Beyond the mean

Valuing adaptation under rapid change

Roger Jones, Celeste Young and John Handmer

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VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

RMIT UNIVERSITY

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Contents

This context paper was prepared for the 'Beyond the mean: valuing adaptation under rapid change' workshop on 30 November, 2012, held at Victoria University, Melbourne, Australia, and contributes to the National Climate Change Adaptation Research Facility Project SD11 12 Valuing Adaptation Under Rapid Change. The purpose of this paper is to provide context and information to participants of the 'Beyond the mean' workshop.

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Project background

'Valuing adaptation under rapid change: anticipatory adjustments, maladaptation and transformation' is a collaborative research project between Victoria University, RMIT University and the Net Balance Foundation funded by the National Climate Change Adaptation Research Facility.

The objective of this study is to develop a robust economic methodology that will support decision-making on adaptation actions and investments ranging from adjustment to transformation. The methodology will explicitly identify and respond to the limitations in current approaches. It will draw widely from different disciplines and account for rapidly changing climatic and socio-economic factors.

The key research question is: how will the impacts of changing climate extremes influence the economics of valuing adaptation?

In doing this, the research will:

- Identify critical points where the economics of adaptation have not yet integrated key climate science findings and offer improvements.
- Provide a practical response to the challenge of providing valuation tools for end-users that can cope with the realities of uncertain damages, ambiguous climate futures and the potential for non-marginal change.

The purpose of the workshop

The overall purpose of this workshop is to help understand how the risks of a rapidly changing climate can be managed at the institutional scale and to explore the policy options needed to support effective responses. It will apply three scenarios to survey how rapid changes in the climate may impact economically at different levels of government, industry and society. The value of adaptation is guided by how effectively the cost of various adaptation options can sustain the values at risk. Those values at risk are monetary and non-monetary.

The workshop will examine:

- How climate-related risks and related adaptation measures can be transmitted across scales and are shared between private and public sectors.
- How our understanding of disasters and disaster risk reduction can contribute to adaptation.
- What tools and processes are currently available to assist people with this task and what new arrangements may be required?

Introduction

Traditionally, adaptation planning has assumed that climate is a stable system with occasional extremes. Such planning relies heavily on our understanding of mean climate and the envelope of variability surrounding it. Under climate change, climate models have skill in predicting mean change, but their ability with changing extremes is limited. Adaptation assessments have tended to concentrate on the more predictable aspects of mean change but it is becoming increasingly evident that changing extremes will dominate damage costs.

Understanding the economics of changing extremes across a variation of time frames (short-, intermediate and long-term) is difficult. There is also currently no clear delineation of who is responsible for, or who manages, the risks of changing extremes if they extend beyond the limits of past experience.

People are constantly responding to environmental stimuli by either modifying their environment or behaviour. The narratives accompanying adaptation are both old and new, which is why adaptation appears both familiar and unfamiliar – particularly in relation to climate change science, large uncertainties and **reflexivity**, where the actions we take can change the system itself.

The current adaptation narrative

The most widely answered climate change question is "How much will climate change?" "How will the climate change?" is a question not often asked or answered.

The strongest narrative accompanying adaptation is that of **gradualism**. Climate change is described as a gradual change in variables such as mean temperature and rainfall, occurring on top of natural climate variability. If adaptation is thought of as an adjustment to those changes, then the practice of adaptation too, becomes gradual.

Economic tools also conform to the narrative of gradualism:

- Most economic and policy analyses have focussed on incremental climate change.
- Such studies support a view that developed societies and economies can adjust to climate change without major disruption (in the short- to medium-term) or substantial socio-economic change.
- Exceptions include long-lived infrastructure that has to survive these changes intact – analyses then assess how much climate will change by a particular date and the role of environmental stressors that may affect that piece of infrastructure.

Projections of socio-economic change, price and economic growth are generally expressed as smooth curves. These tend to overlook the dynamic aspect of the economy because it is unpredictable, even though we recognise that changes are unlikely to be regular.

Commonly used methods such as **cost-benefit analysis** assume marginal changes but are limited in their effectiveness when dealing with fundamental changes in the economy or the complete loss of an irreplaceable, valued asset. In such cases, methods such as economic transformation become important.

