of rapid changes to population, the economy and climate.

The initial design focus of the Prioritisation Framework has been on high-value, large-scale hard infrastructure interventions, such as:

- the retrofitting of critical and defensive infrastructure;
- adaption of buildings and urban spaces; and
- management of the relocation of physical assets or settlements from at-risk areas.

The Prioritisation Framework has been designed to be scalable and flexible in its application.

The general principles and approaches of the Prioritisation Framework can be contextualised and applied to smaller-scale decisions, a wider range of hazard types/events, in regional or urban locations, communities, and to inform assessments of hard and soft or green options for reducing climate and disaster risks.

Using the Guidance will require some understanding of economics and financing concepts and their application.

Collectively, this Guidance and the Prioritisation Framework present a first iteration in building these capabilities.

These will be iteratively improved and refined through diverse applications by a variety of users over time.

This further testing and development will promote consistency and standardisation in:

- the assessment categories and sub-categories of value at risk and value potential;
- the criteria and measures of each sub-category; and
- the procedures for choosing/estimating values for variables that drive the assessment outcomes such as: 'base vulnerability', 'resilience change ratio' and 'vulnerability change'.

1 United Nations Office for Disaster Risk Reduction ***https://www.unisdr.org/we/inform/publications/49574***, Australian Government, Department of Home Affairs. 2018. *Profiling Australia's Vulnerability: The interconnected causes and cascading effects of systemic disaster risk*.

2 Examples of soft or green options for reducing climate and disaster risk include investments in enhancing natural capital and the supply of ecosystem services, improved land-use and urban planning, and capacity building of communities.

2. Principles of Vulnerability

The widespread and interconnected nature of the causes and effects of climate and disaster risks means that prioritisation of investments to reduce these risks needs to consider the interdependent systems that deliver essential services to communities. When hazards occur they can lead to disaster where there is an exposed and vulnerable community or where the impacts and consequences exceed people's capacity to cope.

Vulnerability is a function of our relationships with what we value – people, places, objects, services and socio-economic and cultural activities.

These elements ought to be explicitly **considered in measures** of vulnerability when assessing initiatives or potential investments in climate and disaster risk reduction.

What is valued varies among people and across communities. These values can also change with time because what is valued during periods of stability shifts at times of disruption.

Choices and trade-offs are relevant when thinking about climate and disaster risk reduction and building resilience. Where do we allocate our time? How much effort and investment should we put into disaster preparation, response, recovery or risk reduction? If we are investing in climate and disaster risk reduction how do we prioritise the allocation of funds between interventions and to what end?

Profiling Australia's Vulnerability identifies the themes, components and causes of societal vulnerability, which have been synthesised into accessible and instructive Guidance on Vulnerability. The Prioritisation Framework considers these and, where relevant and possible, attempts to include them in the prioritisation assessment using largely qualitative measures. The Guidance on Vulnerability should be referred to when undertaking an assessment using this Prioritisation Framework.

3 *Profiling Australia's Vulnerability: The interconnected and cascading effects of systemic disaster risk.* ***https://knowledge.aidr.org.au/collections/disaster-risk-reduction/***

3. Responding to Uncertainty

The potential for large, systemic and 'deeply uncertain' changes in relation to the events and impacts of climate and disaster risk raises the importance of explicitly considering these aspects in assessment and prioritisation.

Considering uncertainty presents numerous challenges to the development and use of decision criteria, measures of value, and processes for valuing, assessing and prioritising options for reducing climate and disaster risks. Some of the most important of these challenges include:

1 Choosing between relative or absolute values and between practicality or precision

Vulnerability of people and socio-economic activities do not readily lend themselves to certain and absolute quantitative estimates for use as inputs into an assessment framework.

The Prioritisation Framework is intended to be applied to support strategic planning and early identification and assessment of options in a strategic decision process. A practical approach to such an assessment therefore places the emphasis on considering or accounting for all of the critical determining factors upfront based on a 'best endeavours' basis. The opportunity for a more precise assessment is at the subsequent more detailed business case stage of the process.

The Prioritisation Framework assists decision makers to make better decisions in their early rapid assessments of options that are more inclusive and comprehensive of uncertain and qualitative aspects of vulnerability or wellbeing.

Such a capability can support the rapid cost-effective short-listing of options that then form the basis of more detailed (and costly) evaluation in a business case assessment.

A 'low-regrets' decision is a key principle of the Prioritisation Framework: to keep future options open, avoid locking in or amplifying current risks or to identify options that perform satisfactorily under all/most scenarios.

2 Balancing quantitative and qualitative estimates of value

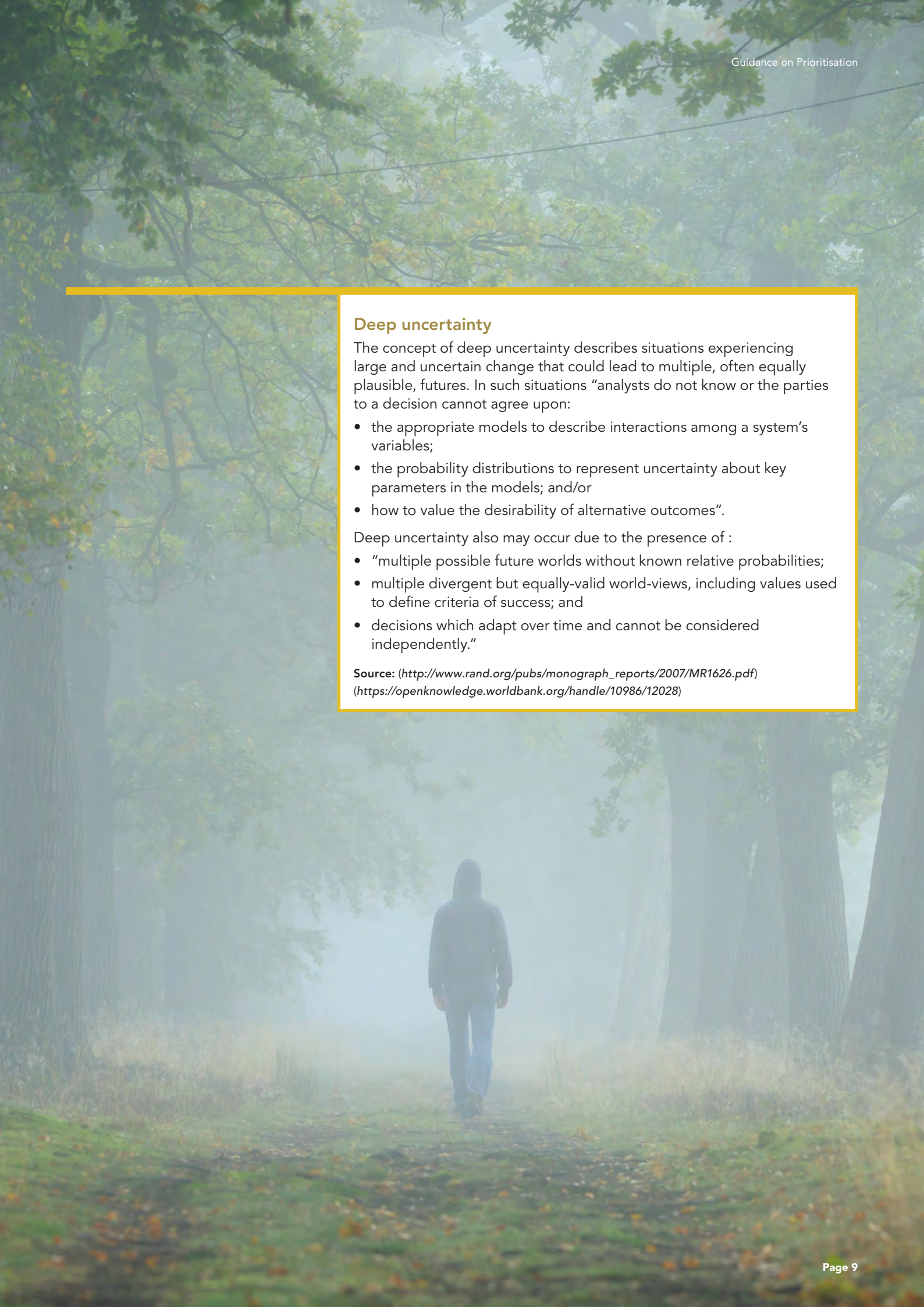
Until now assessments of initiatives for climate and disaster risk reduction have largely considered quantitative measures, typically in relation to their expected economic benefits and costs. These have inevitably focussed on the subset of variables or factors which can be monetised.

Including vulnerability as an explicit dimension in the assessment and prioritisation of climate and disaster risk reduction highlights a number of factors that cannot be monetised and lend themselves to qualitative measurement.

The Prioritisation Framework recognises the absolute and relative merits of both the quantitative and qualitative (especially intangible and non-monetisable) dimensions. Both are necessary to form a holistic view when assessing options.

A balance is struck by maintaining the integrity of each dimension during the assessment itself, with the results for each brought together only on completion (if desired) and plotted on a decision matrix.

In this way, each of the dimensions is uncompromised and the potential effects of climate and disaster risk on each of the dimensions is also uncompromised. These effects will be readily accessible to inform choices by participatory deliberation and negotiation of non-commensurable trade-offs.



Deep uncertainty

The concept of deep uncertainty describes situations experiencing large and uncertain change that could lead to multiple, often equally plausible, futures. In such situations "analysts do not know or the parties to a decision cannot agree upon:

- the appropriate models to describe interactions among a system's variables;
- the probability distributions to represent uncertainty about key parameters in the models; and/or
- how to value the desirability of alternative outcomes".

Deep uncertainty also may occur due to the presence of :

- "multiple possible future worlds without known relative probabilities;
- multiple divergent but equally-valid world-views, including values used to define criteria of success; and
- decisions which adapt over time and cannot be considered independently."

Source: (*http://www.rand.org/pubs/monograph_reports/2007/MR1626.pdf*) (*https://openknowledge.worldbank.org/handle/10986/12028*)

3 Choosing the decision criteria and associated trade-offs

It is necessary to consider a range of decision criteria that tend to result in different orderings of priorities and options and that explicitly account for uncertainties and variability in models and data (see Guidance on Scenarios). Some examples include:

- optimal criteria - e.g. a Benefit-Cost Ratio (BCR) for a 'preferred' option under a single, generally most likely or 'best estimate' scenario;
- low-regrets criteria – e.g. strategies that yield benefits even in absence of change or disruption or strategies that avoid very negative outcomes (e.g. minimax criterion and based on the precautionary principle); and
- robustness criteria – which reveal the options that perform robustly (satisfactorily) over a range of future conditions.

In the case of decision criteria relating to more significant, even systemic changes, different standards of quality and styles of analysis are appropriate. Within the Prioritisation Framework various uncertainties are incorporated as probabilities to weight the outcomes. Prior information is coupled with the probabilities to deliver a multi-faceted assessment which has the potential to maximise return for which there will be minimum regret. This is then applied in a scenario-based approach.

Probabilities and Scenario based approaches

We can no longer solely rely on existing methods and practices to evaluate the merits of projects for investment where facts are uncertain, values are in dispute, stakes are high and decision timeframes are urgent[4].

We require new or evolved approaches and frameworks to deliver the analysis to support decision makers. Data and knowledge are available that can provide leading indicators of systems rather than only using historical data and relying on old assumptions.

There are now improved systems and processes to utilise historic information to produce forward looking probability distributions (which are much more accurate than traditional classical estimates) or scenarios of quite distinctly different possible futures for which probability distributions cannot be estimated (see Guidance on Scenarios).

For example, the Prioritisation Framework has the capability to be rapidly recalibrated and run within participatory processes to allow stakeholders to explore the performance of options under many different scenarios.

We still need to do the sums right, but we also need to do the right sums.

At this point, the economic criterion used in the Prioritisation Framework is the Benefit-Cost Ratio, as this is the primary indicator used in most prevailing assessment approaches and facilitates adoption /integration of the Prioritisation Framework. The limitations of the Benefit-Cost Ratio criterion are recognised (see Supplementary Materials) and future iterations of the Prioritisation Framework will require capabilities to estimate other criteria such as 'net benefits' and 'rate of return'.

4 *http://www.nusap.net/downloads/funtowiczandravetz1994.pdf*

4. A Prioritisation Framework

Responses to climate and disaster risk can be:
• reactive in the form of recovery from disaster events;
• defensive with the objective to resist the change and maintain the status quo; or
• proactive and adoptable in response to the changing environment/threats.

