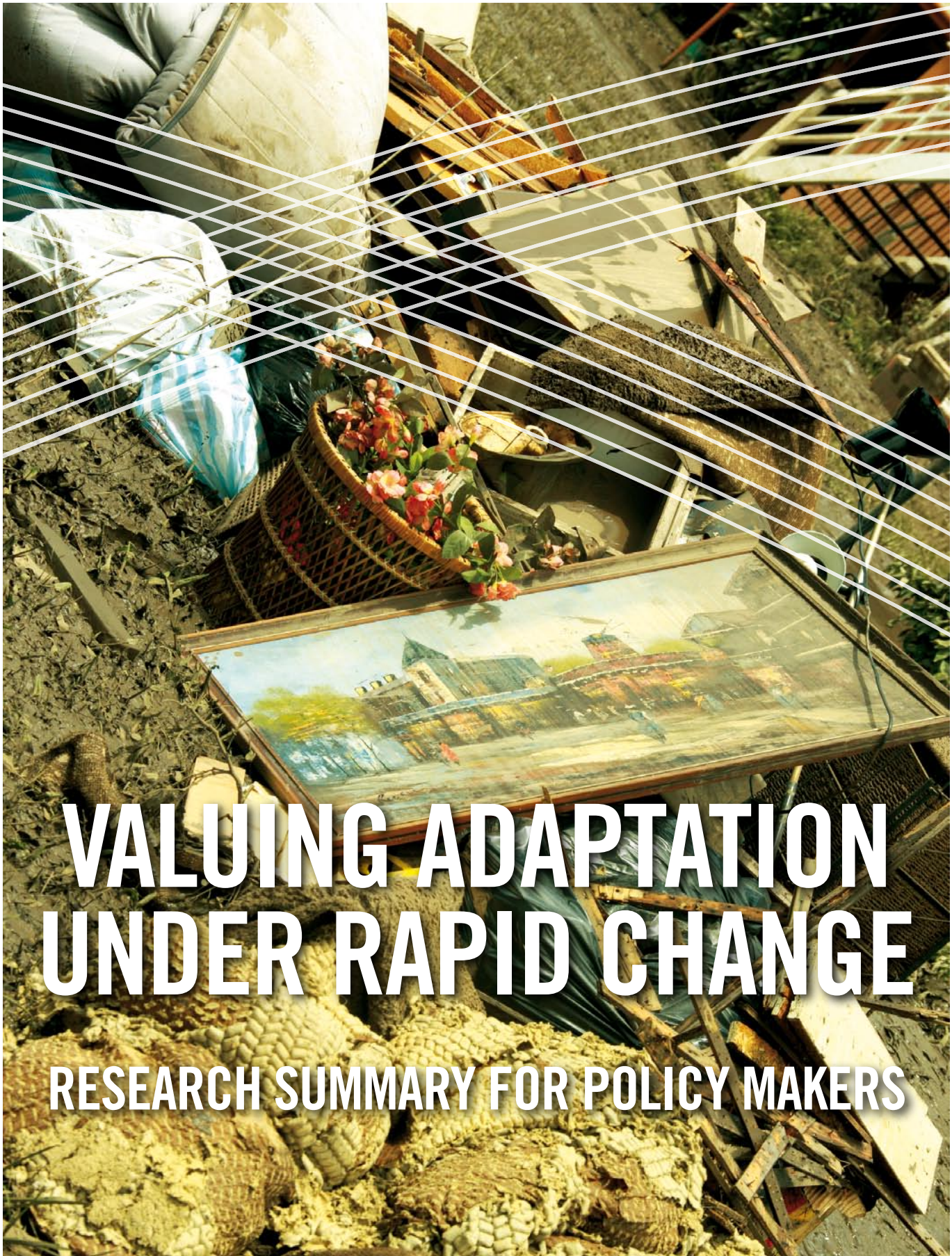

VALUING ADAPTATION UNDER RAPID CHANGE

RESEARCH SUMMARY FOR POLICY MAKERS

Roger Jones, Celeste Young, John Handmer, Adriana Keating, Gayathri Mekala and Peter Sheehan

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Published by the Centre for Strategic Economic Studies, Victoria University, Melbourne, Australia.

ISBN: 978-1-86272-698-7

Recommended citation: Jones, R. N., Young, C. K., Handmer, J., Keating, A., Mekala, G. D., Sheehan, P. (2013). *Valuing adaptation under rapid change: research summary for policy makers*. Centre of Strategic Economic Studies, Victoria University, Melbourne, Australia.

Acknowledgements: This work was carried out with financial support from the Australian Government (Department of Climate Change and Energy Efficiency) and the National Climate Change Adaptation Research Facility (NCCARF). The Victorian Centre for Climate Change Adaptation Research is thanked for in-kind support of Celeste Young and for knowledge exchange. The role of NCCARF is to lead the research community in a national interdisciplinary effort to generate the information needed by decision-makers in government, business and in vulnerable sectors and communities to manage the risk of climate change impacts.

Research summary compiled by Celeste Young.

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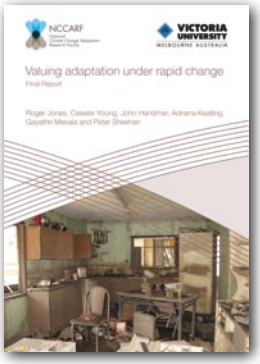
Report editing, design and production: Ascending Horse, Melbourne, Australia.



This publication represents a summary of the research in: Jones, R. N., Young, C. K., Handmer, J., Keating, A., Mekala, G. D., Sheehan, P. (2013), *Valuing adaptation under rapid change*. Final Report. ISBN: 978-1-925039-27-6. NCCARF Publication 56/13. National Climate Change Adaptation Research Facility, Gold Coast, Australia.

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Valuing adaptation under rapid change

- Adaptation to date has been dominated by a gradualist approach to policy and practice, but rapid climate change happens in a step-like manner. As a result, the costs of changing risks have been underestimated, contributing to a general lack of preparedness.
- Rapid change is a non-linear process that requires iterative and innovative procedures. New ways of thinking are needed to develop the methods and tools suitable for effective planning and response. In order to achieve this, some systems and institutions may need to transform.
- Current economic tools in use are inadequate for valuing adaptation under rapid change. This is likely to lead to the underestimation of values at risk, in particular values that are important to individuals and communities, especially those that are hard to quantify.
- The risks associated with rapid change can escalate; crossing from one geographic or institutional domain into another. This can result in confusion as to who is accountable, leading to some risks being un-owned.