Gradual climate change

Climate change and its impacts, especially its economic impacts, are generally shown as smooth curves of change that describe **mean change** (Figure 1). Such curves may combine several types of uncertainties. However climate information currently being communicated tells us **how much** climate will change and by when but not **how** the climate will change. Effective adaptation decisions require consideration of both aspects.

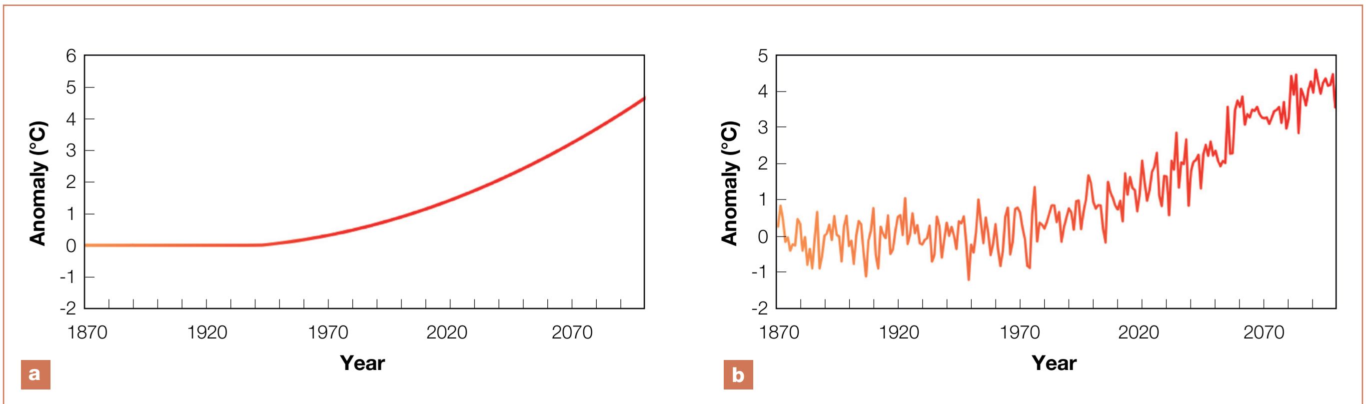

Figure 1 Single climate model simulation for south-east Australian temperature showing a) the mean and b) annual variability for a high emissions pathway.

The smooth curves used to communicate climate change and its resulting economic impacts have strongly influenced institutional narratives on adaptation as illustrated by the statements below:

- 'Within limits, the impacts of gradual climate change should be manageable'. www.pc.gov.au (Productivity Commission Report 2011)
- 'Therefore, climate change adaptation can be understood as: (a) adapting to gradual changes in average temperature, sea level and precipitation'. www.prevention.web
- 'Gradual climate change allows for a gradual shift in the mix of crops and to alternative farming systems'. www.ers.usda.gov

This perception of gradual changes in climate and **delayed costs of damage** occurring decades into the future presents a large psychological barrier when dealing with adaptation in the present day.

Gradual economic impacts

Top-down economic models assume that the climate variability experienced over time will average out to a smooth change in costs: this shapes the understanding and perceived value of the economics of adaptation.

Establishing an accurate estimate of the costs of climate change impacts is difficult, as top-down (macro-economic) and bottom-up (micro-economic) costs need to be combined. This is a problem of 'apples versus oranges' that challenges all economic costing methods, not just climate change.

Macro-economic costs tally **mean** impacts across whole sectors, while micro-economic costs assess individual impacts. Aggregating individual impact costs to estimate whole of economy costs is a huge challenge.

The Garnaut Review (Garnaut 2008) is the most comprehensive economic modelling project for Australia to date, which anchors the general expectations as to the costs of climate change. It assumes that in 2008 the net costs of climate change were zero, increasing slowly to about 2% of GDP by 2050. Although these costs were developed to assess the long-term benefits of mitigation they are only partial. Areas that were omitted included: some infrastructure costs; non-market costs; and insurance for extreme outcomes.

According to this model, in 2012 the costs of climate change to the Australian economy would currently be about \$3–\$4 billion per annum (Figure 2). However bottom-up costs of recent climate events are much higher, although it is difficult to separate the costs of climate change from climate variability. Figure 2 shows that costs to around 2040 are locked in, independent of the effectiveness of global greenhouse gas reductions.