Recovery strategies (e.g. build back better) and defensive strategies (e.g. levees and walls that attempt to defend against and resist change) commonly involve substantial and repeated financial outlays, largely borne by government. They also involve societal costs (largely borne by the most vulnerable) when it turns out they have underestimated and cannot effectively mitigate the risks. Both financial and societal costs are projected to continue to rise due to the increasing frequency and intensity of hazards and the growing exposure and vulnerability of assets and people. This places unnecessary and avoidable expense and loss on all elements of our society[5].

Accordingly, the Prioritisation Framework in this Guidance has a number of clear aims and objectives:

- **To provide a catalytic change in approach and practice for project proponents to unlock a broader and more strategic and adoptive approach to climate and disaster risk assessment and reduction;**
  - The Prioritisation Framework encourages users to re-visit investment, program and project objectives by shifting the focus from assets to services and communities. It facilitates consideration of the cross-scale and multi-stakeholder nature of the problems and therefore opens up a more comprehensive set of options for assessment (that span multiple scales and include many diverse stakeholders).
- **To clarify the relative risk and return for the options considered, in a way that makes comparisons and trade-offs meaningful and which is replicable and reliable;**
- **To identify investment pathways to expand the funding envelope for climate and disaster risk reduction;**
  - These pathways need to reach beyond government and realistically and meaningfully connect into the private sector. In particular there should be a focus on accessing alternative funding sources, including value capture.
- **To support a timely and cost-effective rapid assessment that can be used across government and the private sector and that is scalable and flexible for projects and locations;**
  - This assessment must also provide the necessary and sufficient set of measures to equitably prioritise options.

Investments in climate and disaster risk reduction options and pathways are potentially sourced from different domains, are applied differently and may operate on different scales from asset specific to jurisdiction wide. Interventions may also operate on vastly different timeframes too.

5 *Profiling Australia's Vulnerability: The interconnected and cascading effects of systemic disaster risk.* ***https://knowledge.aidr.org.au/collections/disaster-risk-reduction/***

4.1 Applying Drivers of Vulnerability

Current assessments and measures of initiatives to address climate and disaster risk reduction have been largely contained to be in line with existing business case processes. A central component of the business case process is an evaluation of the expected net benefits. For government agencies, this typically takes the form of a Cost-Benefit Analysis (CBA) used to measure relevant costs and benefits from a proposed expenditure and often for allocating resources across different possible projects.

When introducing measures of various dimensions of vulnerability these traditional economic analyses such as CBA alone are not sufficient to effectively assess and prioritise climate and disaster risk reduction investments. They do not acknowledge:

- intangible social and community impacts of vulnerability, which can include aspects of personal wellbeing, stress, mental health, etc.;
- delayed and unpredictable non-marginal changes (threshold effects) associated with sea-level rise and transforming ecosystems, for example (see Introduction to Guidance);
- potentially substantial intergenerational inequity of these changes;
- values and preferences of people and communities as citizens, stewards and consumers, becoming increasingly unstable/ dynamic and even unknown; and
- increasing need for solutions that are robust and low-regret, rather than a focus on optimal ones.

At this time an assessment using the Prioritisation Framework does not require a detailed economic analysis. This would be applied later as part of preparing a business case assessment of a subset of preferred options.

While not addressed specifically in the Prioritisation Framework at this point in time, there is an opportunity to test the complementary role of Cost-Benefit Analysis as a basis for prioritising options within the assessment.

This could also consider, the introduction of additional decision criteria for evaluating and prioritising options such as the present value of net benefits and measures of rate of return. These are critical to considerations of the inter-temporal, scale-dependent, and uncertain aspects when assessing initiatives for climate and disaster risk reduction (see Supplementary Material).

Cost-Benefit Analysis is a standard tool for policy and project evaluation. It is used to measure relevant costs and benefits from a proposed expenditure and often for allocating resources across different possible policies and projects. As a policy instrument it attempts to quantify in monetary terms the value of all aspects of a given policy, project or planned expenditure. It can incorporate, depending on context, both private and social costs and benefits.

The way it is applied in practice is important, because its misuse can have potentially severe consequences (see Supplementary Material).

5. Elements of the Prioritisation Framework

Many of the benefits from reducing the vulnerability of a community or region are more qualitative than quantitative in nature.

In 2015 Deloitte Access Economics conservatively estimated the qualitative social cost to be more than 50 per cent of the value of the impacts on a community in the event of a disaster[6]. It is important to consider these in assessments of interventions to reduce climate and disaster risk even if difficult to consistently and objectively measure and capture. The economic and financial viability of interventions are also important to the well-being of a local community, and these financial dimensions of vulnerability will tend to me more readily captured in an assessment.

Investment in climate and disaster risk reduction, is not just about avoiding damage and harm. It can also enhance and catalyse economic activity, community well-being and vibrancy, which we call value potential. The Prioritisation Framework therefore captures and assesses both the 'Value at Risk' (i.e. the damage, harm and costs that could be avoided through an investment into climate and disaster risk reduction) and the 'Value Potential' (i.e. the additional economic value created by the investment) of investments being considered, which together involves qualitative and quantitative elements (Figure 1).

5.1 Assessment categories

These two broad categories of value underpin the prioritisation of climate and disaster risk reduction options: 'Value at Risk' comprising sub-categories of Asset Restoration, Socio-economic Disruption and Environment and Heritage Disruption; and 'Value Potential' that includes categories of Service Performance, Economic Uplift and Community Reliance (Figure 1).

All categories and sub-categories are likely to play a role in affecting the vulnerability and resilience of individuals and communities, but emphasis may vary by jurisdiction or organisation. The Prioritisation Framework is applicable across disaster types, jurisdictions, and public and private sectors.

A facility has been included to allow relative weightings to be negotiated, tested and applied to the assessment categories and sub-categories if required or preferred by those involved. The Prioritisation Framework can also support participatory processes where stakeholder preferences are to not weight or combine the assessment categories and sub-categories.

The Prioritisation Framework provides the flexibility for category weightings to be applied if users want to align to specific strategic priorities or objectives of their organisation.

6 "The economic cost of the social impact of natural disasters": *http://australianbusinessroundtable.com.au/our-research/social-costs-report*

Where users of the Prioritisation Framework decide to weight the sub-categories and categories, these should sum to 100 per cent. Note, there is no requirement for the Value at Risk or Value Potential categories to equate to 50 per cent each. The Prioritisation Framework also allows for users to not weight and sum the values of the various sub-categories and instead to leave these as separate measures to enable transparency about the trade-offs in these values associated with the various options.

Wide application of the Prioritisation Framework requires consistency and agreed standards in the categorisations, definitions, variables, measures/criteria and approaches to scoring. This is required for both qualitative and quantitative measures for the various categories.

The categories are made up of commonly used terms, which may be interpreted slightly differently from one context to another. The category definitions used for this Prioritisation Framework are detailed in Table 1.

Figure 1: Categories of criteria for informing the prioritisation of climate and disaster risk reduction

Table 1: Assessment category definitions

Dimension	Category	Definition
Value at Risk		**Combination of exposure to event, likely impact, and ability to withstand event**
	Asset restoration	Cost to replace discrete assets to pre-disaster condition
	Socio-economic disruption	To work, commerce and access to essential and non-essential social services
	Environment & Heritage disruption	Impacts to natural capital (i.e. flora and fauna, soil quality) and/or ecosystem services (i.e., water, air, climate stability, agricultural productivity), cultural heritage or historical significance
Value Potential		**Latent potential for increased asset performance, economic activity and community well-being, combined with the likelihood of being realised**
	Service performance	Increase in discrete asset or service capacity, availability and/or longevity through betterment or sustainment
	Economic uplift	Additional economic activity in the form of increased investment, commerce and employment, along with wealth effects of increases in property and asset values
	Community resilience	Increased well-being resulting from better health and safety, access to services, income security and wealth protection

Each of the assessment categories is comprised of sub-categories for which base-level assessments are completed. Some of these assessments are quantitative and others are qualitative. Collectively, they provide a basis for capturing the measurable and judgement-based evaluations.

The following tables detail the sub-categories of each category, descriptions and the nature of the assessment and whether the assessment is qualitative, quantitative or mixed. Once again, the Prioritisation Framework provides the flexibility for sub-category weightings to be applied that align with an organisation's or region's strategic objectives and how climate and disaster risk could affect these.

Consequently, the processes by which these criteria are chosen, valued, weighted (or not) and assessed are important as their credibility and legitimacy in decision-making will depend on their inclusiveness of stakeholder perspectives/interests and their transparency.

The Prioritisation Framework allows/promotes the capturing of the relevant rationales behind these choices for both the quantitative and qualitative assessments of the various categories.

It is typical for such a rationale to include explanations of the sources of the information. This includes the confidence in this information in terms of its authoritativeness, salience and credibility and the nature of the stakeholder engagement process used to determine the variables, values and processes used in the assessment. The rationale can also include: explanations of why and how the final variables, measures, descriptions or values were chosen; suggestions for what could be done to improve the information and the benefits that would come from this; and judgements about the pedigree, accuracy, precision and confidence in the salience and credibility of the information and process (i.e. inclusiveness, participatory, expert-driven or stakeholder driven).

Table 2: 'Asset restoration' sub-categories, definitions and type of assessment

Sub-category	Description	Qual	Quant
Asset function	Purpose or function of asset	Description	
Replacement value	Cost to replace or repair asset to deliver functional capability		$
Asset condition	Condition and/or useful life of pre-event asset. May reflect physical condition or depreciated value	Good/ Moderate /Poor	%

Table 3: 'Socio-economic disruption' sub-categories, definitions and type of assessment

Sub-category	Description	Qual	Quant
Economic - trade	Commerce lost as a direct consequence of the disaster event; retail, transportation, tourism, primary industry stock and crop losses		$
Economic - employment	Lost incomes and/or productivity resulting from employees being injured, disconnected or diverted to recovery activities		$
Social connectivity	Interrupted access to social/community services	High, Medium, Low, N/A	

Table 4: 'Environment and heritage disruption' sub-categories, definitions and type of assessment

Sub-category	Description	Qual	Quant
Flora/fauna loss	Destruction of local vegetation and/or deaths of local indigenous wildlife, especially for threatened or unique to area species	High, Medium, Low, N/A	
Long term habitat loss	Irreversible damage to local habitats, making repopulation of flora and fauna impossible or very difficult. Includes degradation of water, soil or air quality	High, Medium, Low, N/A	
Water, soil, air quality/ quantity decline	Long term degradation of local water, soil or air	High, Medium, Low, N/A	
Cultural and/or historical sites damaged	Loss of, or damage to, cultural heritage and/or historically significant sites and artefacts	High, Medium, Low, N/A	

Table 5: Service performance sub-categories, definitions and type of assessment

Sub-category	Description	Qual	Quant
Capacity	Incremental change in service capability		% change
Availability	Ready and accessible for efficient service delivery		% change
Longevity	Expected lifespan of service delivery		% change
Resilience change ratio[7]	Proportionate change in ability to withstand event type (e.g. 1 in 10 years to 1 in 20 years = 2) that is likely as a consequence of improvements in assets or systems to better cope with events of a known scale, based on historical experience, data or reports.		Numeric value

7 While disasters are ultimately the product of vulnerability, physical assets can be improved so that their resilience to events is increased, without necessarily removing all vulnerability. The '*resilience change ratio*' relates to the improved capability of physical assets to deliver required services/ outcomes. Typically, the scale of this ratio reflects capability to withstand greater historical events, e.g. 1 in 50 year event rather than 1 in 20 year event, but doesn't remove all vulnerability to more extreme future events. An example might be installing a levee that would contain any historical rain event, improves the resilience, but does not necessarily remove all vulnerability to all potential future rain events, especially in the context of climate change.

Table 6: Economic uplift sub-categories, definitions and type of assessment

Sub-category	Description	Qual	Quant
Investment	Attractiveness for investment in immediate vicinity – government and private sector, including catalysing value creation		% change
Trade	Increase in commercial and industrial activity in the vicinity. Could catalyse consumer confidence from wealth effect of property and asset value enhancement and/or protection		% change
Jobs	Increase in jobs created from new investment and/or average incomes from nature of new employment		% change

Table 7: Community resilience sub-categories, definitions and type of assessment

Sub-category	Description	Qual	Quant
Income security	Confidence in income stability enhances preparedness to consume and invest	Very High, High, Medium, Low, Very Low	
Wealth protection	Increase in property and business values resulting from reduced damage and/or disruption	Very High, High, Medium, Low, Very Low	
Health, safety and well-being	Physical and psychological benefit of living in a safe and stable environment, enabling positive long term planning	Very High, High, Medium, Low, Very Low	

5.2 Exposure and Vulnerability overlays for Assessing Value at Risk and Value Potential

Assigning qualitative and quantitative measures/descriptions to the relevant variables in Tables 1-7 provides a baseline description or assessment of the status of each category in a particular region at a point in time. 'Value at Risk' is then determined by applying (i.e. multiplying) estimated measures of exposure (%), base vulnerability and vulnerability change (%) (Table 8) to the variables described and quantified completing Tables 2, 3 and 4.