Table of contents

Introduction 5

Background 5

The role of narratives 6

Key aspects of valuing adaptation under rapid change 7

Rapid climate change 7

Assessing values at risk 8

Combining rapid climate change and valuation at the institutional scale 8

Domains, thresholds and risk ownership 9

Risk governance 10

Application of economics 11

Economic methods and tools 12

The role of innovation 13

Building capacity 14

The role of research 16

Adaptation across institutions 16

Key findings of this research 18

Policy implications 19

Glossary 20

References 20

Introduction

As climate systems respond to increasing greenhouse gas-induced climate change, rapid, non-linear changes are occurring.[1] These changes are illustrated by the increase in extreme climate-related events such as heatwaves, fires, droughts and storms. Other changes, such as increases in human populations and newly built infrastructure, are occurring in areas where impacts are already severe and likely to worsen. Rapidly growing peri-urban areas vulnerable to flood and fire, and coastal locations are especially vulnerable.

Economically, the deficit between government outlays on responding to extreme events and disasters compared to spending on risk reduction is greater than 20 to 1. In the context of rapid change, which includes all climate-related events not just extreme events, the deficit is likely to be even larger. Without an adequate planned response, the losses that result from these events will continue to increase, placing extra burdens on the public, business and future generations.

If this situation is to be managed in ways that enable current and future communities to thrive, it is imperative to address the knowledge gap regarding how to effectively value adaptation. Being able to do this will depend on how well society can recognise and understand the monetary, social and environmental values at risk. It also depends on whether public and private institutional frameworks capable of evaluating and implementing solutions can be developed.

Background

The mainstream scientific narrative that describes how to adapt to a changing climate, understates current and future climate risks. This is due to climate data being analysed and communicated as a gradual process represented by smooth curves. As a result current impacts of climate change are widely assumed to be minor, with many scientific and government documents not anticipating serious risks for decades. Although the influence of climate variability on the size and number of extreme events presently being experienced is widely acknowledged, they are largely considered to be random in nature and their underlying increase is assumed to be slow.

The economic narrative is similar: the current benefits of adaptation in a developed economy are widely assumed to be low, accruing gradually over time. Top-down economic models assume that the climate variability experienced over time will average out to a smooth change in costs, which shapes the understanding and perceived value of the economics of adaptation.

The standard economic approach is dominated by optimisation tools such as cost-benefit analysis (CBA). Such models contain many assumptions, such as the following:

- The costs of adaptation and the benefits of avoided risk and increased resilience are assumed to be equivalent for market-based, social and environmental benefits over time.

- Benefits are assumed for an economy similar to today's, and are assessed on a case-by-case basis. Cross-sectoral benefits, irreversible loss, maladaptation and transformation are all beyond these models' scope.
- The likelihood of future events can be calculated and alternatives can be optimised to find the greatest benefit for the least cost, which will enable market forces to respond efficiently.
- Climate change is a gradual process that can be addressed incrementally and efficiently, using standard planning tools.

The result is that adaptation is often undervalued.

The full report shows the following limitations of valuing adaptation as a response to gradual change:

- Climate shows step-like changes that result in rapid changes in extremes. These changes require different statistical analysis methods to assess risk.
- The values at risk from climate change are highly diverse and complex. Some can be easily monetised, are substitutable and discount rapidly over time; others are qualitative, irreplaceable and maintain high values over generations.
- The greatest risks are not from single events but from combinations of events; these cannot be predicted but can be anticipated using tools such as scenarios.
- The most severe risks cross domains, which leads to a range of institutions being affected and risk ownership and responsibility being unclear.
- Existing methods work well when framing adaptation as adjustments to present activities, but fall short when assessing path dependency, transition and transformation.

Valuing adaptation under rapid change requires an expanded set of methods that can cope with the inherent complexity of change processes. This project has examined the economics of disaster, which has methods such as disaster risk reduction and the economics of transformation that can be used in adaptation. It has also developed:

- concepts to assist a wider understanding of the crossing of domains, taking into account thresholds, risk propagation and risk ownership;
- an expanded set of valuation methods that assess the monetary (tangible) and non-monetary (intangible) aspects of social, economic and environmental values;
- an expanded set of methods for assessing adaptation that take into account problem (predictive) and solution (outcome) uncertainties;
- a problem–solution framework for economics that provides the transition from problem to solution; the economic framework considers values at risk, the cost of adaptation and the benefit provided through avoided damages, new opportunities and/or increased resilience; and
- the incorporation of knowledge generation and innovation into adaptive management, processes that are being developed to implement adaptation under uncertainty.

The role of narratives

The gradualist narrative that informs current adaptation policy and practice is likely to lead to a lack of preparedness for such events.

The project has identified narratives as a barrier and an enabler of knowledge transfer. Narratives are a barrier if they convey inaccurate or incomplete information or convey framing that leads to misperception of risk. Narratives enable when they describe the climate change more fully in terms that people can understand, informing decision making and the potential for action. There are, for example, many analogies for unpredictable but rapid changes in other areas of natural hazard (earthquake, tsunami), economics (financial crises) and conflict. Attributes needed for adaptation, such as transformation and resilience, can also benefit from the use of narratives as they can assist with creating a shared understanding that enables action.

Scientific narratives are the key means by which sense is made from scientific findings and communicated between scientists and the community. These narratives influence how adaptation practice and policy are perceived and acted upon. The strongest narrative currently accompanying adaptation is that of gradualism, which leads to an emphasis on how much the climate will change, not how it will change. Current statistical approaches manage climate uncertainty by smoothing over climate variability, biasing the theoretical understanding of how climate changes. If adaptation is thought of in similar terms, then the practice of adaptation also becomes gradual. The climate science literature openly discusses the possibility that climate change is non-linear, but at this point this has not transferred to adaptation practice or policy.

These scientific narratives are related to similar narratives in classical economics. Existing economic models aim to optimise outcomes by oversimplifying the world. This method is appropriate for simple problems, but because adaptation qualifies as a wicked problem, different systems and ways of thinking are needed.

Key aspects of valuing adaptation under rapid change

To fully understand the problem that rapid change presents, it is important to understand the nature of rapid climate change and the widespread values at risk.

Rapid climate change

Statistical analysis of observed and model data demonstrates that climate change on decadal time scales shows a step and trend process, where relatively stable periods of climate are punctuated by step changes. Some examples are:

- Analysis of recent Australian climate change shows that Australia has warmed in two episodes, 1968–73 and 1994–97, with little change in between. All regions of Australia experienced step changes in minimum temperature in the period 1968–73, southwest Western Australia experienced a decrease in rainfall of 12 per cent and northern Australia an increase of 22 per cent. In 1994–97, all regions of Australia experienced an increase in temperature of up to 0.8°C for maximum temperature. These rises included sea surface and air temperatures.
- These increases in mean warming post-1996 have been accompanied by non-linear changes in heat-related extremes, such as days over 35°C and fire danger index. Less evidence is available for rainfall-related variables, but recent record extreme rainfall and floods suggest there may also be a relationship.
- Climate model output for mean global air temperature and temperature and rainfall for southeast Australia show multiple step changes in all temperature records and about half of rainfall records. Similar rapid climate changes are widespread, occurring in all regions of the world and in a number of climate variables.