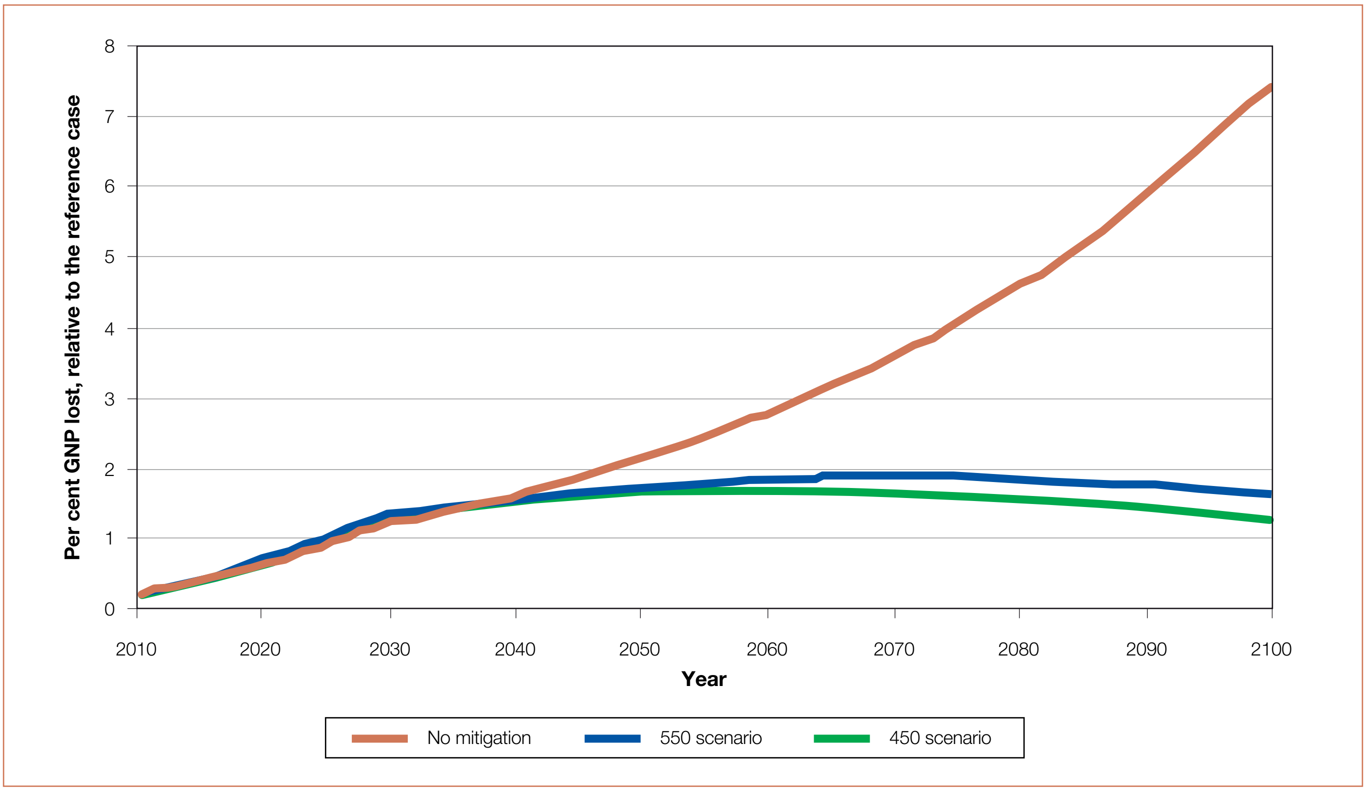

Figure 2 A comparison of the modelled expected market costs for Australia of unmitigated and mitigated climate change up to 2100 (Garnaut 2008).

Top-down cost estimates like these assume that the climate variability over time will average out to produce gradual changes in costs. This reinforces the gradualist model that adaptation is a largely incremental process. The exceptions to this are adaptations that have long life times (eg. infrastructure and natural assets), those close to critical limits that require an urgent response, or where activities are vulnerable to current climate.

Beyond the mean – anticipating climate change

Regional warming measured by observations and simulated by climate models follows a step-like pathway, rather than a smooth curve.

A solid body of research reinforced by recent findings for Australia shows that the distribution over time of warming in the oceans and atmosphere is highly **non-linear** (Figure 3; Reidel and Lanzante, 2004; Jones 2011, 2012). Regional warming measured by observations and simulated by climate models follows a step-like pathway, rather than a smooth curve.