In doing this, the vulnerability of an asset or community is accounted for through the user-defined measures of the '*base (existing) vulnerability*' (between 0 and 5) and an assessment of the potential or likely change in vulnerability due to an investment or intervention. This measure of '*vulnerability change*' is intended to reflect to what degree the initiative or combination of initiatives impacts the fundamental (base) vulnerability to this type of event.

For example, a levee on a river which runs through the heart of a town reduces the likelihood of an event, but without other changes the community is still vulnerable if the levee is breached. If, however, the course of the river was diverted away from the town, such that a flooding river will not inundate the town, the fundamental vulnerability to this type of event is removed. Whether or not this intervention is acceptable on environmental and amenity grounds is a separate issue.

The Guidance on Vulnerability can be applied to build understanding of the causes and effects of vulnerability and help inform deliberations about how to characterise and calibrate exposure and vulnerability in the Prioritisation Framework.

'Value Potential' is determined by applying the assessments of 'value creation', 'value capture', and 'value options' (Table 9) to the variables identified from the processes adopted by the stakeholders to complete Tables 5, 6 and 7.

The Rapid Assessment of value creation and capture provides a fit-for-purpose and rapid determination of the potential to increase or create value at this early stage of an assessment. The approach is not intended to provide the detailed analysis that would be required at subsequent stages of the assessment, for, say, a rating agency.

Drawing on the cost estimating protocol, this might be considered a P50 value creation assessment, i.e. a 50 per cent confidence level of the estimate. In line with the stages of the assessment approach that this Prioritisation Framework is designed to inform (i.e. Stages 1 and 2, Figure 4), the 'Value Options' assessment in Section 6 intentionally does not explore the efficacy of options considered, merely whether or not some alternative options have been considered.

Table 8: Value at Risk variables and assessment modes

Variables	Description	Qual	Quant
Exposure	Likelihood of a hazard or disaster event impacting an asset and/or community in a particular location. The *'exposure'* of an asset or community (i.e. thing of value) is accounted for in the Prioritisation Framework through a user-defined estimate of the likelihood of a hazard or disaster event affecting an asset or community.	Very High, High, Medium, Low	Probability; %
Vulnerability change	Vulnerability is the susceptibility to damage or negative impact from a hazard or climate impact. A change in vulnerability can be realised through improvement in community and/or asset resilience by reducing or eliminating causes and effects of vulnerability. A low rating would represent little or no change in vulnerability for similar events based on historically known scale or may even introduce unexpected consequences that increase vulnerability. A very high rating would reflect complete removal of community and asset vulnerability for any future events, whatever the scale. Where vulnerability is reduced for events of scale historically experienced, but vulnerability remains for larger events, a rating of 'medium' would likely apply.	Very High, High, Medium, Low	Probability; %
Base vulnerability	Susceptibility to damage or negative impact to assets and/or community. A '0' rating represents little or no risk of damage or disruption; and a '5' represents catastrophic impacts with large scale loss of human life, environment and community assets, infrastructure and cohesion.	0 to 5	

Table 9: Value Potential variables and assessment modes

Variables	Description	Qual	Quant
Value Creation	Opportunity for enhanced physical, economic and social outcomes resulting from investment	Very High, High, Medium, Low	Rapid Value Assessment ($)
Value Capture	Likely potential for part of value created to be captured to contribute to funding of infrastructure	High, Medium, Low	
Value Options	Have mechanisms for retaining value options through the investment life considered. For early stage options analysis, this does not demand an assessment of option efficacy, rather prompt whether multiple options have been considered.	Yes, No, N/A	

Quantitative assessments of exposure, vulnerability and value creation are often preferred for decision making purposes but these are often not calculable. Rapid but robust qualitative assessments of these variables can be undertaken; and is the basis of the approach underpinning the Prioritisation Framework. Doing so can facilitate early filtering of investment opportunities to inform more detailed assessment of short-listed priorities, which may well involve the commissioning of new research.

5.3 Combined Assessment of Net Benefits and Change

This initial assessment of the relative merits of early stage climate and disaster risk reduction options also seeks to provide the flexibility to evaluate options or scenarios under different sets of assumptions and conditions. Preferred investment options can then undergo further analysis and consideration of both 'Economic Impact' and 'Vulnerability Impact'.

Economic Impact is derived from the collective quantitative assessments moderated by the 'Value at Risk' and 'Value Potential' variables. Sub-categories included are:

- asset replacement value;
- asset condition/depreciation;
- current commercial trade and wages subject to disruption;
- service performance improvement;
- resilience change ratio;
- economic investment;
- increased trade; and
- increased jobs.

Vulnerability Impact is derived from a combination of the qualitative assessments and the 'Value at Risk' and 'Value Potential' variables. The relevant sub-categories included are:

- social connectivity;
- environment and cultural or historical heritage loss or damage;
- community health and safety;
- income security; and
- wealth protection.

It is important to emphasise that this dimension relates to vulnerability reduction (or resilience increase) as a result of the investment in climate and disaster risk reduction rather than the starting (or base) vulnerability. An investment which does not reduce vulnerability is not contributing to the goal of reducing climate and disaster risk, or increasing resilience, whether or not it is economically compelling. In other words, the Prioritisation Framework helps users rapidly identify options that reduce vulnerability and have a positive economic return (top right quadrant, Figure 2) and then focuses on prioritising these options according to their relative economic and vulnerability impacts (Figure 3).

This approach can reveal where to get the largest returns on resilience investment. It can also reveal situations where returns on climate and disaster risk reduction might be lower but there are other equity or political reasons for supporting the intervention.

Where two or more climate and disaster risk reduction options offer a similar impact on vulnerability, it makes most sense for greater emphasis to be given to the option responding to a higher initial vulnerability. This distinction is enabled in the assessment with one of the 'Value at Risk' variables being *base vulnerability*, which reflects the vulnerability prior to the proposed intervention.

The sections of the chart in the top right quadrant of Figure 2 can be described as detailed in Figure 3. In some situations there will be options that have a positive vulnerability impact (i.e. reduce vulnerability) but do not have a positive economic impact (i.e. bottom right quadrant in Figure 2). These could be considered 'might do' options and highlight situations where innovative financing mechanisms could be identified to shift the economic impact from negative to positive.

Once assessed, initiatives are plotted on the dual axes of Economic Impact and Vulnerability Impact as shown in Figure 2.

Figure 2: Investment options plotted against axes

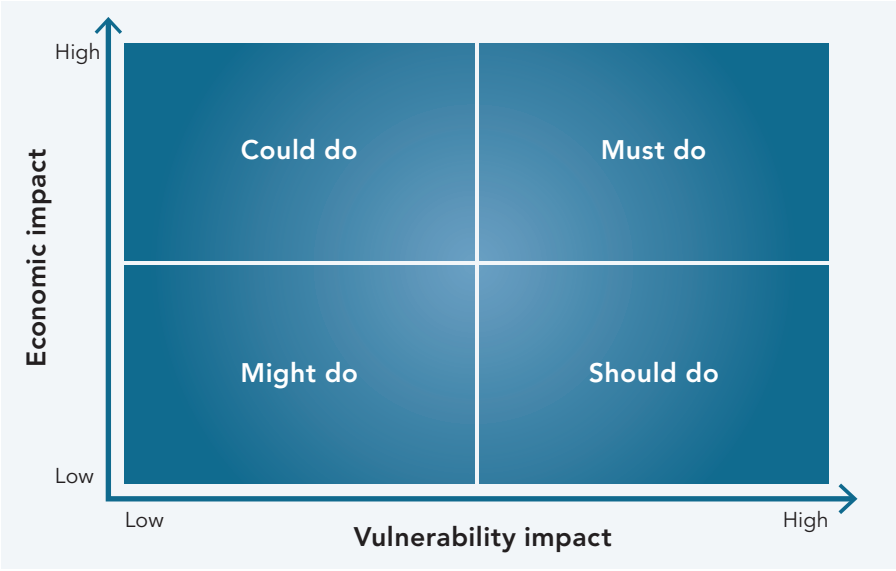


Figure 3: Assessment quadrants

The quadrants in Figure 3 are directional, not absolute, so recommended strategies are only a guide. The following characteristics would typically relate to investment options mapped to the respective quadrants.

'Must do' – high vulnerability change, high economic impact:

- there is a critical community and political imperative
- the economic imperative is compelling
- this investment could be conducive to government and/or private sector funding
- there is likely to be significant potential for value creation
- detailed analysis could make value capture a realistic funding source
- there are likely to be interdependent systems and resilience dependencies to be considered
- the compelling nature warrants fast tracking decision processes

'Should do' – high vulnerability change, low economic impact:

- there is a critical community and political imperative
- the economic case for investment is weak
- requires priority government funding (despite potentially poor Benefit-Cost Ratio)
- relevant for vulnerabilities of a temporal nature, especially decisions with inter-generational impacts
- there is likely to be interdependent systems and resilience dependencies to be considered
- more capital efficient options should be explored

'Could do' – low vulnerability change, high economic impact:

- there is a compelling economic imperative
- the community resilience imperative is low
- this may be conducive to private sector funding
- any government investment should seek to catalyse private sector investment
- traditional economic justification for investment applies
- may provide opportunities for value capture-based funding with further analysis

'Might do' – low vulnerability change, low economic impact:

- the economic and community resilience imperative is low
- there is unlikely to be private sector investment interest
- this is a low priority for government investment, unless there is a resilience dependence
- requires further options analysis, including capital efficiency assessment

Such categorisation can be useful for organisations exploring possibilities and mechanisms for increasing their investments in climate and disaster risk reduction. Options in the 'must do' quadrant are likely to be few in number or already known and being acted upon.

The real value of the assessment comes from understanding whether the option falls in the bottom right or top left quadrant. This informs the nature of the mechanisms required to make the option attractive to funding and financing (i.e. how to shift it to the top right quadrant).

In exceptional circumstances there may be a need to override usual priorities. These exceptional circumstances might be described as super-normal or hyper-critical. Super-normal refers to out of the ordinary circumstances, perhaps never seen before. Hyper-critical would be a broad-based impact and probably catastrophic to highly vulnerable communities.

These situations may either manifest with absolute impact or do not materialise at all. The challenge becomes to not treat normal critical as super-normal or hyper-critical. As such, use of this sort of override would require thorough explanation and justification; reiterating the importance of the assessment process being undertaken in an inclusive, participatory and transparent way.

5.4 Enhancing Existing Decision Frameworks

The Prioritisation Framework aligns and can be readily integrated with established stage-gate investment methodologies. In particular, it provides another perspective to the problem and initiative identification phases of prevailing decision-making processes such as the Stages 1 and 2 of infrastructure assessments as depicted in Figure 4[8]. The Prioritisation Framework provides a prioritised set of climate and disaster risk reduction projects to go to business case phase.

Enhancements to existing business case, procurement, delivery and benefits realisation processes should be subsequently applied with care to not compromise the climate and disaster risk reduction objectives of the initiative.

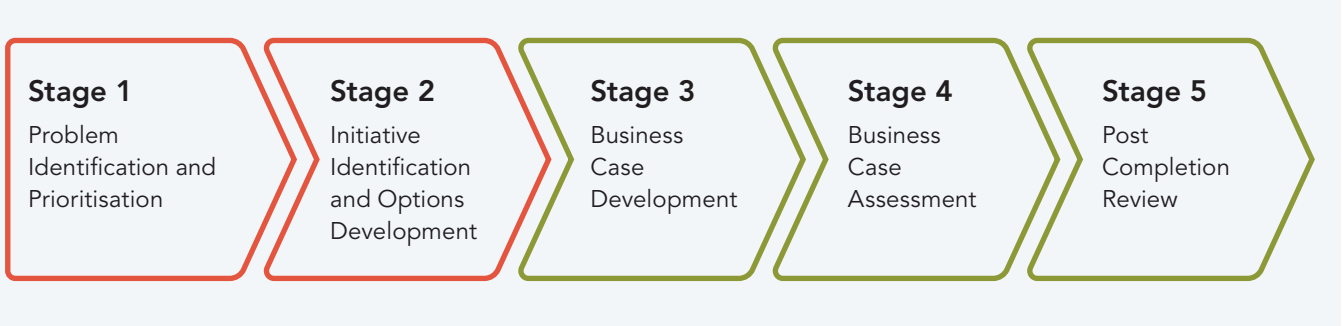


Figure 4: Infrastructure Australia investment assessment framework

8 For example see the Australian Transport Assessment and Planning framework ***https://www.atap.gov.au/framework/*** and the Infrastructure Australia Assessment Framework ***https://www.infrastructureaustralia.gov.au/policy-publications/publications/files/IFA_Infrastructure_Australia_Assessment_Framework_Refresh_v26_lowres.pdf***

6. Alternative Funding Pathways

Across the globe, the need for urban physical infrastructure investment vastly exceeds the readily available funds.