Climate-related events such as floods, droughts, heatwaves, bushfires and storms are likely to show rapid increases as a result of these step changes. Clusters of extreme events that are unpredictable, such as the succession of droughts, fires, storms and floods that affected Australia between 2006 and 2012, may be amplified due to climate change and have the potential to significantly harm a wide range of economic, social and natural values.

Recent climate extremes experienced in Australia have been more extreme and produced more severe impacts than conventional climate scenarios and impact models suggest they would. Economic assessments of future impacts under rapid change show such events are likely to be more costly than assumed under a gradual model of change. When combined with population growth, the resulting increases in damages and loss are likely to be substantial.

Case studies undertaken for heat stress and fire, for example, showed that costs due to rapid change were greater than those assumed for gradual change. Total losses mid century

for Victoria after a rapid change in fire risk exceeded $6 billion in 15 years, assuming no increases in exposure. Likewise, potential heat deaths in Melbourne with a growing and ageing population showed rapid increases of up to 200 deaths per year (a 33 per cent increase) were possible by mid century.

Strategies for assessing how to adapt to rapid change in a cost-effective manner are only now emerging and will require further development and testing before they can be widely implemented.

Assessing values at risk

Values at risk relate to the monetary (tangible) and non-monetary (intangible) values that may be harmed. Broadly, such values can be divided into monetary, social and environmental groupings.

The project developed a framework for assessing values at risk that has the following attributes:

- Values are grouped across five adaptation clusters: goods, services, capital assets and infrastructure, social assets and infrastructure, and natural assets and infrastructure. These clusters were chosen by how impacts manifest economically.
- The first three of these clusters are well represented in the monetary economy, the social assets and infrastructure cluster is partially represented and the natural assets and infrastructure cluster is very poorly represented.
- Social and environmental values in particular are widely appreciated at the individual and community level, but not well represented at the institutional scale.
- Social and natural values are represented as assets and supporting infrastructure for aspects such as resilience and ecosystem services. Expenditure on such values can be seen as investments in the future rather than a cost burden on current budgets.

Institutions have a wide range of values that need to be considered when assessing values at risk and when valuing adaptation. These cover a wide spectrum ranging from economics to ethics. Financial institutions, for example, will place a different emphasis on values (for example, profit) from institutions concerned with social justice (for example, livelihood). Values can also be mandated by policy, law and international treaties.

Some values, often linked to the commons (commonly owned assets such as public land and air) are not well represented institutionally and some can be considered un-owned.

The cost of adaptation includes the research and development of options, and ongoing monitoring and review. The benefits of adaptation include avoided risk, improved resilience and accompanying co-benefits.

Combining rapid climate change and valuation at the institutional scale

To date, most adaptation assessments have taken place at the scale of individual events, organisations or locations. However, for rapid climate change to be appropriately addressed, institutions and institutional values need to be taken into account.

Risks associated with rapid changes are broad ranging. A succession of extreme events can combine to cross institutional domains that span areas of responsibility, leading to larger and more widespread economic, social and environment impacts. Over time, damages may accumulate, thereby increasing vulnerability to future events. If these risks are to be effectively managed it is important to understand the nature of these risks and the institutions affected by them.

In particular:

- how institutional thresholds are related to domain-crossing events, for example, large or repeated events, may exceed the capacity of local institutions to deal with them, which means they will require state or territory and federal support;
- uncertainties include not only those linked to predicting specific events, but also those associated with decision processes that relate to the outcome of specific events. These relate to the broader socioeconomic and institutional contexts within which risks may occur and include policy-related, economic and social uncertainties (for example, levels of agreement);
- preparation for and effective management of rapid changes in extreme events will, in many cases, require transformation of current systems and frameworks;
- planned responses will be needed to avoid reactive responses that can be costly and potentially maladaptive; and
- incremental actions taken by individuals or organisations to reduce vulnerability may make a whole system more vulnerable to the impacts of disasters, for example, the so-called levee effect, in which barriers reduce the impact of small floods but make a system more vulnerable to disaster. This is primarily due to extra development occuring behind a flood protection levee; thereby increasing potential future damages.[2] It can also create a false sense of security where people assume they are protected against all flood risks so do not take further protective measures.

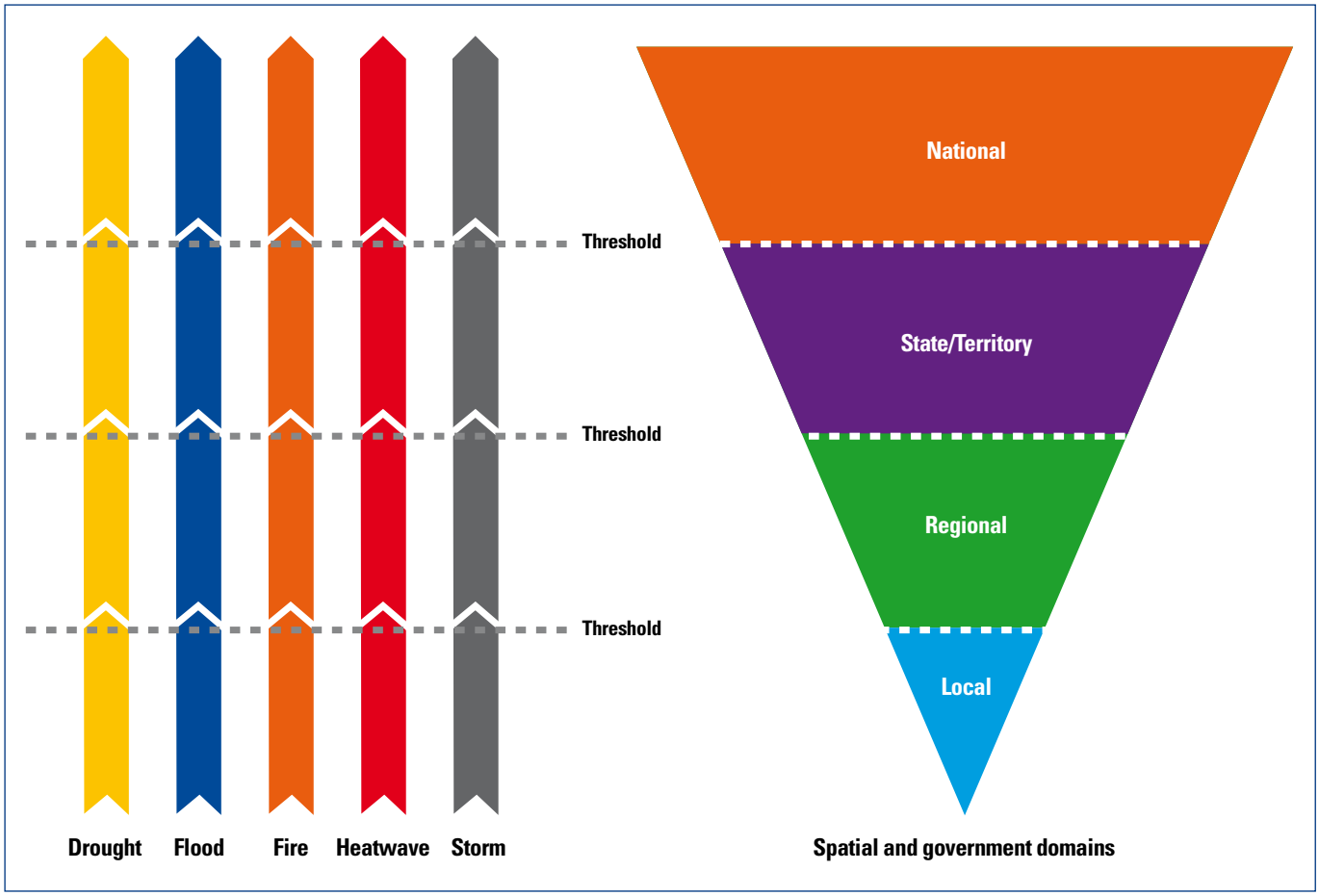

Figure 1: Schematic representation of spatial and government domains, with some extreme events likely to cross domains either singly or in succession.

