Climate Change Impacts & Implications for New Zealand

Framing Conversations around Risk and Uncertainty

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Resilient decision-making on climate change adaptation options and policies addresses existing and future risks and opportunities while accounting for a range of scenarios of the future. There will always be inherent uncertainty associated with the knowledge that helps to shape this process and some of this uncertainty is irreducible. However, uncertainty does not diminish the requirement for timely action and need not be a barrier to effective decision-making.

The following provides significant considerations for effectively dealing with climate change-related risk and uncertainty as well as highlighting the importance of considering a range of future scenarios when making decisions that are affected by climate change.

Key decision-making relevant concepts for risk management

- Capturing uncertainty versus 'best estimates'
- The role of means and extremes
- The interactions between impacts
- Adaptation pathways rather than a single adaptation action
- Ongoing change

Positioning Climate Risk

- Risk of climate-related impacts results from the interaction of climate-related hazards (including damaging climate events and trends) with the vulnerability and exposure of human and natural systems.
- Changes in both the climate system (left) and socioeconomic processes including adaptation and mitigation (right) are drivers of hazards, exposure, and vulnerability (Figure 1).

In general terms **Risk** can be described as the likelihood of an impact occurring and the magnitude of the consequences of the impact. However, risk is also defined as "the effect of uncertainty on objectives" (global ISO 31000:2009 standard). In situations where future risk profiles are changing, likelihoods cannot be calculated due to uncertainties and consideration of the consequences across a range of scenarios of the future will be necessary

Exposure relates to the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected by climate change.

Vulnerability refers to the propensity or predisposition to be adversely affected.