In its 2012 Infrastructure Financing and Funding Report, Infrastructure Australia recognised the need:

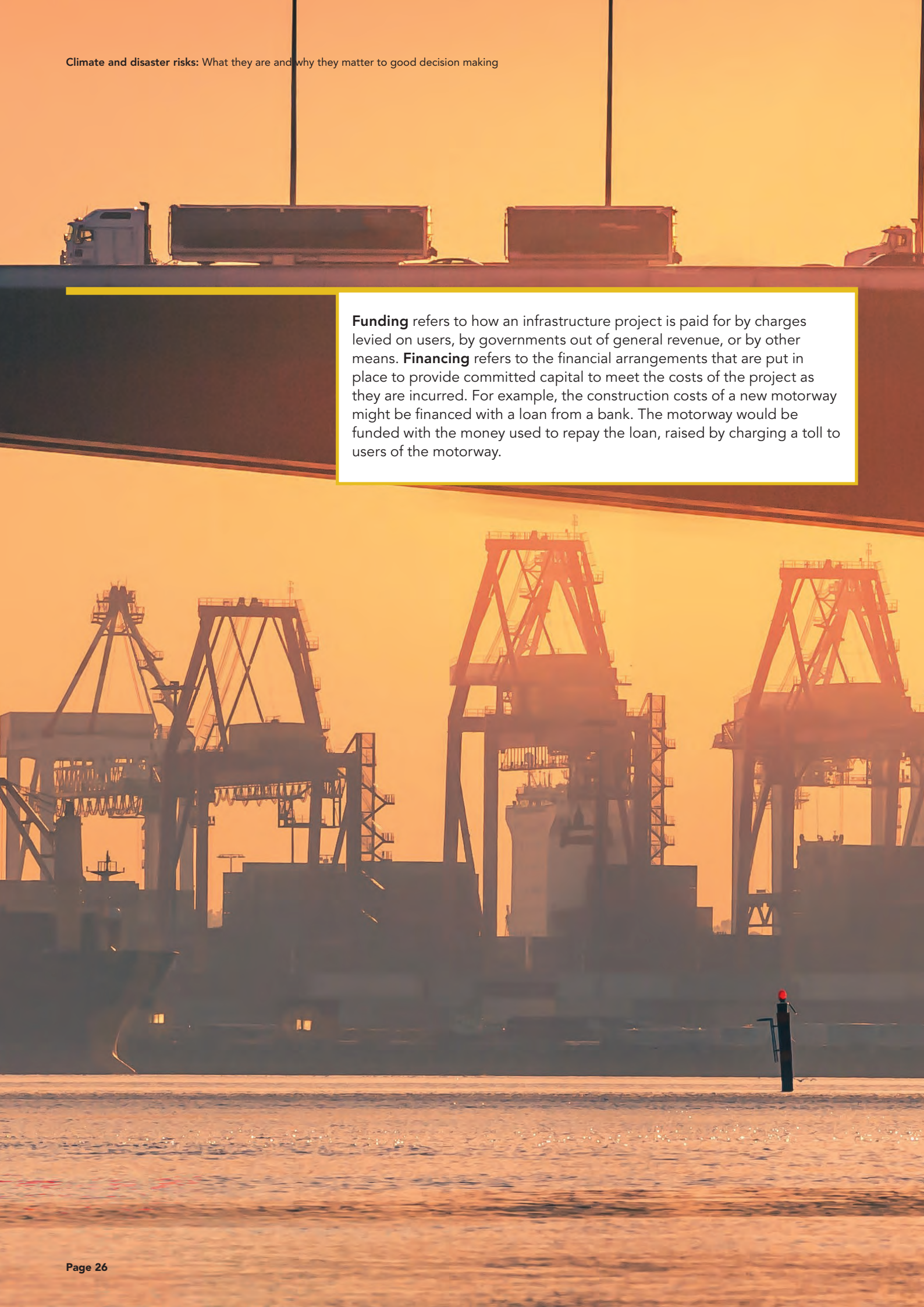
- for greater infrastructure investment;
- to identify current barriers to attracting infrastructure finance; and
- to develop options to encourage greater private sector investment.

The report noted that a major constraint on the delivery of social and economic infrastructure is the **funding capacity** of Australian governments, which was seen as distinct from the capacity of the private sector to provide **financing capital** for infrastructure projects.

Recommendations included that the Australian Government should consider greater use of alternative funding models. It also suggested that governments should utilise appropriate models to drive revenue from the broader benefits delivered by major infrastructure projects, such as value capture.

Infrastructure investment is needed for climate and disaster risk reduction. The financing of this requires the translation of the benefits into measurable returns on investment in the context of emerging risks that capital markets can understand and appreciate.

There is a resistance to debt financing infrastructure investments associated with concerns over creditworthiness. This becomes more acute when it comes to the incremental costs associated with climate-resilient infrastructure.



Funding refers to how an infrastructure project is paid for by charges levied on users, by governments out of general revenue, or by other means. **Financing** refers to the financial arrangements that are put in place to provide committed capital to meet the costs of the project as they are incurred. For example, the construction costs of a new motorway might be financed with a loan from a bank. The motorway would be funded with the money used to repay the loan, raised by charging a toll to users of the motorway.

6.1 Enhanced Investment

The *National Disaster Risk Reduction Framework* (citing the 2017 Deloitte Access Economics report to the Australian Business Roundtable for Disaster Resilience and Safer Communities) highlighted that over the past 10 years disasters have cost the Australian economy around $18 billion per year. Assuming current development patterns and population growth continue, Deloitte Access Economics forecast this would reach $39 billion per year by 2050. This forecast does not account for the effects of a changing climate, which are expected to create greater impacts and costs.

These estimates include the intangible costs of disasters such as death, injury and impacts on health and wellbeing, employment and community connectedness. These intangible costs are estimated to be as great, or greater than, tangible costs.

Much of the work needed to reduce climate and disaster risk and to contain this growing cost will require upfront financial investment. The basic problem is that the long-term costs of not investing in infrastructure are often not communicated to, or recognized by, decision-makers. Similarly, the immediate benefits of making infrastructure more climate-resilient tend to be overlooked.

Priority 3 of the *National Disaster Risk Reduction Framework* is Enhanced Investment. This Framework recognises that all levels of government, communities and the private sector already make significant investments to reduce disaster risk but are now actively seeking a return on that investment in terms of immediate outcomes and avoided losses.

This presents a significant opportunity for public and private sectors to work together to identify and leverage the broader economic value and opportunity created by investments in climate and disaster risk reduction and resilience. In particular, there is a need to focus on:

1. finding or developing financing and funding pathways to address existing high priority risks across all environments; and
2. identifying financing mechanisms[9] and pathways to pursue climate and disaster risk reduction measures in planned projects, particularly infrastructure and development projects.

The Prioritisation Framework sets out a number of strategic actions to respond to this Priority, including to identify additional current and future potential funding streams.

9 Refers to the delivery models and pathways available to project proponents - both the public and private sectors - to access project finance and funding. This is described in more detail in the section 'Monetising the value created'.

6.2 Value Capture

Value capture offers the potential to generate new funding streams by increasing and leveraging the value created for beneficiaries. This in turn allows governments to deliver new infrastructure that otherwise would not be funded or to bring forward planned infrastructure ahead of time.

Value capture can also facilitate investment in resilient infrastructure. Public investment in infrastructure creates value (benefits) in a broad range of areas – land/property value uplift, labour force accessibility, provision of community services and travel time savings among others – in addition to the economic benefits enjoyed by the users of the infrastructure.

Figure 5 shows that infrastructure in its many forms delivers benefits and value to both users as well as a broader set of beneficiaries. Value capture leverages these benefits, or the value created, by asking the beneficiaries to contribute project funding.

The paradigm changes from one centred on cost recovery to one of sharing the value created. In practice this perspective encourages infrastructure project planning and design to fully consider all the opportunities to create (community) value.

Infrastructure can be designed to enhance local areas and improve connectivity to work, play and home. The conventional approach to infrastructure delivery, which relies on government funding, does not always fully recognise the additional value to individuals, communities and companies that infrastructure can create. This can limit the value created by new infrastructure, creating a missed opportunity to boost productivity and liveability.

Value capture can provide a framework to monetise the wider benefits of new infrastructure to provide government with additional sources of funding. These can be targeted directly at the beneficiaries of the particular infrastructure.

Value capture works through both funding and financing. Funding mechanisms are deployed to collect contributions from beneficiaries, sized to represent a fair portion of the incremental benefit they will receive. Financial arrangements are then constructed to use the revenues to provide committed capital to meet the costs of the project as they are incurred, which usually means up front during the construction and delivery phase.

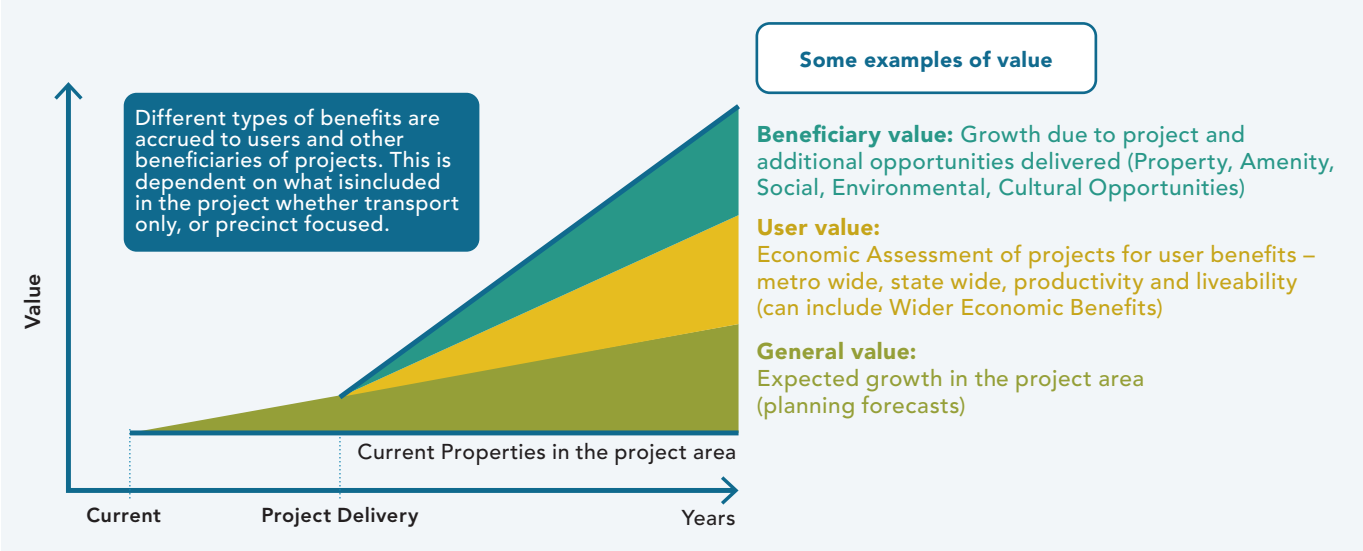


Figure 5: Value is delivered in multiple ways by the project

6.3 Infrastructure Planning and Investment Process

To innovate the way infrastructure is thought about and funded, in addition to the economic assessment of an individual infrastructure project, decision makers should also consider what else can be done in the area around the infrastructure to create the most value to the community from the investment.

Figure 6 shows that the infrastructure planning and investment process needs to be broadened. It needs to examine, in addition to the primary service need, the many ways value can be delivered through secondary drivers to improve urban and community outcomes.

Value capture could be an integrated solution for a variety of infrastructure types to achieve an equitable and efficient (non-wasteful) outcome. This applies equally to investment in resilient infrastructure, both at the upfront options assessment and planning stage for new infrastructure and when planning to replace or restore infrastructure in the recovery from a disaster event.

The impacts of infrastructure investment are not always only positive. In addition to the creation of value for certain beneficiaries, there will almost always be some reduction of value too. Examples of 'dis-benefit' include decreased visual amenity, noise and other forms of pollution, and increased congestion.