Domains, thresholds and risk ownership

To manage the risk of rapidly changing impacts, coordination is needed across government, industry and civil society, as these risks can affect many sectors and jurisdictions, crossing both temporal and spatial scales (domains). Clear ownership of these risks is particularly important and needs to be considered holistically so as not to inadvertently facilitate maladaptation.

Domains, which can be geographic, sectoral or institutional, denote an area of institutional responsibility. Responsibility can be defined by aspects of governance such as rules, control, knowledge and agency. Government institutions at all levels form an important link between geographic and institutional domains.

The propagation of risks across domains can accelerate when a number of linked and/or successive climate-related events such as drought, heatwave and fire combine, resulting in a number of domains being crossed (see Figure 1). In such situations, the ownership of risks can change and spread to new institutions, such as when state or territory and federal governments are required to supply disaster relief and act as the insurer of last resort.

Institutional thresholds, where risks cross boundaries between domains and the potential consequences if these thresholds are crossed, are poorly understood. Thresholds are hard to pinpoint, so it is important to identify the early signals that precede these thresholds being reached, because often, if a threshold is clearly visible, it is too late to take action to avoid it.

Management of risk ownership, particularly those propagating across the boundary of one domain into another, requires an understanding of:

- who will be impacted by the risk;
- who has responsibility for risk response and risk mitigation;
- who owns the risk (for example, in legal and ethical terms); and
- who pays for the risk, post-event and future prevention.

Because these different areas overlap and are context specific there is often a tension between them. Who is affected by a risk does not, for example, always determine who owns that risk and who is responsible for a risk does not always determine who pays for it.

Risk ownership under rapid change is further complicated by the number and diversity of institutions affected. While some risks may be clearly owned by one to two institutional entities, many risks have a shared ownership, while still others have limited or no ownership or accountability. This is illustrated in Table 1, which summarises the results from the Beyond the Mean Workshop, held as part of the project. Ownership is not always exercised. Certain social or environmental risks may be highly valued and have clear lines of responsibility but be left unmanaged. Important natural assets can fall into this category.

Risk ownership may change if an impact increases or amplifies over time, particularly if this triggers different governance arrangements. Most institutional structures are not suited to the flexible, collaborative processes and iterative frameworks required to monitor and manage escalating risks; rather, they tend to be inflexible and siloed. This may result in such changes not being anticipated, and/or action being delayed until a critical threshold is crossed.

Table 1: Un-owned risks by area, *Beyond the Mean Workshop Report*[4]

Social
■ Lack of willingness to act cooperatively ■ Management of those with chronic illnesses ■ Exacerbation of vulnerability of already vulnerable groups ■ Compassion fatigue ■ Blame
Environmental
■ Ecosystems issues ■ Degraded environment
Capital assets
■ Households under insured ■ Properties uninsurable due to the extent of damage of fire or flood, that is, limits to adaptation
Economic
■ Rising food prices on a long-term basis ■ Reduced consumption due to reduced consumer confidence ■ Household accounts in disarray
Legal
■ Legal action ■ No insurance – legal disputes, indemnity ■ Clean up toxic waste that crosses borders
Governance
■ Joint ownership of responses ■ Joint ownership of food security ■ Domain dispute

Risk governance

Risk governance for adaptation is complex. The primary responsibility for action is usually at a local level, while the responsibility for financing public good adaptation is at the state, territory or federal level, which requires cross-institutional arrangements. One institution may be accountable and set the formal rules for adaptation (for example, state, territory or federal government), another may own the risk in its current status and be responsible for its ongoing management (for example, local government or industry), and yet another may be responsible for planning future adaptations (for example, another state or territory department, a regulator or appointed working party).

These cross-institutional arrangements, with multiple institutions sharing direct and indirect costs, mean that financial arrangements can be complex (see Figure 2). Large flood events that impact on infrastructure, for example, incur costs across all levels of government. Industry and civil society may also bear some of the cost of infrastructure failure through secondary impacts, such as loss of business income or increased operational costs.

Governance arrangements need to adopt processes capable of dealing with unexpected outcomes over multiple timeframes while involving diverse stakeholders. Pathways for the integration of research and new knowledge into the adaptation process are also needed.

Currently, governance frameworks are evolving through learning by doing, an important area of innovation. Adaptation strategies innovate as they move through the implementation stage by being sensitive to specific end-user needs.[3] As a result, policy and governance need to foster iterative processes flexible enough to respond to new needs as they emerge.

Key aspects of adaptation governance are:

- collaborative decision making mechanisms that enable a common understanding among diverse stakeholders;
- iterative processes and frameworks that accommodate changing circumstances and evolving outcomes;
- clear allocation of roles and responsibilities;
- knowledge frameworks that enable effective communication and transferral of new information as it emerges; and
- monitoring and evaluation mechanisms that are fit for the task.