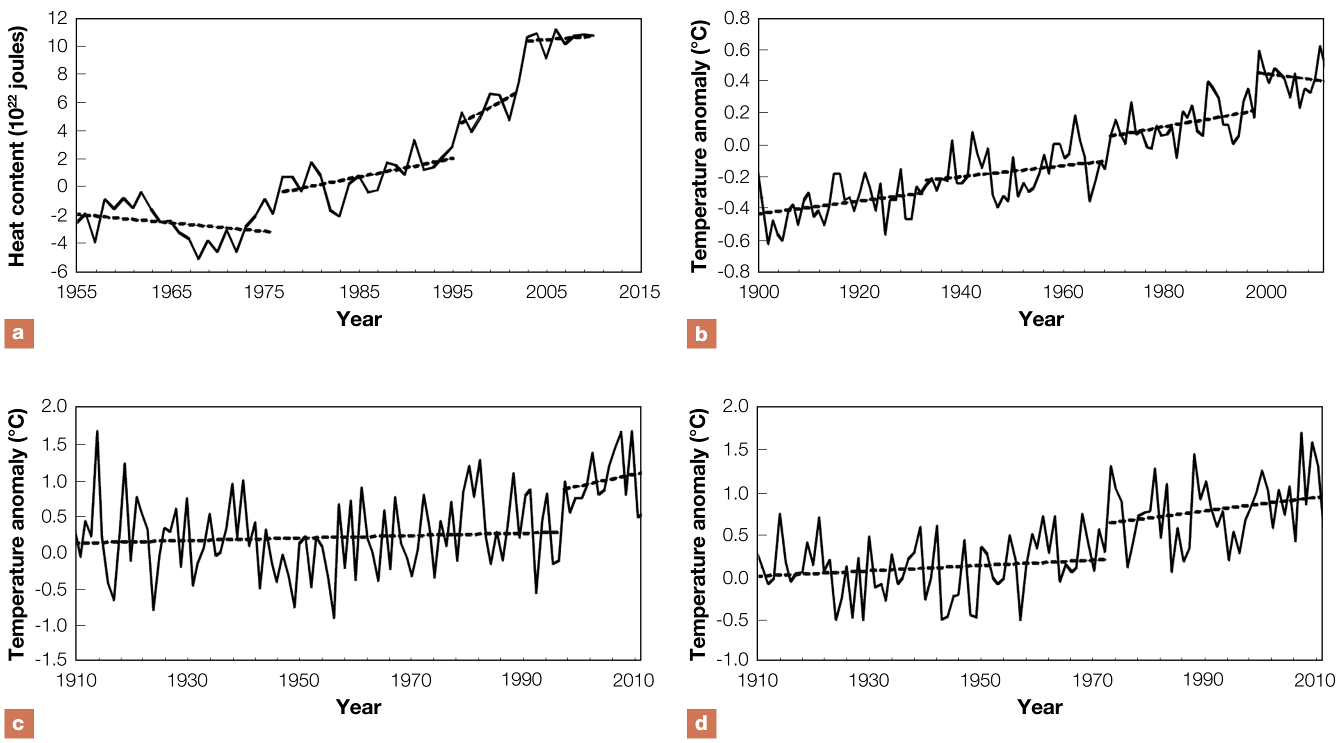

Figure 3 a) Ocean heat content of the top 700 m 1955–2010, showing annual data (solid line) with a statistically significant step and trend profile (long dashes); b) sea surface temperatures for Australia; c) maximum temperature for south-east Australia; d) minimum temperature for south-east Australia.

For further examples of step changes affecting other climate-related variables please see Figure 6, Appendix A.

These changes will produce clusters of extreme events occurring after a shift that are more frequent and larger than the statistics of gradual change would suggest (Appendix A). This has implications for how future risks and hazards should be managed and costed as extreme events can cause knock-on effects through several systems, leading to system failure and disaster.

CASE STUDY

After 13 years of drought and higher than usual temperatures Melbourne experienced record temperatures in late January–early February 2009 (Figure 4). In late January, three days above 40°C led to power brownouts, public transport network failure, crop and animal losses and widespread heat stress in people.