With regards to uplift in property prices, increased value in one area as a result of an infrastructure project may have flow-on negative implications for property values elsewhere. The demand for housing might be reduced in areas where there is little or no infrastructure investment. Developing funding solutions that are genuinely fair will also need to consider the potential dis-benefits experienced by sectors of the community.

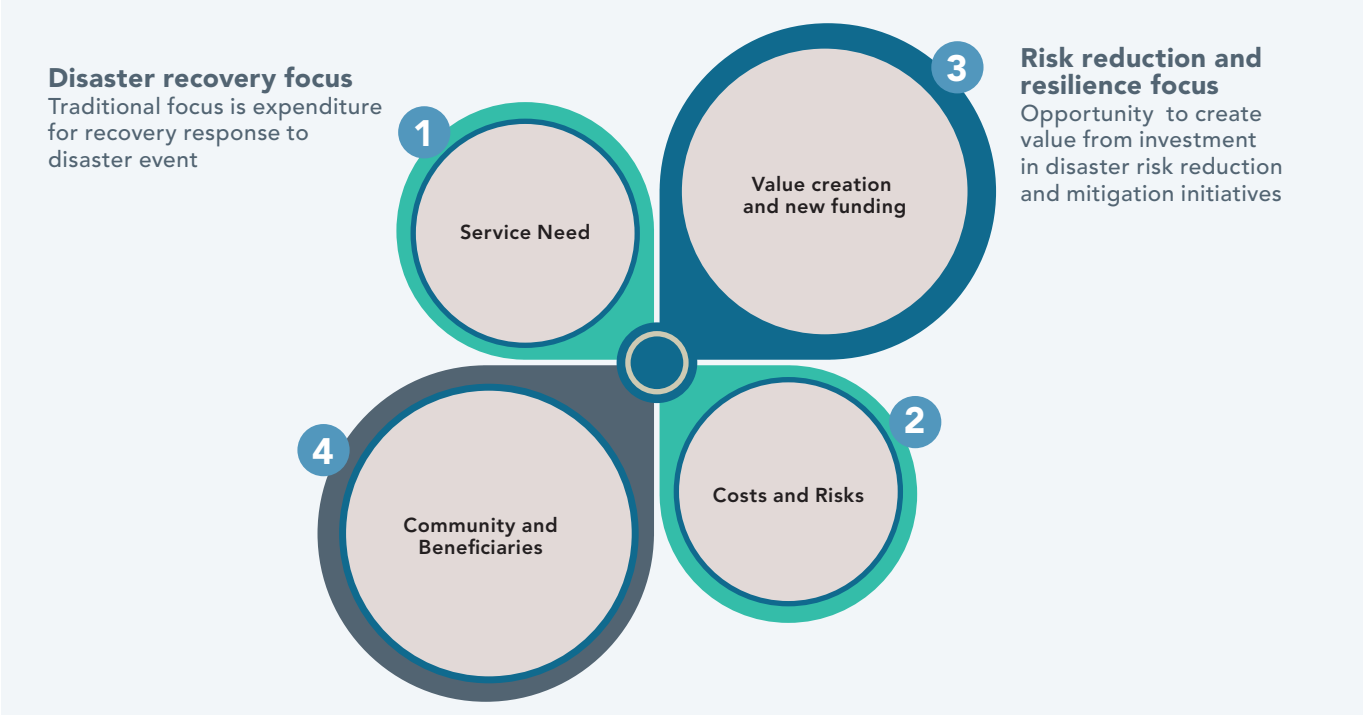


Figure 6: Investment in infrastructure creates value to a range of beneficiaries

6.4 Rapid Assessment of Value Creation and Capture

Figure 7 identifies the essential elements that need to be present for an effective assessment of opportunities to create and capture value from investment in infrastructure. These key elements or conditions include:

1. There needs to be a clear spatial nexus of linkage that connects the benefit and beneficiary to the infrastructure and further value creation opportunities. This needs to be attributable to the project and therefore able to be captured for project funding. It needs to be clear that the benefits are as a result of the infrastructure and not as a result of other factors.
2. The quantification of the value created requires a robust methodology and evidence base. This will support the stance that potential value capture revenues for project funding are considered bankable for investment purposes.
3. A valid range of value capture mechanisms is available through current legislation or can be readily made available through new or adjusted legislation. It can be activated to collect revenue from the identified beneficiaries.
4. The collection of value capture revenues from the identified project beneficiaries should be scheduled or timed in line with when the value created from the infrastructure is realised by the beneficiary.

The assessment of opportunities for value creation should:

- respond directly to the identified infrastructure or service need;
- extend beyond the specific project and its objectives to more broadly consider the locational context and the opportunity to create additional value;
- consider not just the economic benefits but also the social and environmental benefits;
- consider all potential forms of value creation and a wider group of potential beneficiaries than the immediate user group of the project/ precinct;
- take account of land use planning and regulatory requirements; and
- seek to optimise design quality.

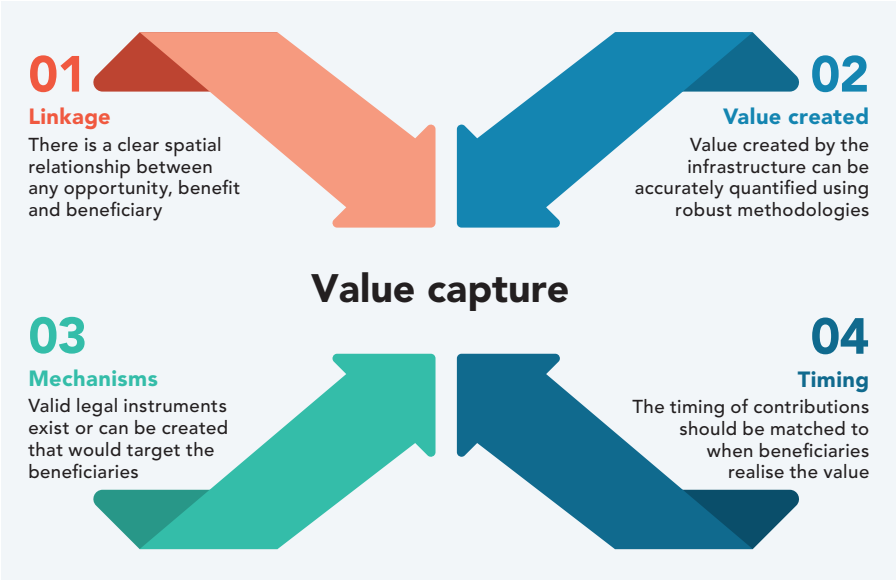


Figure 7: Conditions for an effective value capture assessment

Mechanisms to capture value created should be:

- equitable, recognising government's role to build better communities;
- fair, by ensuring any costs to beneficiaries should not impose undue financial hardship;
- proportionate, by applying mechanisms that are demonstrably commensurate with the amount of private value created;
- cost efficient to implement and comply with;
- transparent and easily understood;
- effective, not creating unintended consequences or distorting market actions;
- evidence based, by ensuring benefits are quantified and attributable to intervention;
- timely; and
- able to be clearly communicated to stakeholders.

6.5 Monetising the Value Created

An effective value capture assessment requires evidence of the value created (e.g. land value uplift, land use change, travel time savings, etc.) from new or enhanced infrastructure that will be delivered to the beneficiaries within a location. Part of the value created for beneficiaries can be captured in the form of revenue as a source of funding for the investment. An effective value creation and capture strategy requires integration of the detailed value creation and value capture analyses with governance models, implementation strategies, including developing financial instruments, contract requirements and delivery models.

One pathway to implement value capture for infrastructure funding is described in Figure 8. This pathway considers funding by developing a detailed value capture assessment at a high level of confidence.

From there, governance models (Step 3, Figure 8) need to be developed that will consider important issues such as:

- Who the proposer of the infrastructure works is, and how to consider them in the value capture revenue streams?
- Can the funding be applied to the type of infrastructure?
- Is there an enabling charging regime in place or does it need to be created?
- Avoiding double counting in the revenue streams?
- Can the market provide the solution through an alliance or Public Private Partnership (PPP) model?
- What contracts need to be developed to ensure the reliability of revenue streams?
- Is there a public authority required or Special Purpose Vehicle required to ensure the revenue streams can go to the funders?
- Where do the assets vest as part of the delivery?
- Who will collect and enforce the value capture regime?

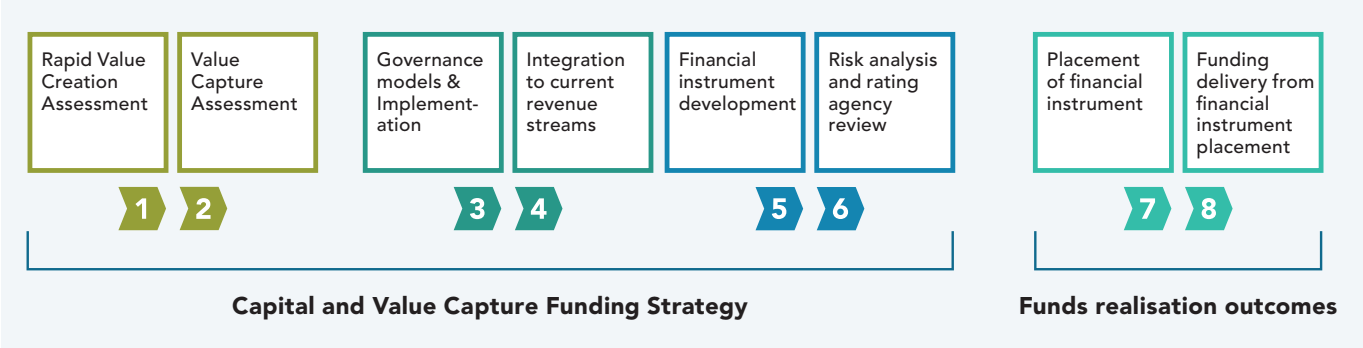


Figure 8: Investment in infrastructure creates value to a range of beneficiaries

The financial instruments (Step 5, Figure 8) developed need to consider multiple factors such as:

- risk allocation and risk transfer;
- risk of recovery of revenue streams;
- regulatory oversight of the revenue streams;
- rights and obligations of the revenue stream owner and the asset owner;
- accounting treatment of revenue streams (i.e. on or off balance sheet, etc.); and
- tax treatment of revenue streams.

Once an appropriate financial instrument has been developed and applied, discussions should be had with credit ratings agencies and ratings (Step 6, Figure 8). Treasury departments in jurisdictions have ongoing arrangements with ratings agencies and the approach to the monetisation should consider:

- minimising the impact of the project on the cost and quantum of existing debt;
- placement of debt on or off the balance sheet; and
- current and future debt levels of government jurisdictions.

The financial instrument will be influenced by the appropriate governance structure and ratings agencies. Treasury departments can provide guidance as to the appropriate structure, mechanisms, instrument and ratings agencies to approach.

6.6 Rapid Assessment of Value Created

The Prioritisation Framework is intended to assist with the preparation of a quick assessment of the relative benefits (net economic return and reduced vulnerability) of a range of options being considered for climate and disaster risk reduction. In line with requirements of existing infrastructure investment decision-making frameworks, the assessment at this stage is not required to include detailed analysis of the benefits; this will be required when preferred options are identified and a final business case is prepared (Stage 3, Figure 4).

For these early stages of the investment decision-making process (Stages 1 and 2, Figure 4) it is sufficient to prepare a high-level assessment of the benefits, including the value created. This is intended to provide the level of confidence necessary for early stage comparison of investment options. A rapid assessment of the value created can provide an early order-of-magnitude estimate of the value for the range of benefits and dis-benefits, as well as for the identified beneficiaries.

While the rapid assessment of value created does not replace detailed analysis and would not be sufficient for the preparation of a value capture strategy, it does guide such activity, enhancing the efficacy and efficiency of detailed work.

A Rapid Assessment should include:

1. **Assessment of the local area context (including cross-scale factors)**

   Develop a profile of the study area based on its socio-economic and strategic characteristics, existing planning framework, land uses and constraints. Identify gaps to generate a list of preliminary opportunities to create value.

2. **Identification and categorisation of opportunities to create value**

   Following the context assessment, ask further questions to identify the potential value creation opportunities in the project.

3. **Identification of beneficiaries and benefits**

   For each opportunity identify the benefits and the beneficiaries to whom the benefits would accrue.

4. **Assessment of both timing of delivery and realisation of the benefits of the infrastructure**

   Assign a delivery date and period of analysis (up to 30 years) for each opportunity and identify if the benefits to beneficiaries will be ongoing or realised as once-off.

7. Case studies

The Prioritisation Framework has been developed with the intention of being practical and pragmatic. Outputs seek to provide relative priorities rather than absolutes.