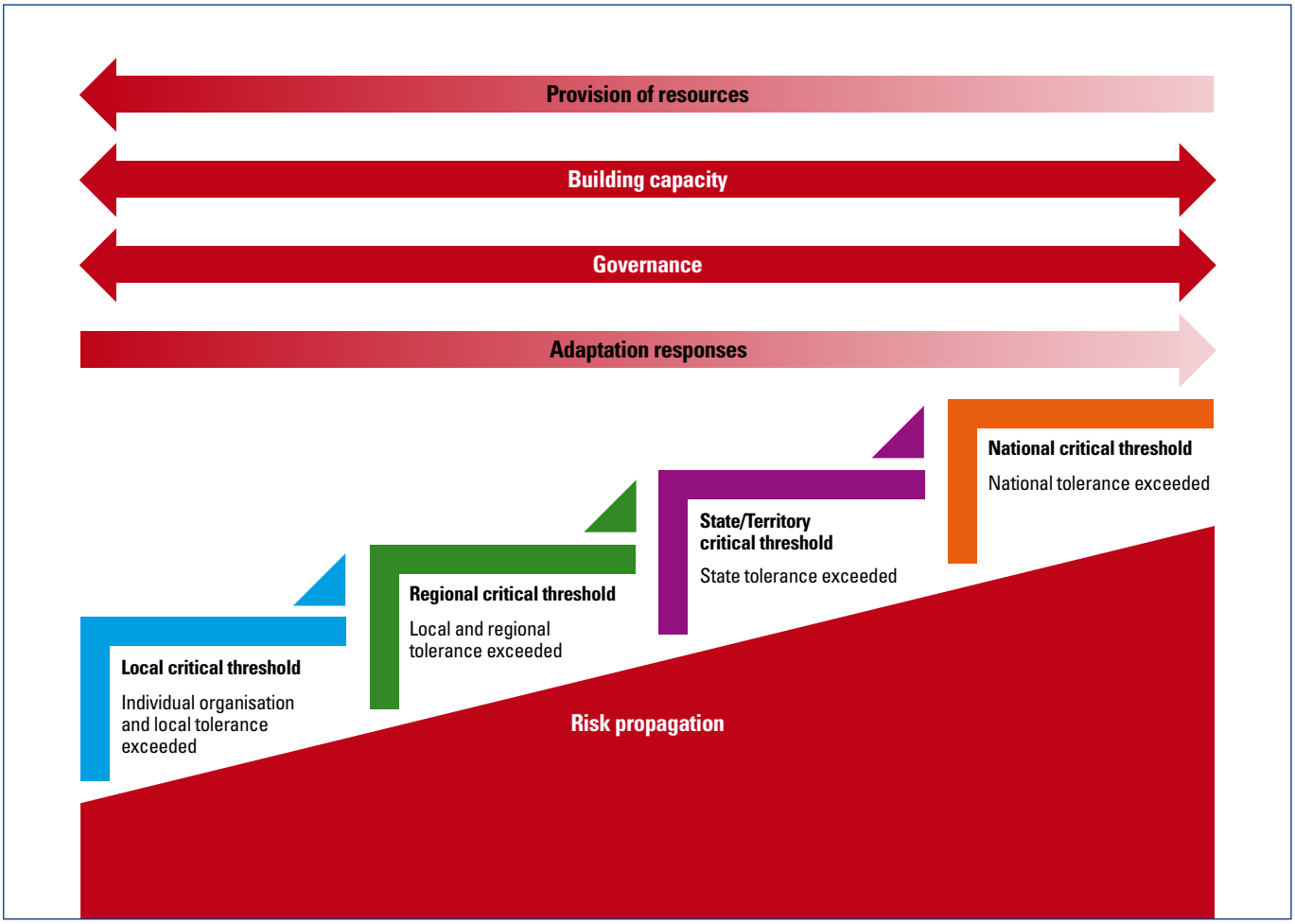

Figure 2: Propagation of risks across spatial and institutional domains showing the demand for adaptation, resources to adapt, capacity and governance.

Application of economics

Valuation of risk

> '… is not a logical process because value is not just about cost, it is also about what we as individuals and communities hold as precious to us.'

– Participant, Beyond the Mean Workshop, 30 November 2012.

The project has developed three phases in the economic approach to valuing adaptation. They are:

1 assessing the values at risk;

2 evaluating the cost of adaptation options; and

3 assessing the benefits of those options.

These three phases explicitly recognise that values at risk and those sought as benefits are diverse, ranging from monetary to ethical. The costs of adaptation options can be assessed separately from those values. Factors affecting the consideration of costs include the opportunity costs of acting now or later (the payoff between action and delay), the cost of funding (for example, interest rates) and rates of discounting to be used (that is, a measure of the social preference for money now balanced against achieving longer term, but perhaps delayed, benefits). The benefits of acting (including taking no action) include the benefits of avoided damages, the benefits of reduced uncertainty gained by acting, of increased resilience and co-benefits of specific actions or strategies.

Economic analysis has been applied to a wide range of disaster-related issues at every scale of government. Three long-standing issues in disaster economics of potential relevance to the economics of adaptation are:

- the treatment of **intangibles** – the inclusion of losses not normally valued in money and for which there are no existing markets;
- **maladaptation** – valuing the potential negative effects of strategies intended to reduce losses, for example, flood levees; and
- **transformation** – one view is that relocation is transformative, and disaster economics has long undertaken economic assessments of whether relocations are worthwhile.

The integration of this large body of work with adaptation research is ongoing.

Further considerations from disaster economics and impact studies include the possible loss of a place or resource, and critical or irreversible damage to a valued system or process. In such cases the values at risk can be said to demand some level of response but may not be readily assessable using conventional economic tools, the result of which is the need for a risk management approach.

These approaches to valuing adaptation are placed within a problem–solution framework that recognises two distinct aspects of the adaptation process (see Figure 3). These two aspects are interlinked and together inform the type of economic, scientific and process tools selected for an assessment and how they can be applied by policy makers and practitioners. Critical to this are psychological and behavioural aspects of the problem–solution matrix, how they influence the perception of risk and value, and the selection of methods and tools by the actors involved.

The problem phase's primary task is the valuation and analysis of climate change impacts and associated risks. The framing used during this phase is risk. Tools are generally diagnostic and concerned with identification of the priority risks, their impacts and the values associated with these risks. The primary uncertainty in this phase is the predictive uncertainty.

The solution phase's primary task is the evaluation of adaptation actions and their implementation. The primary framing of this phase is innovation; the tools are treatment-based. The tools are used to identify and implement viable solutions and assess their outcomes. Although some actions will produce a short-term benefit, many adaptation options will need to be monitored over the long-term, either because the outcome of the action is unclear (for example, regional sustainability) or the pathway to a desired aim is uncertain. The primary uncertainty in this phase is that surrounding the outcomes of actions undertaken.

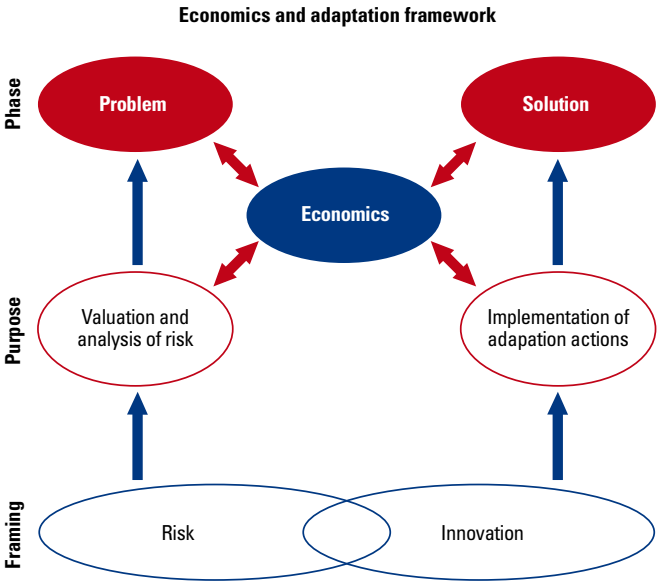

Figure 3: Problem–Solution Economic Framework, adapted from C. Young, Problem–Solution Framework, 2012.