On Black Saturday February 7, temperatures rose to record levels, the system failures experienced in ten days earlier returned and catastrophic fires caused unprecedented amounts of damage. Three hundred and seventy-four people are estimated to have died of heat stress, 173 people died in the fires, over 400 were injured and over 2,000 buildings were lost. The fires were estimated to have cost over $4 billion of which $1.3 billion was covered in insurance payouts.

In Melbourne, the Southern Star observation wheel, open only for a month, developed cracks during the heat and remains idle over three years later at a direct cost of over $100 million with associated losses to businesses in the Docklands area caused by the wheel's closure. Step changes in the frequency of temperatures >35°C and in Forest Fire Danger Index in the region are statistically significant (Young and Jones, 2012).

This emerging narrative raises key questions for policy makers and practitioners as to how rapid changes and new extremes will affect critical thresholds and adaptation responses.

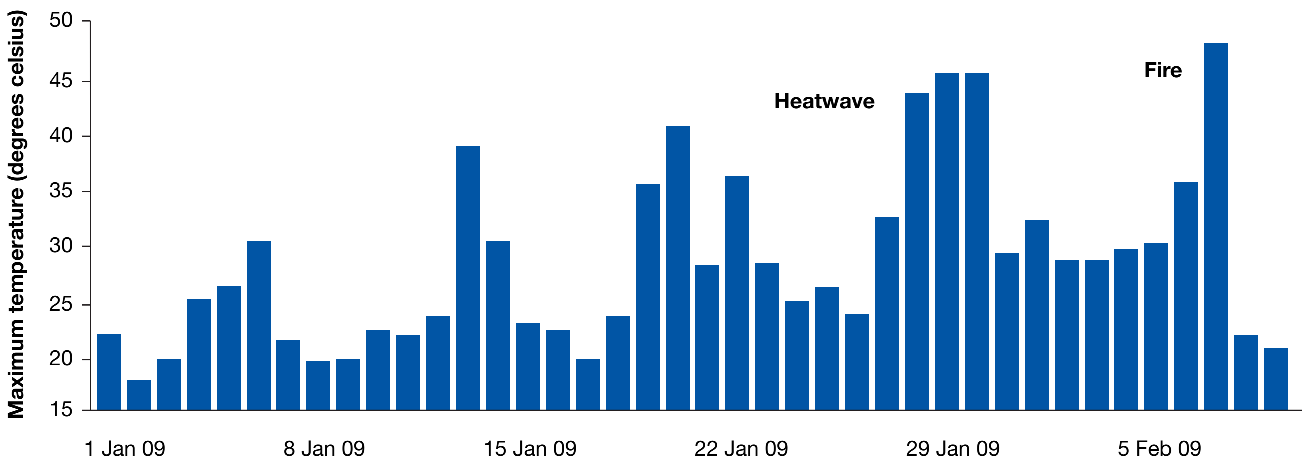

Figure 4 Maximum temperatures measured at Laverton Jan–Feb 2009 showing the heatwave (43.2°C, 44.8°C, 44.8°C) and fire (Black Saturday; 47.5°C) peaks.

Figure 5 shows an idealised distribution of temperature frequency, with thresholds for extreme hot and cold. If distribution shifts rapidly to warmer conditions as in the lower graph, then temperature thresholds can be exceeded much more frequently than would occur if those changes were gradual. It shows that adaptation to conditions around the mean will be market dominated, whereas adaptation to rapidly changing extremes will be policy dominated.