It is not intended to limit thinking to a narrowly defined problem and small set of traditional local scale or infrastructural solutions. The intent is to support decisions by broadening the framing of the problem and numbers of stakeholders in order to expand the options available.

Ease of use and simplicity have been key factors informing the design and intent of the Prioritisation Framework. There is, due recognition of the sometimes complex environments, the cross-scale and uncertain nature of events, and incompleteness of information.

The following case studies show how the Prioritisation Framework could be applied to different situations.

7.1 Eastern River flood in Brown (2023)

East Lake is the major water supply for the city of Brown and surrounding area. It is a gated dam, which releases water into the Eastern River, which weaves its way through the suburbs and the centre of Brown, discharging to the sea at the Harbour.

In February and March 2023, the Brown area, including the East Dam catchment, experienced an unprecedented rain event, seeing record rainfall of 1,134 millimetres in the 10 days, resulting in the East Dam peaking at 42.99 metres height or 244.8% of capacity. The rainfall from this event represented more than twice the average Brown rainfall for January and February combined. The chart of historic dam levels highlights the scale and speed of dam level rise in 2023 (Figure 9).

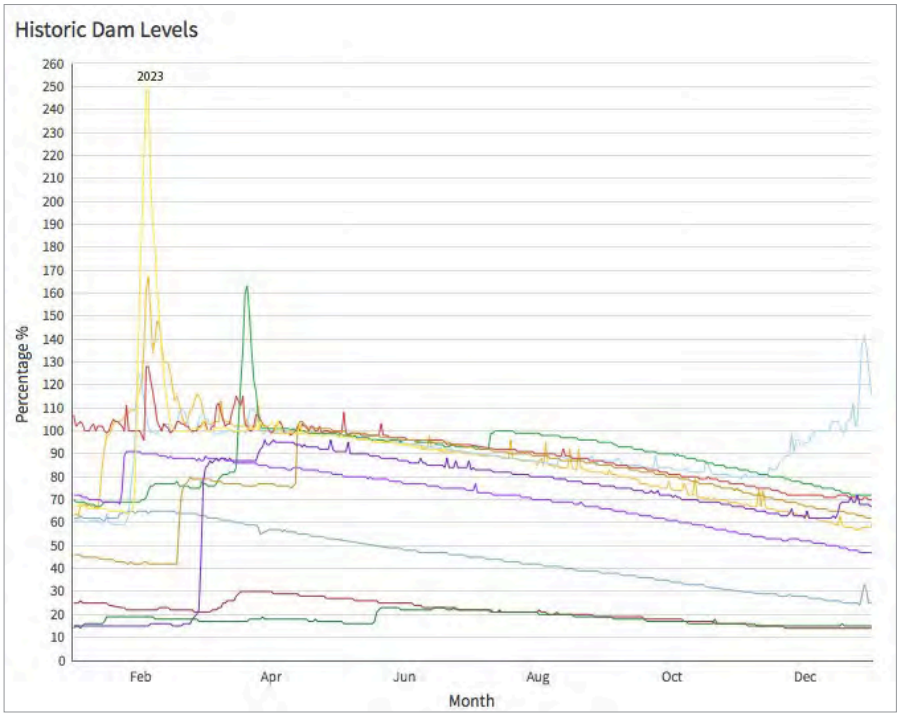


Figure 9: Historic dam levels (2013-2023) of the East Dam in Brown

Brown has a tropical climate with a Summer wet season which is most intense through February and March. The 2023 deluge was preceded by drought conditions from 2019 to 2021 where no major rain events were experienced, with dam levels falling below 15% of dam capacity.

Dam levels recovered quite well late in the 2022 wet season, but even that was later than normal. Brown entered 2019 with dam levels at a healthy 70%. This left no option but to release water following the extreme rain event in late February and early March.

The 2023 rain event was so extreme it is unlikely that an early release of water from the dam would have totally avoided some level of flooding. It does serve to demonstrate, however, how extreme events reveal tensions and potential conflicts in values, objectives and priorities that can contribute to vulnerability, aside from any systemic susceptibilities. Extreme and changing weather patterns, both wet and dry, only exacerbate the challenges decision makers face with respect to when to release water for flood management.

The ultimate release of water from the dam resulted in extensive flooding of properties in the lower lying areas of the city of Brown.

Estimated damage toll from an event such as this could be:

- 3170 properties experienced minor damage (<27cm inundation)
- 994 properties with moderate damage (up to 1m inundation)
- 123 properties with severe damage (>1m inundation)
- Estimated losses in Brown ~$500m (90% domestic, 10% commercial)
- Stock losses in the region ~400,000 = ~$470m
- Properties potentially uninsurable, or exorbitant premiums to insure

Hypothetical options considered:

- **Option 1 - Raise dam wall to accommodate 2023 event**
- **Option 2 - Build supplementary dam outlet to sea**

Option 1 - Raise the dam wall to accommodate 2023 scale event

Raising the dam wall would have the dual effect of making the dam able to accommodate larger rain events than it could in the past and increasing the water storage capacity to make the city more resilient to drought. One limitation would be that if rain events become more extreme or more frequent, there would remain some chance of another flood event. Estimated capital cost of $300m, 30 year operating life, and $3 million per annum of operating costs at current value.

Assessment:

Category	Sub-category	Qualitative Assessment	Quantitative Assessment	Rationale	Sub-category score	Category Raw score*	VaR/VP** adjusted quant score	VaR/VP adjusted qual score
Asset Restoration (10%)						50	25	-
	Condition (50%)	Medium						
	Replacement value (50%)		1,000,000,000	3,000 x $330k	500			
Socio-economic Disruption (20%)						2	1	30
	Trade (40%)		20,000,000	$10m/week x 2 weeks	8			
	Wages (30%)		3,000,000	$1.5m/week x 2 weeks	0.9			
	Social connectivity (30%)	High		Eliminates or reduces flood impact	300	60		
Environment & Heritage Disruption (10%)						20		10
	Flora/fauna losses (20%)	Low			50			
	Permanent habitat loss (20%)	Nil			0			
	Water, soil, air quality (30%)	Low			150			
	Cultural or historical heritage (30%)	N/A			0			

Category	Sub-category	Qualitative Assessment	Quantitative Assessment	Rationale	Sub-category score	Category Raw score*	VaR/VP** adjusted quant score	VaR/VP adjusted qual score
Value at Risk	Exposure	High		Weather events more frequent and more extreme, so high prob.				
	Vulnerability change	Medium		Will accommodate a lot more events, but not more extreme ones				
	Base vulnerability	4		Flood zone through heart of Brown – broad impact to residents, businesses and service provision				
	VaR multiplier					0.5		
				Value at Risk sub-total:			*26*	*40*
Service Performance (10%)							2.3	-
	Capacity (10%)		0					
	Availability (20%)		0					
	Longevity (20%)		0					
	Resilience change ratio (50%)		1.25	Able to withstand larger events than previously (~25% larger) @500m current value	63			
Economic Uplift (20%)							0.4	-
	Investment (60%)		2,000,000	20% x $10m annual investment	1			
	Trade (20%)		15,600,000	3% x $10m/wk x 52 wks	3			
	Jobs (20%)		2,340,000	3% x $1.5m/wk x 52 wks	0			

Category	Sub-category	Qualitative Assessment	Quantitative Assessment	Rationale	Sub-category score	Category Raw score*	VaR/VP** adjusted quant score	VaR/VP adjusted qual score
Community Resilience (30%)							-	28
	Income security (20%)	Medium		Some increase in confidence to spend and invest	0			
	Wealth protection (30%)	High		Reduced risk of damage; insurable properties	150			
	Health, safety, well-being (50%)	High		Reduced likelihood and severity of damage	100			
Value Potential	Value creation	Medium		Increased property values from being less flood prone and insurable				
	Value capture	Medium		Some willingness to pay for becoming insurable				
	Options assessed	Yes		2 options				
	VP multiplier					0.38		
				Value Potential sub-total:			3	28
				Grand Total:			**29**	**68**

* with weighting applied

** VaR multiplier = Base Vulnerability x Vulnerability change x Exposure
VP multiplier = 'Value creation' potential x 'Options assessment' premium

Option 2 – Build supplementary dam outlet to sea

Another action could be to create an alternative water release option, probably piped at least part of the way, diverting flows away from the Eastern River and the city centre and suburbs. The only limit to flood mitigation would be the designed flow rate of the alternative outlet. This solution would not change the drought resilience. Estimated cost is $1,200 million, with a 30 year expected life and $2 million per annum operating cost at current value

Assessment:

Category	Sub-category	Qualitative Assessment	Quantitative Assessment	Rationale	Sub-category score	Category Raw score*	VaR/VP** adjusted quant score	VaR/VP adjusted qual score
Asset Restoration (10%)						50	100	-
	Condition (50%)	Medium						
	Replacement value (50%)		1,000,000,000	3,000 x $330k	500			
Socio-economic Disruption (20%)						2	4	120
	Trade (40%)		20,000,000	$10m/week x 2 weeks	8			
	Wages (30%)		3,000,000	$1.5m/week x 2 weeks	0.9			
	Social connectivity (30%)	High		Eliminates or reduces flood impact	300	60		
Environment & Heritage Disruption (10%)						20		40
	Flora/fauna losses (20%)	Low			50			
	Permanent habitat loss (20%)	Nil			0			
	Water, soil, air quality (30%)	Low			150			
	Cultural or historical heritage (30%)	N/A			0			

Category	Sub-category	Qualitative Assessment	Quantitative Assessment	Rationale	Sub-category score	Category Raw score*	VaR/VP** adjusted quant score	VaR/VP adjusted qual score
Value at Risk	Exposure	High		Weather events more frequent and more extreme, so high prob.				
	Vulnerability change	High		Will accommodate a lot more events, but not more extreme ones				
	Base vulnerability	4		Flood zone through heart of Brown – broad impact to residents, businesses and service provision				
	VaR multiplier					2.0		
				Value at Risk sub-total:			*104*	*160*
Service Performance (10%)							12.5	-
	Capacity (10%)		0					
	Availability (20%)		0					
	Longevity (20%)		0					
	Resilience change ratio (50%)		1.25	Able to withstand larger events than previously (~25% larger) @500m current value	125			
Economic Uplift (20%)							1	-
	Investment (60%)		2,000,000	20% x $10m annual investment	1			
	Trade (20%)		15,600,000	3% x $10m/wk x 52 wks	3			
	Jobs (20%)		2,340,000	3% x $1.5m/wk x 52 wks	0			
Community Resilience (30%)							-	75
	Income security (20%)	Medium		Some increase in confidence to spend and invest	0			
	Wealth protection (30%)	High		Reduced risk of damage; insurable properties	150			
	Health, safety, well-being (50%)	High		Reduced likelihood and severity of damage	100			

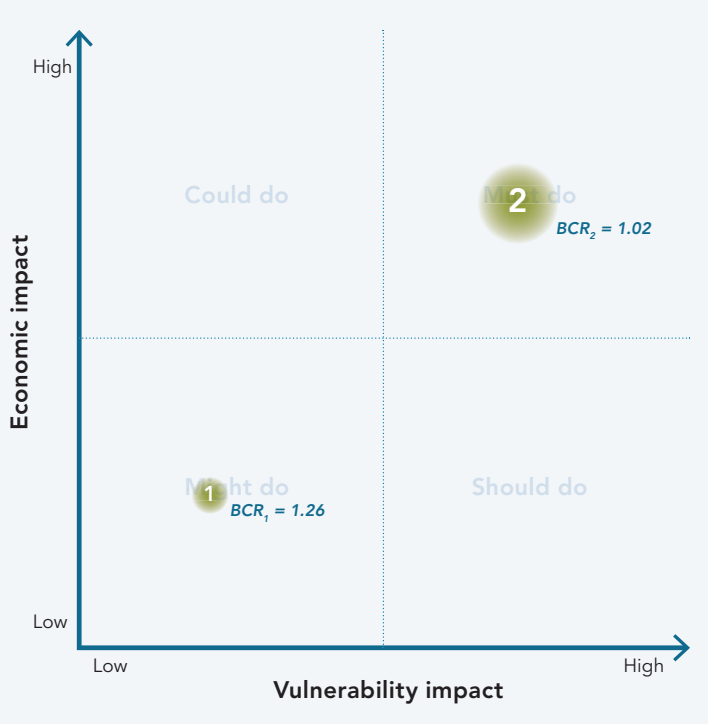
Category	Sub-category	Qualitative Assessment	Quantitative Assessment	Rationale	Sub-category score	Category Raw score*	VaR/VP** adjusted quant score	VaR/VP adjusted qual score
Value Potential	Value creation	High		Increased property values from being less flood prone and insurable				
	Value capture	Medium		Some willingness to pay for becoming insurable				
	Options assessed	Yes		2 options				
	VP multiplier					1.0		
				Value Potential sub-total:			*13*	*75*
				Grand Total:			**117**	**235**

* with weighting applied

** VaR multiplier = Base Vulnerability x Vulnerability change x Exposure
VP multiplier = 'Value creation' potential x 'Options assessment' premium

Having provided the inputs for the options and got qualitative and quantitative scores for each the options are plotted on the chart. The dimensions of Change in Vulnerability and Economic Impact display relativity of the considered options, as shown in the chart. In line with the framework described earlier, Option 1 returns a relatively low change in vulnerability and economic impact, and is classified as a 'Might do' from a resilience investment standpoint. Option 2 presents a high change in vulnerability and high economic impact, or a 'Must do' classification.