Economic methods and tools

Diverse settings, system complexity and different types of uncertainty require the application of a wide range of tools, from simple cost-benefit analysis through to collaborative programs that undertake innovation through adaptive management. The integration of disaster economics, institutional values and environmental and social valuation with more conventional methods of applied economics is a feature.

The framework requires the harmonisation of top-down (macroeconomic) and bottom-up (microeconomic) costs and benefits. At the macroeconomic level, net impacts are aggregated to obtain costs across whole sectors, which are usually underestimated. Microeconomic cost assessments occur at the local level and, while they are likely to be more accurate, are difficult to aggregate. This highlights the challenge affecting all economic costing methods, not just climate change, which is the issue of dealing with incommensurables – where top-down methods that give economy-wide results do not align well with bottom-up methods. An example is where ethical and monetary values used to assess fairness, which is highly context-specific, are contrasted with market efficiency, which is not. The two are often at odds with each other because of this.

Existing guidelines for the use of social discount rates need to be re-evaluated for their applicability to high uncertainty, rapid change and long-term planning horizons. Australia has among the highest recommended official social discount rates in the world. This devalues the future in favour of the present, which leads to social and environmental values being devalued over intergenerational timescales.

The cost effectiveness of current policies also needs to be considered. The current focus on disaster response could provide a perverse incentive if people and organisations fail to adequately manage their own risk because they expect to be compensated after extreme events. Poor planning decisions that expose community and infrastructure to increasing risk will also increase future costs to potentially unsustainable levels.

Understanding uncertainty is a key aspect of effective decision making. Two key types of uncertainty are associated with the adaptation process (see Figure 4, overleaf):

- **Predictive uncertainty** (problem phase) – the uncertainty associated with scientific and socioeconomic projections of future circumstances.

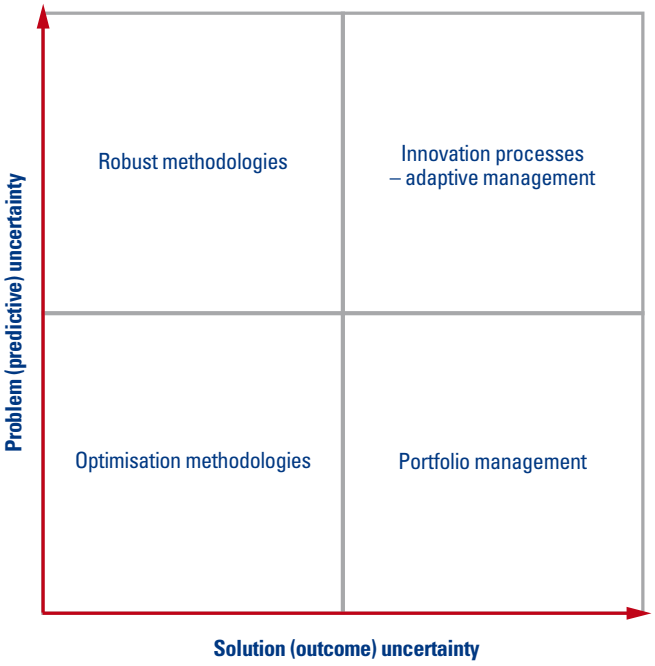

Figure 4: Problem–solution uncertainty matrix, with key economic approaches to managing these uncertainties.

- **Outcome uncertainty** (solution phase) – the uncertainty associated with the potential outcome of actions undertaken to manage risks.

These two aspects require different but complementary decision making strategies. Predictive uncertainty requires risk-based strategies for which informed judgements are made in relation to what is known about future risks. Outcome uncertainty requires innovation processes that are flexible and iterative to incorporate new information as it emerges over time, especially from formal monitoring and review processes.

The weighting of these two uncertainties determines which key economic methodologies will be most useful. They are summarised as follows:

- **Optimisation** – used when uncertainty around the problem and the solution can be constrained. Methods suitable for this type of assessment include cost-benefit analysis, cost-effectiveness analysis and multicriteria analysis. The valuation of impacts separate to the costing of adaptation options may be needed.
- **Portfolio management** – works best when problem uncertainty can be constrained but the potential success of adaptation measures remains uncertain. By not putting all the adaptation eggs in one basket, the risk of widespread maladaptation due to uncertainty can be reduced because the chances of some approaches being successful are increased. These strategies are likely to be most successful in market-dominated situations.
- **Robust decision making** – robust management comes into play when problem uncertainty is high but the solutions are fairly well understood. These methods, which are very flexible, can utilise a wide range of tools.
- **Process-based methodologies and frameworks** – include risk, innovation and adaptive management processes with the capacity to achieve transformation. Innovation processes and adaptive management become necessary when problem and solution uncertainty are difficult to constrain. These become necessary in complex settings where problem and solution uncertainty are difficult to constrain.

The role of innovation

Adaptation requires the development, adoption and implementation of new knowledge and technologies. At its core is innovation and the need to transform our current institutions.

In the solution phase of decision making, adaptation actions are identified and implemented. Innovation frameworks and processes are designed to manage the uncertainties inherent in new processes and technologies and their integration into current systems. They do this through iterative processes that, during the process, allow for adjustments that can help manage the risk of surprises. The type of innovation process can also help inform the timing and amount of investment needed to implement adaptation and help identify monitoring and review processes.

Innovation needs are consistent with factors commonly identified as comprising adaptive capacity. Innovation, like adaptation, is a social process that relies heavily on social capital that requires diverse players to cooperate in achieving outcomes.

Innovation can also lead to transformation. The Intergovernmental Panel on Climate Change (IPCC) defines transformation as:

> 'The altering of fundamental attributes of a system (including value systems; regulatory, legislative, or bureaucratic regimes; financial institutions; and technological or biological systems).'[5]

Transformation is the point at which these changes occur within or to a system. Transformation can be spontaneous, by default or be triggered by an extreme event, for example, the relocation of vulnerable settlements. In any case, many social and ecological systems will transform due to changing technology and other factors; in such cases innovation can be used to steer that system towards more sustainable outcomes.

Many systems, including the economy, are operated on the assumption that the ecological systems that support them will remain stable; consequently, the overriding aim of adaptation is to preserve their current status.[6] Some of these systems may need to undergo transformation in order to build sufficient resilience to cope with rapid change.

It will be important in the case of planned transformation to ensure that:

- appropriate time is allocated to the task – generally, transformation requires medium to long-term timeframes; and
- adequate resources are allocated to the parties undertaking the transformation.

Building capacity

Adaptation for climate change is a relatively new field of endeavour. In the context of rapid change, institutions need to develop new capacities, particularly in relation to understanding and valuing the resultant risks. Innovative frameworks, mechanisms that enable the development of new knowledge and skills and the resources to support them, are needed to facilitate this.