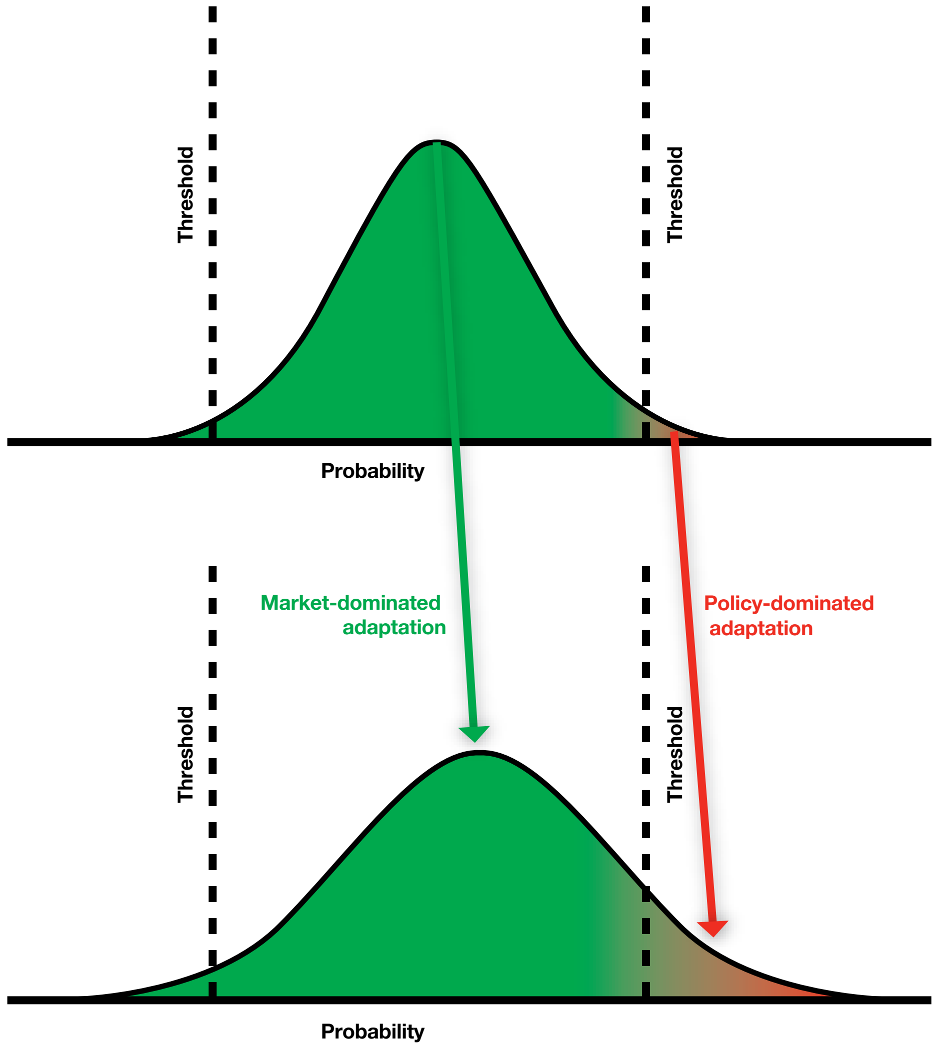

Figure 5 Schematic of temperature frequency about the mean showing a shift to warmer conditions (from upper to lower chart) with a greatly increased exceedance of extreme heat events

Beyond the mean – anticipating future costs

Market-dominated adaptation will adjust to changes in average conditions whereas policy-dominated adaptation will be needed to manage change in extremes. Markets may eventually manage these extremes but not as an unplanned activity.

Recent costs of extreme events and disasters indicate that the projected costs of gradual climate change are often partial and therefore underestimate the **aggregate cost**. The comparison of direct weather-related costs with additional climate change costs is not straightforward. This is largely due to the uncertain role of climate change in such events.

- Weather-related events in 2011 may have accrued losses of up to $31 billion, although this is not **net cost** (Weiberg and Keenan, 2011) as government and insurance payouts used in reconstruction can contribute to regional growth.
- The Queensland floods are estimated to have cost impacted Queensland gross state product by 2% or $5.1 billion between 2010–11, falling to $1.4 billion in 2013–14 (Hartley et al ., 2012).

A number of other events in the period 2009–2011 have also accrued costs running to billions of dollars. Earlier events such as the drought of 2006–08 and 2002–03 have also been implicated in GDP losses and have lead to large investments in desalination facilities in most states.

Flow-on costs due to secondary impacts can also affect how cost is constructed and reported. Examples are when:

- People are affected by post-event trauma,
- Access to natural resources is lost,
- Business closures increase due to financial stress.

In areas where regional population and land-use is rapidly changing, climate risks and the associated economic losses can accrue rapidly. Urban and regional areas subject to heat stress, flood risk, fire risk or coastal storm surge, are most likely to be affected.

Such shocks would have significant flow-on effects in the economy if they were to occur unanticipated.

Beyond the mean – anticipating adaptation needs

The starting point for planning adaptation to changing climate variability and extremes is in assessing the exposure of the economy, people and regions to the prevailing climate. For already well-adapted activities, continuing adaptation will grow out of normal business or management practises. However, vulnerable populations and regions face an existing **cost burden** due to climate extremes. If a shift has occurred and is unattributed to climate change, current exposure to those extremes may be under-estimated. Over-reliance on gradual adjustments to anticipated future change in climate and in other important environmental variables such as changing populations or land-use may also lead to under adaptation and maladaptation.