A traditional economic assessment, in nominal terms, would see Option 1 return the Benefit-Cost Ratio of 1.26, while Option 2 has a BCR of 1.02. It is important to note that these BCR estimates do not equate with the measures of economic impact in the chart. This is because the Prioritisation framework provides a facility for variable weighting of income, commerce and asset protection; which BCR estimates do not account for. The pure economic justification gets the opposite priority to the resilience priority. This is not a particular surprise, as they are seeking to achieve different objectives, economic return versus resilience. If the intended use of the funding is resilience, a purely economic assessment cannot be expected to be effective.



7.2 Bootsville Fires – (2030)

On 18 February 2030, Australian weather conditions which gave rise to this disaster included extreme heat, high winds, low humidity, and severe drought conditions. These fires caused great loss of life for a bushfire event and wiped out whole communities.

Heat – Immediately preceding 18 February 2030, there were consecutive days of extreme temperatures culminating in 46 degrees Celsius on the day.

Drought - This intense heatwave occurred within the worst drought ever recorded in Australia's history. The region experienced little to no rainfall in the two months preceding 18 February 2030.

Wind – The northerly wind exceeded 100km/h and was hot and dry from passing over central Australia. The wind then changed to gale force south-westerly winds which reached up to 120 km/h. This second wind caused the fires to merge into one huge fire front that burned with speed and ferocity.

Asset Losses – These fires caused great loss of human life from a bush-fire event.

- 180 people died.
- Over 2,100 houses and 3,500 structures were destroyed, with thousands more damaged.
- Several towns were completely destroyed while many other towns suffered serious damage.
- The total area burnt was approximately half a million square kilometres.

Environmental Impacts – the RSPCA estimated that wildlife injury and death would tally more than a million. Many of the surviving wildlife suffered burns and other injuries. The plants in the bush were severely affected, impacting animals who need the vegetation for survival.

Ongoing effects – 26% of high impact communities, 17% of medium impact communities, and 12% of low impact communities were reporting symptoms of depression, post-traumatic stress disorder (PTSD) or severe psychological distress following the event.

The topography around Bootsville had helped it avoid previous fires. On the day of the fire, people thought it would go around the town, but within minutes the town became an inferno. Around 5.00pm, electric power was lost, and the northerly wind stopped. Minutes later the wind came back from a south-westerly direction, creating an extended fire front with strong winds, burning embers raining down from the sky, and the fire up raced up the valley to the township.

Communication delays and difficulties meant that residents didn't receive warnings from emergency services until it was too late to leave, and people couldn't get messages out to emergency services that the town was ablaze.

Hypothetical options considered:

- **Option 1 - Rebuild the town and build safety shelters**
- **Option 2 - Rebuild the town, including safety burners, upgrade emergency services communication systems, weather forecasting and emergency procedures.**

Option 1 – Rebuild the town and build safety shelters

Rebuild the houses, commercial and community facilities, and design and build emergency fire safety shelters for the community.

Assessment:

Category	Sub-category	Qualitative Assessment	Quantitative Assessment	Rationale	Sub-category score	Category Raw score*	VaR/VP adjusted quant score	VaR/VP adjusted qual score
Asset Restoration (10%)						25	2.5	-
	Condition (50%)	M						
	Replacement value (50%)		50,000,000	200 x $250k	250			
Socio-economic Disruption (20%)						17	1.7	9
	Trade (40%)		15,600,000	$300k/week x 52 weeks	62			
	Wages (30%)		7,800,000	$150k/week x 52 weeks	23			
	Social connectivity (30%)	H		Helps to keep people alive, but homes may still be lost	450	60		
Environment & Heritage Disruption (10%)						20		27
	Flora/fauna losses (20%)	H		Large fires burn out large tracts of land	1,000			
	Permanent habitat loss (20%)	M		Extensive loss of Mountain Ash forests	600			
	Water, soil, air quality (30%)	L		Extreme smoke clears quickly	150			
	Cultural or historical heritage (30%)	M		Historic buildings lost	900			

Category	Sub-category	Qualitative Assessment	Quantitative Assessment	Rationale	Sub-category score	Category Raw score*	VaR/VP adjusted quant score	VaR/VP adjusted qual score
Value at Risk	Exposure	H		Periodic bushfires in region				
	Vulnerability change	L		Some change to protecting life, but little change to loss of assets				
	Base vulnerability	4		Bushfires of this scale can be catastrophic to individuals and communities				
	VaR multiplier					0.1		
				Value at Risk sub-total:			*4*	*36*
Service Performance (10%)							0.2	-
	Capacity (10%)		0					
	Availability (20%)		0					
	Longevity (20%)		0					
	Resilience change ratio (50%)		1.25	Human life protection	31			
Economic Uplift (20%)							0	-
	Investment (60%)		100,000	5% x $2m annual investment	1			
	Trade (20%)		312,000	2% x $300k/wk x 52 wks	1			
	Jobs (20%)		156,000	2% x $150k/wk x 52 wks	0			
Community Resilience (30%)							-	0
	Income security (20%)	M		Confidence to spend and invest, at best, back to normal	0			
	Wealth protection (30%)	L		Risk of property loss remains	150			
	Health, safety, well-being (50%)	M		Some improvement with shelters	100			

Category	Sub-category	Qualitative Assessment	Quantitative Assessment	Rationale	Sub-category score	Category Raw score*	VaR/VP adjusted quant score	VaR/VP adjusted qual score
Value Potential	Value creation	L		Little property or business value increase				
	Value capture	L		Little to capture				
	Options assessed	Y		2 options considered				
	VP multiplier					0.06		
				Value Potential sub-total:			*0*	*0*
				Grand Total:			**4**	**36**

* with weighting applied

Option 2 – Rebuild the town, including safety bunkers, upgrade emergency services communications systems, weather forecasting and emergency procedures

Assets replaced and emergency bunkers installed for when people are exposed to danger, but also invest in reliable supporting capabilities to better coordinate protection activities, improved planning and weather forecasting to best prepare this community and others.

Assessment:

Category	Sub-category	Qualitative Assessment	Quantitative Assessment	Rationale	Sub-category score	Category Raw score*	VaR/VP adjusted quant score	VaR/VP adjusted qual score
Asset Restoration (10%)						25	12.5	-
	Condition (50%)	M						
	Replacement value (50%)		50,000,000	200 x $250k	250			
Socio-economic Disruption (20%)						17	8.6	45
	Trade (40%)		15,600,000	$300k/week x 52 weeks	62			
	Wages (30%)		7,800,000	$150k/week x 52 weeks	23			
	Social connectivity (30%)	H		Helps to keep people alive, but homes may still be lost	450	90		

Category	Sub-category	Qualitative Assessment	Quantitative Assessment	Rationale	Sub-category score	Category Raw score*	VaR/VP adjusted quant score	VaR/VP adjusted qual score
Environment & Heritage Disruption (10%)						265		133
	Flora/fauna losses (20%)	H		Large fires burn out large tracts of land	1,000			
	Permanent habitat loss (20%)	M		Extensive loss of Mountain Ash forests	600			
	Water, soil, air quality (30%)	L		Extreme smoke clears quickly	150			
	Cultural or historical heritage (30%)	M		Historic buildings lost	900			
Value at Risk	Exposure	H		Periodic bushfires in region				
	Vulnerability change	M		Better communications, procedures and forecasting will aid protection of life and property				
	Base vulnerability	4		Bushfires of this scale can be catastrophic to individuals and communities				
	VaR multiplier					0.5		
				Value at Risk sub-total:			21	178
Service Performance (10%)							4.7	-
	Capacity (10%)		0	10% extra tourism x $300k/wk	2			
	Availability (20%)		0		0			
	Longevity (20%)		0		0			
	Resilience change ratio (50%)		2	Supporting systems, forecasting and procedures improve capability to manage events	125			

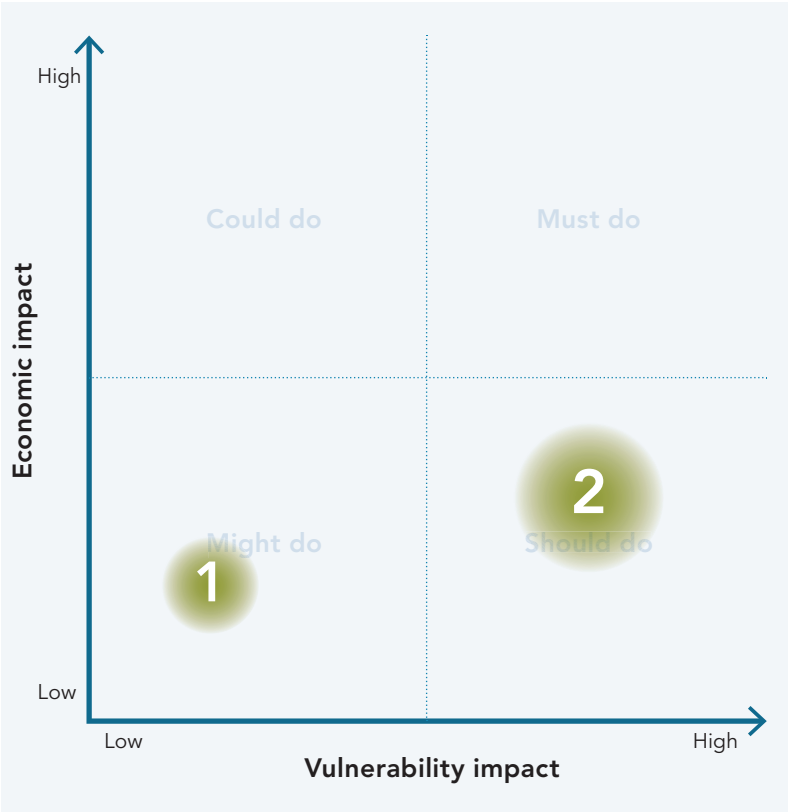
Category	Sub-category	Qualitative Assessment	Quantitative Assessment	Rationale	Sub-category score	Category Raw score*	VaR/VP adjusted quant score	VaR/VP adjusted qual score
Economic Uplift (20%)							0.3	-
	Investment (60%)		100,000	10% x $2m annual investment / 100k	1			
	Trade (20%)		312,000	5% x $300k/wk x 52 wks	2			
	Jobs (20%)		156,000	5% x $150k/wk x 52 wks	1			
Community Resilience (30%)							-	2
	Income security (20%)	M		Confidence to spend and invest, at best, back to normal	0			
	Wealth protection (30%)	H		Risk of property loss remains, but reduced with better capabilities to manage	15			
	Health, safety, well-being (50%)	H		Significantly improved with communications and forecasting	3			
Value Potential	Value creation	M		Some value created with safer community				
	Value capture	L		Little to capture				
	Options assessed	Y		2 options considered				
	VP multiplier					0.38		
				Value Potential sub-total:			*5*	*2*
				Grand Total:			**26**	**180**

* with weighting applied

Mapping the options onto the assessment framework shows that neither option has a particularly compelling economic case.

It is crucial in such cases to understand the system interdependencies in order to promote community safety and resilience. In this case the investment in human capabilities or 'soft assets' is potentially more important than the investment in hard assets. This is because the direct benefits will be more equitably shared, there will be additional co-benefits, and these will be low regrets or robust to any possible future.

Option 1 has limited impact on vulnerability or economic activity, while Option 2 has a greater effect on reducing vulnerability.



8. Making decisions based on prioritisation

Effective decision making associated with climate and disaster risk reduction investments is inherently imprecise. It involves complex and interdependent systems, deals with an unknown and unknowable future, and operates in an environment of varying community understanding, constrained funding, and human biases. Instead of precision, decision processes in the context of ambiguity and uncertainty need to emphasise robustness.