Current institutional frameworks rely upon siloed operational structures that project the future as a mirror of the past. Decisions need to be made in anticipation of risks beyond previous experience. Institutional arrangements also require collaborative rather than competitive mechanisms, for example, the development of collaborative future narratives that can be shared between institutions.

Key institutional capacities can be summarised under the following three topic areas:[7]

- **Human resource development** – the process of equipping individuals with the understanding, skills, access to information, knowledge and training that enables them to perform effectively.
- **Organisational development** – the elaboration of management structures, processes and procedures, not only within organisations, but also the management of relationships between the different organisations and sectors (public, private and community).
- **Institutional, including legal framework development** – the legal and regulatory changes needed to enable institutions and agencies at all levels and in all sectors to enhance their capacities.

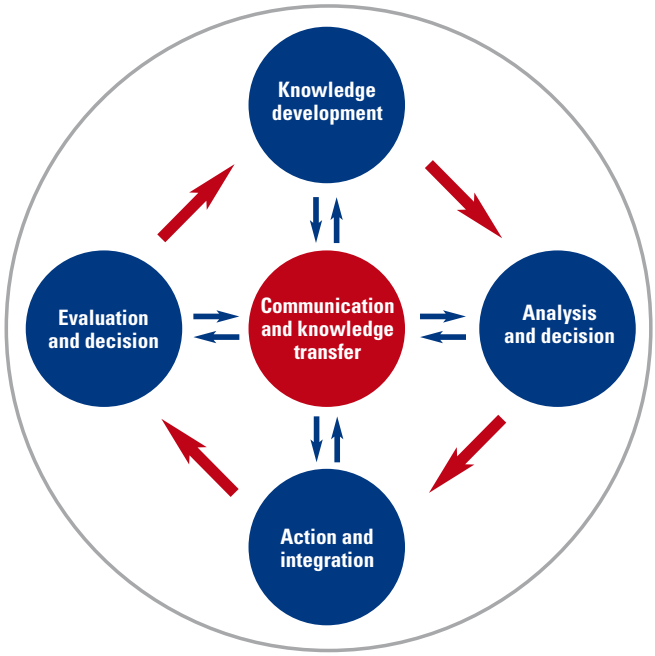

Figure 5: Knowledge development and transfer framework, C. Young, 2012.

A lack of understanding about the risk of rapid change leads to those risks being undervalued, which affects the level of preparedness and response.

Knowledge transfer and communication are key to enabling this understanding. Communication sources across different levels of government and boundary organisations need to be mapped so that information can be effectively disseminated.[8] The process of how knowledge is developed and applied across the adaptation projects requires a continuous process in which knowledge is transferred through the whole adaptation process (see Figure 5). This also ensures that the outputs can be adapted to suit to an end user's context.

The development of tools and supportive frameworks that are fit for purpose and create better understanding of the problems faced and the solution pathways, assist decision making and are an important part of the capacity-building process.[9] These skills and their rationales are listed in Table 2.

Factors that enable institutional adaptive capacity include:[9–11]

- resource availability – financial, technological, human;
- communication, knowledge development and transfer systems;
- governance;
- innovation and transformation of current institutional frameworks and processes; and
- development of specific products – tools, methods and processes, for example, programs for innovative adaptation, and monitoring and evaluation tools.

Table 2: Core institutional capacities for adaptation.

Core institutional capacities for adaptation to rapid change	Rationale
Risk management	Greater understanding of the impacts of rapid changes and the risks they pose. Valuation of risks and the identification of ownership at the institutional scale, which includes the need to review and develop economic tools and methods that are fit for purpose.
Collaborative capacity	Development of effective working relationships between stakeholders to enable effective decision making and implementation.
Transformation/change management	Current institutional systems are not designed to effectively deal with the onset of rapid changes due to their siloed and competitive nature. These systems need to develop an innovative culture that is comfortable with managing transitional processes.
Monitoring and evaluation	Methods for monitoring and evaluating adaptation are a key part of the innovation process. Iterative methods ensure that new learning is captured, especially from unexpected outcomes. Multiple values across different timeframes need to be included.
Knowledge development	Knowledge derived from research needs to be developed in such a way that it addresses the problem–solution space and is not framed in the way that researchers see the problem. Collaboration with end users is required to ensure that knowledge developed is useable and fit for purpose.
Knowledge transfer and communication	Knowledge transfer and communication will transmit, adapt, adopt and implement new and evolving ideas. Narratives and creative processes need to become much more prominent than the current preference for toolkits and traditional decision support systems.
Policy development	New policy mechanisms that enable an all-agency approach to proactive, iterative and non-competitive policy making. Positive incentive funding models can support innovative policy initiatives.
Innovation theory and practice	Innovation theory and practice will help provide thinking frameworks and tools for operational aspects of implementation.
Process and systems development and integration	Adaptive processes can become part of everyday business. The integration of adaptation options into operational systems and processes will ensure that a whole-of-organisation approach is adopted.
Decision making under uncertainty	Skills development, especially how to make decisions under uncertainty, would benefit from a better knowledge of the innovation process. New frameworks, tools and systems of monitoring can facilitate this.
Strategic capacity and visualisation	Strategic capacity and visualisation are key elements for planning and important elements for developing proactive policy and activities.

The role of research

A key role research and research institutions have in adaptation is the development and provision of expert information, evaluation and monitoring of adaptation actions, and assisting practitioners and policy makers with understanding of the issues and decision making.

Currently, the role of research institutions in adaptation is widely acknowledged but poorly understood. Research needs to be embedded in the adaptation process to serve a variety of purposes that are task-specific (see Table 3).

Key tasks for researchers include the development of:

- frameworks for evaluating adaptation options for managing the risks of rapid change;
- guidance and analysis to assist with understanding and decision making in relation to adaptation options and actions; and
- research communication that is fit for purpose, for example, linking scientific information with everyday narratives of risk.

Adaptation across institutions

A significant implication of rapid change for Australia is that governments, businesses and communities will be unable to rely on market-based autonomous adaptation anticipated by models operating under the assumption of gradualism.

Planned adaptation and post-event responses will differ across government, industry and civil society institutions.

Federal government leads in national economic planning, large scientific research programs and policy design for specific sectors of national importance (for example, water, agriculture and forestry). Federal government also has a direct role in adapting existing and planned infrastructure to climate change. This includes transport, energy, water and telecommunications networks, although these also overlap with state, territory and local jurisdictions.

State and territory governments lead in planning and program delivery in many areas, including regulation. At the state or territory level, many planning and regulatory

Table 3: Summary of task-oriented needs for research.