This raises key questions in relation to how to assess the cost of adapting to rapid changes now and in the future, such as:

- Which climate variables are most likely to undergo rapid changes?
- Which risks are likely to cross domains as a result of such changes?
- Who owns these risks?
- What important thresholds are likely to be reached and exceeded?
- What are the direct and indirect costs that need to be anticipated in planning adaptation?
- Which adaptation actions made at one scale are likely to produce perverse outcomes at another scale?

Valuing adaptation

For the context of this workshop, the value of adaptation relates to how well various strategies can manage the values associated with the impacts of rapid changes in climate. Some of those values can be measured as direct monetary values but others can be seen in terms of other currencies such as social, ecological, cultural or financial values. There is also value in actively managing future risks thereby increasing confidence and investment in climate-sensitive sectors and regions.

These values can be categorised into two main areas:

- **Tangible values** include direct market values of a good, service or asset/liability.
- **Intangible values** include non-monetary goods, services or assets/liabilities. These include social, cultural and environmental values that contribute to long-term social welfare.

Various economic tools can be used to estimate the monetary value of social values, which often involves values elicited from stakeholders.

Part of the value of adaptation is in how risk is managed. Rapid and unpredictable changes generally require a higher level of readiness, measured as resilience or reserves that can be drawn upon to respond to such changes when they occur.

Three long standing issues in disaster economics of potential relevance to the economics of adaptation are:

- **Intangibles** – identifying and including 'indirect' and 'intangible' impacts – or extending loss assessments beyond damage to physical assets for which there are active markets. As monetisation of intangibles could greatly increase the benefits of flood risk reduction strategies, considerable effort has been spent in this area.
- **Maladaptation** – valuing the potential negative effects of strategies intended to reduce losses. For example, decades of research on the 'levee effect' shows how short-run risk reduction strategies that may appear economically optimal can be maladaptive in the long term, and increase the risk of catastrophe.
- **Transformation** – one view is that relocation is transformative, and disaster economics has long undertaken economic assessments of whether relocations are worthwhile.

A range of risk management strategies that can be drawn upon include:

- Risk spreading.
- Transferral of risk from one entity to another.
- Robust planning of adaptations which are suitable for a wide range of potential outcomes.
- Risk options where a range of preparatory measures are invested in to enable rapid responses.
- Diversification of portfolio management where potential measures are trialled to determine which is the most effective.
- Transformation to increase resilience to future extreme events.

Adaptation policy

Adaptation to extreme events requires the development of an institutional framework for managing the risks of rapid changes. This can be complex because compound events:

- can transfer damages and costs from one sector to another,
- affect both tangible and intangible values,
- have the potential to cross domains of scale, governance and institutions.

The indications are that rapid changes in climate extremes requires policy – rather than market-led adaptation as market-led adaptation is more appropriate for adjusting to changes in mean climate. Key questions include: who owns these risks; what the current governance measures are; and how to map the transfer of possible future risks.

A number of opportunities in this area at the policy level could be considered, such as:

- The sharing of governance across the different levels of government and with the private sector.
- The potential for combining this aspect of risk governance across policy portfolios. For example, measures to protect the security of essential infrastructure and services can be shared with those for dealing with military security.
- Combining mitigation and adaptation in the management of natural assets to assist productivity and sustain rural regions through investment.

Key questions:

- **What existing policy and tools do we have that are effective for dealing with adaptation to rapid change?**
- **What tools and frameworks do we need in order to develop and implement effective policy for adaptation to rapid change?**

Key terms and definitions

Adaptation	In human systems, the process of adjustment to actual or expected climate and its effects, which 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 intending 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 occurring over a specified amount of time.
Non-linear	A relationship between one or more variables that changes over time. This change may be gradual, abrupt or the relationship may cease to exist.
Reflexivity	An attribute of complex systems where cause and effect form a feedback loop meaning that actions taken can change the system itself. Reflexive decision-making in a social system has the potential to change the underpinning values that led to those decisions.
Value-added	Calculation of industry contribution to Gross Domestic Product as calculated by the Australian Bureau of Statistics, largely gross output minus expenses.