There is typically no single optimal allocation of investments to ameliorate the challenges faced. It is important to have a consistent approach to thinking about the challenges, the solutions and investment decisions. It is difficult and complex, and may create tension, disagreement and debate, but this means that people are examining the real issues and trade-offs, and genuinely seeking sound investments and improvement around a wider set of shared concerns, values and criteria.

Determining priorities and settings for climate and disaster risk reduction is crucial for an organisation to embed robust investment decision making (see Guidance on Scenarios). Considering and discussing resilience for all investment decisions can assist in making systems and resilience thinking more pervasive.

Every organisation is unique with its own strategic objectives, and will develop its own nuanced priorities and approaches to resilience and investment decision making. Having a common language and framework for examining investment priorities accommodates differences and supports intra- and inter-organisational discourse and coordination to develop shared agendas (see Guidance on Governance).

The need for continual testing and refinement of decision support frameworks, tools, and criteria for climate and disaster risk reduction is essential. As with the complex systems nature of vulnerability and resilience, approaching investment within an adaptive learning framing based on continual measurement and feedback is important. A 'fail safe' culture, which suppresses adaptability and learning will perpetuate sub-standard decision making with the potential for highly regrettable and irreversible outcomes.

A 'safe fail' culture, which acknowledges the potential for large and uncertain change will help reduce highly regrettable decisions being made by promoting adaptability based on rapid trials or pilot projects to promote ongoing learning. This will enable continual improvement and development of tools and processes and further embed knowledge and ownership of the decision process and investment decisions within an organisation.

9. Supplementary materials

9.1. Cost-Benefit Analysis insufficient on its own

Cost-Benefit Analysis (CBA) is a standard tool for project evaluation. It is used both to measure relevant costs and benefits from a proposed expenditure and often for allocating resources across different possible projects. As a policy instrument, it attempts to quantify in monetary terms the value of all aspects of a given project or planned expenditure, incorporating both private and social costs and benefits, depending on context.

There are generally three different approaches used in CBA: a measure of net benefits (NB), an internal rate of return calculation (IRR) and the use of a benefit-cost ratio (BCR) for decision making. NB is the preferred instrument and Broadman's CBA publication is the single best source for how to do this correctly, offering a nine-step procedure[11]. NB itself, after all costs and benefits have been calculated over the life of the project, is simply the difference between the discounted stream of benefits (B) and the discounted stream of costs (C) of the proposed project.

Discounting, with an agreed rate of interest, gives the present value (PV) of the stream of benefits and costs, so that the present value of NB = PV(B) - PV(C). Discounting itself reflects the fact that 'one dollar today is worth more than a dollar in the future' as long as there is a prevailing interest rate. It follows that future dollars must be discounted at compounded rates, depending on the number of time periods, to get comparable values in the present. Discounting also allows for fair comparisons of projects that may have different and time-varying streams of benefits and costs over the lifetime of the project.

The basic decision rule on this basis is that the project should potentially proceed as long as NB is greater than zero. Under these circumstances it may also be appropriate to choose one project over another. i.e., choosing the project that has a higher value of NB. But it must be kept in mind that the measure of NB itself assumes a given scale of activity for the project. It is possible, in other words, that the chosen scale may not be optimal (see Importance of Rates of Return 9.2).

Evaluating the construction of a given sea wall project of a certain length or height to protect coastal infrastructure, for example, says nothing directly about how far the sea wall should be extended or how high. This analysis needs to be included in the construction of NB.

There is often disagreement over the choice of a discount rate to determine present values. For privately funded projects the market rate of interest for borrowing is often best used. But for public assets or those projects that protect environmental assets, including those that extend over a long period of time, it is best to use a lower discount or even so-called hyperbolic discount rates[12]. The reason is straightforward. A high discount rate (say 5%) will make the costs and benefits of a project that extends over 50 years or more, worth virtually nothing in present value terms. This is especially important in cases where climate change impacts are being considered, since the full cost of these impacts may occur from now to well past the year 2100, affecting future generations.

11 Boardman, A., David Greenberg, Aidan Vining and David Weimer, (2018), *Cost-Benefit Analysis: Concepts and Practice*, 5th Edition, Cambridge: Cambridge University Press.

12 Weitzman, M., 1998, 'Why the far distant future should be discounted at the lowest possible rate,' *Journal of Environmental Economics and Management*, 36, 201-208.

The IRR rule for a project is the discount rate at which the Net Present Value (NPV) of a project equals zero, implying that those projects with a higher IRR should be chosen first. Unfortunately, this rule often gives multiple rates of return for a single project, and hence confusion, and incorrect ordering over the comparison of multiple projects.

The same can be said for the BCR rule, in particular in terms of false or inappropriate orderings for investment decisions across alternative projects. This is especially a problem in disaster-risk management, since the use of the BCR rule is prevalent here[13].

The following table provides an example of how things can go wrong with a BCR. Assume every dollar amount across the three projects in the following table is properly discounted to a present value (PV), using the same discount rate, and designate C, B, NB and the BCR.

Table 10. Illustration of the potential for inappropriate orderings of projects based on the Benefit cost ratio criterion

Project 1	2	16	14	8
Project 2	10	30	20	3
Project 3	5	20	15	4

Assume no change in possible scale, or the scale of the projects is simply given. With a BCR rule, the ranking of projects is 1, 3, 2. But the correct ranking using NB is clearly 2, 3, 1.

In general, IRR and BCR rules should not be used. The best practice in climate and disaster risk management is to use NB criteria.

13 Mechler, R., 2016, 'Reviewing estimates of the economic efficiency of disaster risk management: opportunities and limitations of using risk-based cost–benefit analysis', *Natural Hazards*, 81, 2121-2147.

9.2. The Importance of Rates of Return

Although Cost-Benefit Analysis (CBA) is an important tool for project evaluation, it can cause errors in public expenditures, both in terms of how monies are allocated across different projects and within a project. This is especially true when benefit-cost ratios are used to make comparisons; comparisons that habitually give the wrong preference orderings over different projects (see 9.1).

But this can also be an issue in the calculation of net benefits (NBs), as the difference between the present value of the benefits and costs over time of a project, at a given scale. The point is that NBs are not independent of the scale of the project, so that a given expenditure, for example, to mitigate a climate or disaster risk may simply be incorrectly resourced.

It is easy to see this with the following diagram, which is comparable in its approach to the best available treatment of cost-benefit analysis (Figure 10). The vertical axis indicates the measure of benefits in dollar amounts and the horizontal axis measures the magnitude of the project expenditures or budget. The red line (line indicated as 'B', Figure 10) represents benefits and the blue line (line 'C', Figure 12) indicates the costs of a given project. The marginal benefit is the incremental change in benefit for a change in costs / expenditure at a given point in the diagram.

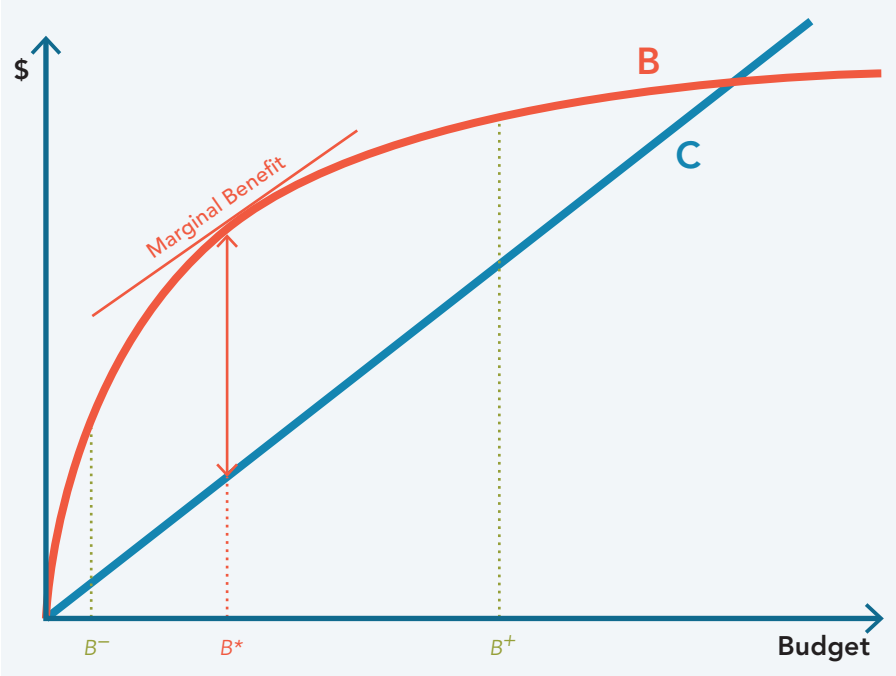


Figure 10: The expected benefits and costs associated with different sized project budgets

In almost all cases in the above diagram NB = B – C is positive and by that rule the project should go ahead, regardless of scale considered. But the figure also indicates that the best possible scale (assuming the funds allow) for the project is at ***B**** where the difference between benefits and costs is the largest.

But clearly scale, or a project at ***B–***, has a NB > 0 and may be chosen, as would projects to the left of this value, depending on scale. The same point holds for B^+ and many points to the right of this project scale. This is a typical property of publicly funded projects. As scale increases the net benefits reach a maximum and then decrease, and at some point even become negative. An analyst may recommend a project at ***B–*** or ***B+*** but the most efficient outcome is at ***B****. A measure of NB alone, independent of a comparison across alternatives, in other words, is not sufficient.

Rates of return, or returns to scale, thus matter and in general using a Rate of Return (RR) rule is a much better criteria for allocating monies both within and across projects. RR asks the question "What is the extra benefit compared to the extra cost of an investment?", and thus justifies expenditure only in cases where extra benefits exceed extra costs. From the figure above it follows that the RR will fall with scale so that the optimal point of expenditure is at ***B**** where extra or marginal benefits are equal to extra (or marginal) costs. At ***B–*** and all points near, extra benefits exceed extra costs, so that scale should be increased. At ***B+*** and all points near, extra costs exceed extra benefits so scale should be decreased.

A further example of an RR ranking, illustrating its superiority over a BCR ranking, in particular, using a 3-project portfolio is included in table below. Assume that returns vary by scale, which would normally be the case. The first part of the table shows that Project 1 has the highest BCR and should (by this criteria) be prioritised for budget. In the second part of the table, however, we show a possible diminishing returns property, again assuming that returns vary by scale. Here, Project 1 has only the third rank. The first unit of budget should be allocated to Project 3, which has the lowest overall BCR, and the second budget unit should be allocated to Project 2. This kind of rate of return could be considered a simpler version of the optimisation principle that equalizes the marginal benefit of each budget unit or block of expenditure[14].

14 Kompas, T. Long, V. Pham Van, H. and Daniel, S. 2019. Budgeting and portfolio allocation for biosecurity measures, Australian Journal of Agricultural and Resource Economics, in press.

Table 11: Comparison of overall Benefit-Cost Ratio vs Rate of Return ranking methods

	Names	Cost (Cumulative)	Benefit (Cumulative)	Ranking metric	Ranking order
Overall BCR	Project 1	1	5	5	1
	Project 2	2	7	3.5	2
	Project 3	7	8	1.1	3
RR Ranking	Project 1	1 (1)	5 (5)	5	3
	Project 2: 1st block	1 (1)	6 (6)	6	2
	Project 2: 2nd block	1 (2)	1 (7)	1	4
	Project 3: 1st block	1 (1)	7 (7)	7	1
	Project 3: 2nd block	1 (2)	0.5 (7.5)	0.5	5
	Project 3: 3rd - 7th block	Each additional block of cost generates 0.1 units of benefit			6

In practical terms, considering projects in terms of their rate of return (to scale) may require a project planner to re-frame the way they have previously approached budget estimation. Instead of asking "What is the budget required to achieve outcome Y?", decision makers must have information on "What is the outcome given a budget $X?". To answer this, a project planner needs to be able to identify ex-ante the benefit generated by each fraction (or at least discrete fractions) of the proposed budget and pick the best possible scale of expenditures.

A final point. Using a RR rule for decision making allows for a consistent ranking of different projects, unlike with the use of BCR, regardless of whether their scales differ. The idea is simply to compare rates of return and allocate budgets accordingly. This is important not only in climate and disaster risk management, but also in the valuation of environmental assets[15] and biosecurity measures[16].

15 Akter, S. Kompas, T and Ward, M. 2015. Application of portfolio theory to asset-based biosecurity decision analysis, *Ecological Economics*, 117, 73–85.

16 Kompas, T. Long ,V. Pham Van, H. and Daniel, S. 2019. Budgeting and portfolio allocation for biosecurity measures, Australian Journal of Agricultural and Resource Economics, in press.