Task	Key aim	Research required	Purpose
Identification of the problem	To create understanding of what the problem is and how it works.	Climate science, impact assessment, economics, risk analysis.	To assist with the collation, analysis and valuation of climate impacts. Development and provision of knowledge and information to enable better understanding of the problem. Development of research communication that is fit for purpose.
Assessment and decision making	To assist with assessing what risks should be actioned and how they should be actioned.	Decision support, economic assessment, social assessment, political science.	To provide support in the form of guidance regarding analysis of options required by decision makers. Development of research communication that is fit for purpose.
Implementation	To monitor and evaluate actions and support analysis and decision making.	Monitoring and assessment, decision support, social science.	To monitor and evaluate adaptation implementation and provide comment and guidance to assist decision making during this process. Development of research communication that is fit for purpose.

responsibilities, such as urban strategies and building design and standards, have long time horizons and are very exposed to rapid change. Planning may require coordination at the national level through COAG to achieve consistent management and property rights. Mechanisms that enable greater levels of cooperation between state, territory and local governments with the private sector will also be needed.

Local government's primary role is at the implementation level; in particular, in planning, risk management and operations. It is the level of government with the most direct link to the community, and therefore has a key role to play in information provision and monitoring, and in the evaluation of actions at the local level. The propagation of shocks through the system is likely to exceed current local government capacity, and so will require extra resources from state, territory and federal levels to support adaptation.

Industry will need cooperation from government to develop the regulatory frameworks for new products and markets. While innovation will most benefit large businesses, small to medium enterprises (SMEs) also need to build a better understanding of their exposure to risks and of potential opportunities. Greater clarity around disclosure and legal liability is needed by businesses of all sizes. Sector-specific information provision is also necessary to assist planning. Accessibility to information and facilitators to promote its incorporation into decision making is especially important for SMEs, and most especially for micro businesses. Investment is also needed to support markets for adaptation goods and services and to support the transformations needed to build resilience.

Civil society's understanding of adaptation is varied, and needs to improve to enable more proactive responses in the face of rapid change. Populations in vulnerable regions potentially need cogent information as a matter of public safety. Vulnerable communities, welfare-dependent people from culturally and linguistically diverse (CALD) backgrounds and the elderly have specific communication needs. Specific investment will be needed to support the development of resilience in soft and hard infrastructure, particularly in communities that are highly exposed and have limited resources.

Key findings of this research

The exploratory nature of this research means that many gaps will need to be filled before it can be implemented in familiar circumstances. It also means that existing methodologies, which needed to take a greater focus on decision making and implementation in any case, need to be overhauled to make the transition from managing gradual to episodic, rapid change.

Better understanding is needed of the full ramifications of rapid change and how it will impact on current systems and institutions. In particular, the nature and types of thresholds that mark where risks cross institutional domains need to be more fully explored. The development of scenarios that include multiple extreme events in a variety of contexts and sequences can be used to assist this task. Research is also needed to develop monitoring and evaluation methods capable of detecting instances of rapid change as soon as they occur and, if possible, to predict them.

Planning for the transformation of current institutional structures and systems is vital, in particular, the development of collaborative frameworks that enable decision making within and across a number of institutions and frameworks to assist with decision making during a time of uncertainty.

Fit for task economic frameworks, capable of integrating and assessing a diversity of costs and values across different timescales, need to be developed. In particular, intangible costs need to be included more fully in these assessments.

Clarification of the use of economic tools in relation to valuing adaptation is needed. In particular, the disparity between discount rates used in different institutional settings needs to be addressed.

Integration of adaptation evaluation and activity processes into pre-existing policy and operational frameworks and processes. For example, innovation and assurance frameworks in which processes and frameworks are designed to enable decision making with uncertain outcomes, the introduction of new ideas and technologies, social interactions, knowledge development and collaboration by a broad range of stakeholders.

Development of capacity through appropriate resourcing is needed, especially the development of knowledge and communication through collaborative mechanisms and frameworks.

Context-specific governance structures that can accommodate multiple institutional domains across multiple timelines involving diverse stakeholders need to be developed. This will require new cooperative arrangements within government and, potentially, between public and private interests.

Evaluation of current expenditure to ascertain the most cost-effective solutions for planned adaptation and resilience building options should be undertaken to reduce the risk of escalating future costs engendered by rapid change. It is important that sufficient funding be allocated to building resilience and to assist with reducing future costs of impacts associated with climate-related events.

Without policy that accounts for rapid change, costs are likely to increase as social, environmental and financial impacts are experienced faster than anticipated. Businesses and communities are also likely to experience unanticipated damages which, in many instances, will increase their vulnerability to future events. Reactive responses that increase expenditure in some sectors may also result in maladaptive actions.

Understanding how rapid change will affect our communities and the full value of what is at risk is pivotal to being able to effectively manage and sustain ourselves in the future. It is also an opportunity to use innovative thinking and practices to revisualise and transform our future in a way that creates greater resilience.

Policy implications

Rapid change will require a new generation of adaptation policies, approached on a larger scale than is currently envisaged and with different intellectual foundations.

Policies will need to address the likelihood of abrupt climate change and pervasive economic and social impacts, even though the nature, timing and location of those impacts remain uncertain. Policies will need to focus on the institutional scale and:

- be cooperative, polycentric and involve the public and private sectors at national, state, territory and local levels;
- pay close attention to diverse risks and the values they threaten;
- consider the propagation of many risks across domains;
- develop iterative strategies and processes to address the deep uncertainty associated with the problem and its solution, in particular, the inclusion of innovation frameworks and processes;
- foster long-term research and planning strategies independent of short-term political cycles;
- assess the types of investment needed for the effective adaptation to be undertaken;
- assess the cost effectiveness of current policies and identify maladaptive processes; and
- combine different methodologies and frameworks so that the value of adaptation can be more fully assessed to ascertain the social and financial benefits and costs associated with adaptation.

Glossary

Adaptation In human systems, the process of adjustment to actual or expected climate and its effects that seeks to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate (IPCC 2012).

Aggregate cost Sum of the distributed costs of an event or set of events across a system that need to be collected in order to understand the total cost.

Cost-benefit analysis Systematic process for balancing the costs and benefits of a project or action. It usually involves changes in marginal values over time, discounted to allow for factors such as the cost of finance, preference for risk, the value of externalities and the cost of opportunity.

Cost burden Cost borne by an actor in order to be able to operate.

Critical threshold The level of system change or impact that prompts a response in terms of management, jurisprudence, legislative requirement or similar. Can often be managed at critical control points within a system.

Delayed costs Sometimes synonymous with deferred costs, the costs ensuing from an action or event that occurred in the past.

Gradualism The belief that a process changes by small, incremental steps over time (policy, evolution).

Learning by doing The process of studying a set of actions to determine how they impact on the system being acted upon and whether they are producing the intended outcomes. This is a reflexive process whose intention is to maximise the benefits of acting and avoiding maladaptation.

Linear A direct relationship between one or more variables that remains constant over time.

Maladaptation The adverse outcomes of adaptation efforts that inadvertently increase vulnerability to climate change. Action that undermines the future ability to adapt by removing opportunities and hampering flexibility is also maladaptive (modified from IPCC 2012).

Mean Technical definition of average; the total of all values divided by the number of values in a sample.

Mean change Change in the mean of a sample that occurs over a specified amount of time.

Non-linear A relationship between one or more variables that changes over time. This change may be gradual or abrupt, or the relationship may cease to exist.

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