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Appendix A: Recent rapid climate change in Australia and its impacts

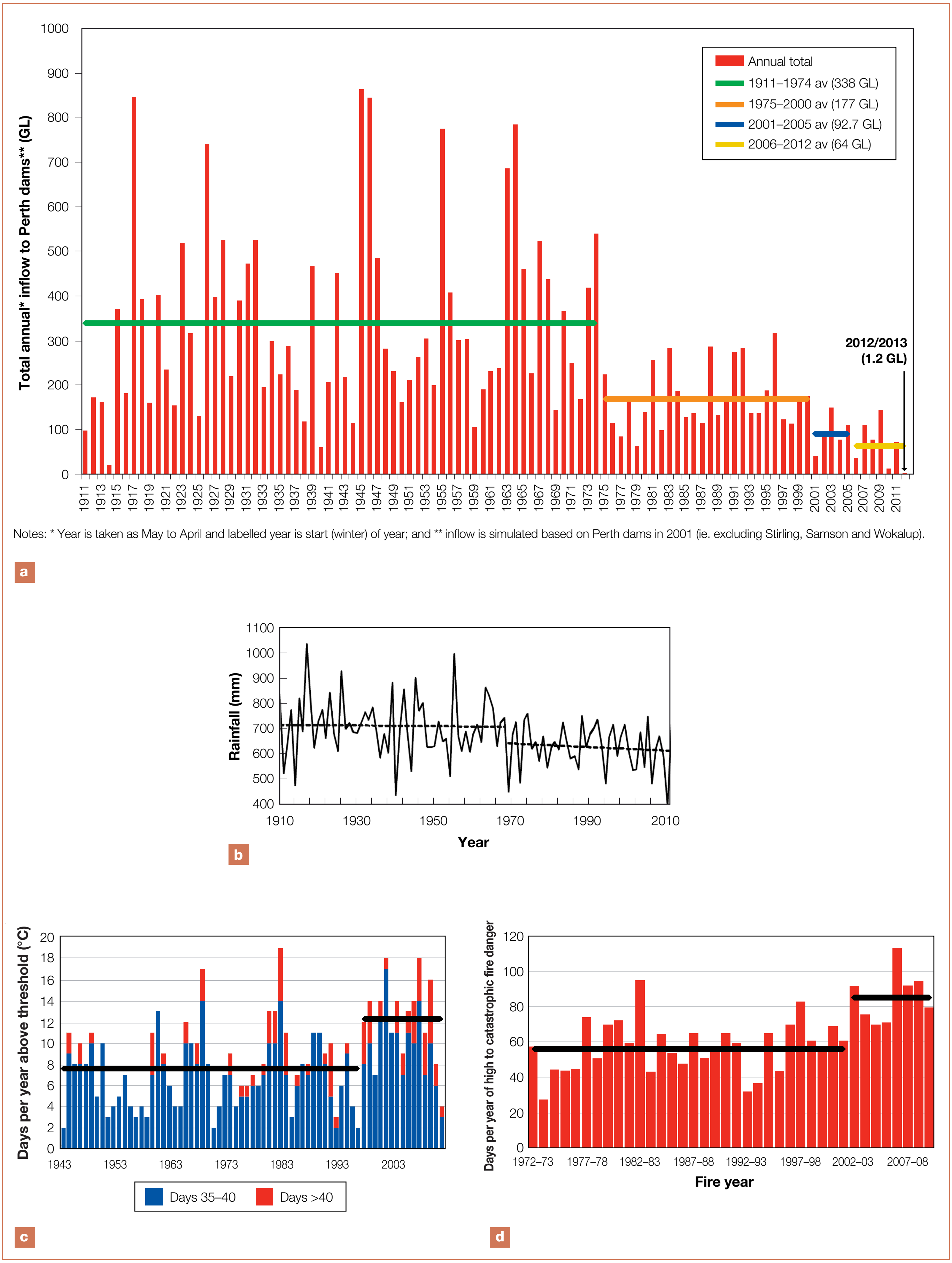

Figure 6 a) Annual streamflow into Perth's water storages (WA Water Corporation); b) south-western annual WA rainfall; c) days per year of extreme heat at Laverton, Victoria; and d) number of days of high to catastrophic fire danger for Victoria using the Forest Fire Danger Index (FFDI).