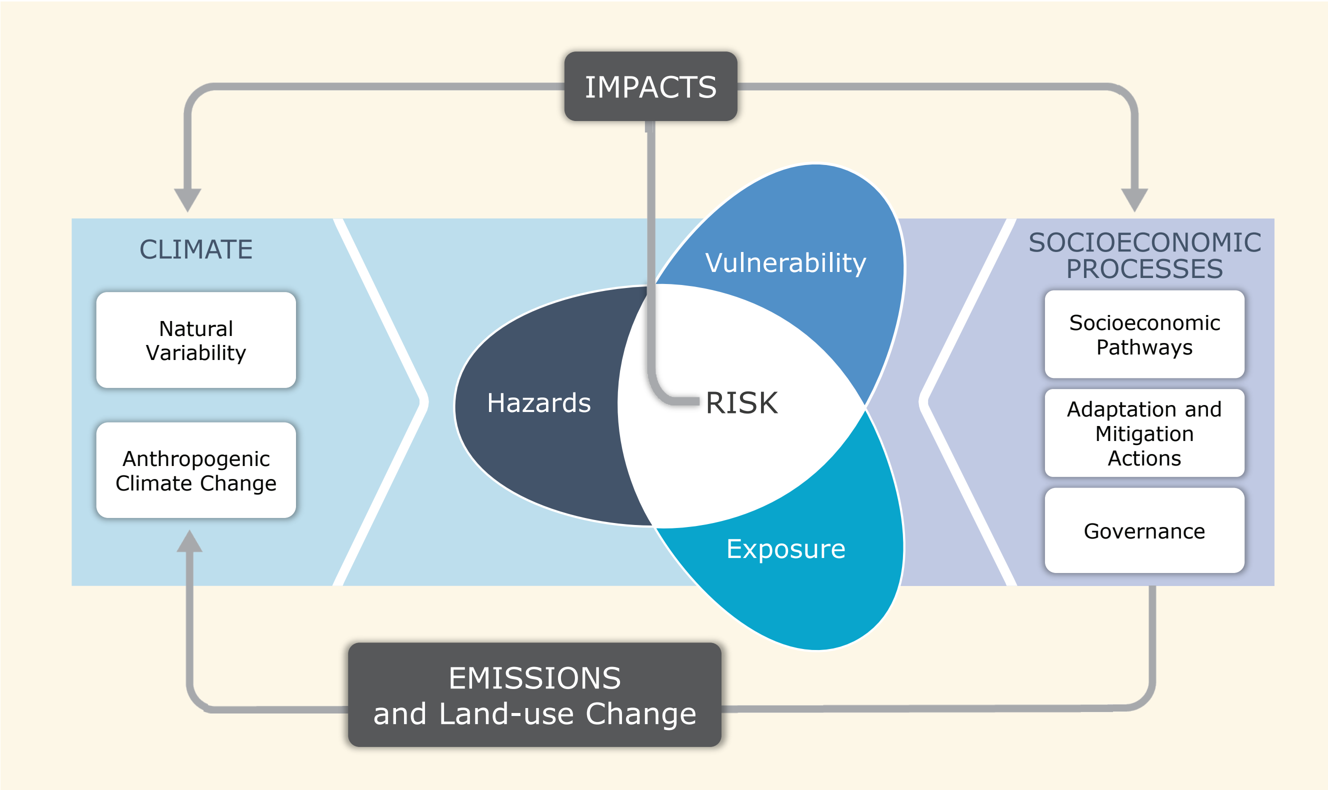

Figure 1: Risk of climate-related impacts (Source: IPCC 2014).

Understanding Climate Change Means and Extremes

- A changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events resulting in changes in the frequency and magnitude of climate-related risks and impacts.
- However, the infrequency of extreme events makes it challenging to estimate their probabilities and manage for their risk of occurrence.
- In addition, events with high consequences are likely to become more frequent.
- Effective risk management thus requires a portfolio of many types of risk reduction, risk transfer and disaster management actions to deal with the residual risk that cannot be avoided.
- Changing extreme weather and climate events can be linked to changes in global temperature distribution through changes in the mean, variance, or shape of probability distributions or a combination of all three distribution changes.
- The impact of changes in both mean and variance of rain fall on damage costs is displayed in Figure 2. Plate A presents a probability distribution function of average yearly precipitation covering

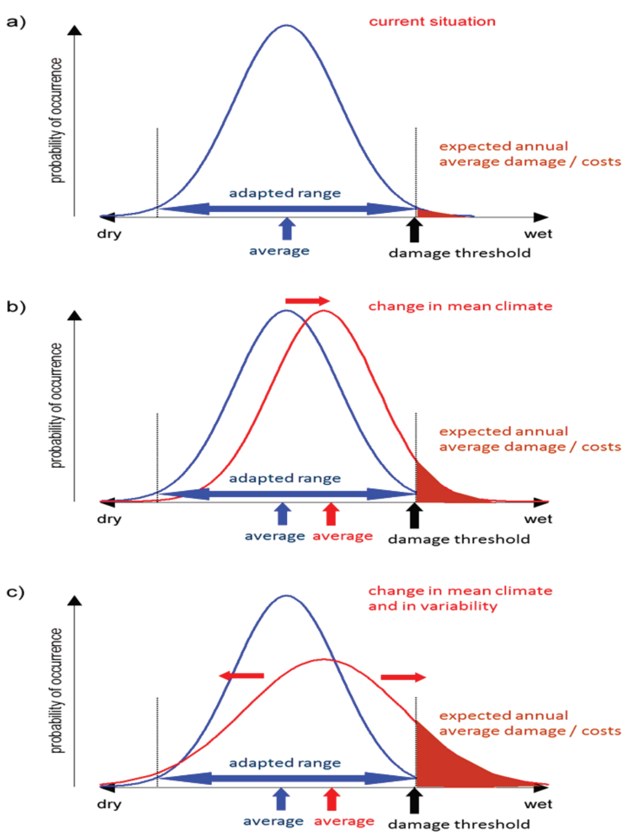

Figure 2: Schematic illustration of climate change and changes in risk (Drawn by A. Reisinger).

the range from wet to dry. In this example this is also considered the current adapted range. The damage threshold point is indicated and expected annual damage or costs are highlighted as the red wedge.

- Plate B highlights the change in expected annual average damage costs with a shifting of the mean in the probability distribution. Costs are expected to increase significantly as the distribution function moves beyond the adapted range.
- Plate C produces the greatest change in impacts with a change in both mean and in variability of the probability distribution function.

Sectoral Impacts

- A shift in the mean or variance of global temperature distribution would have significant impacts on a range of sectors with strong interlinkages between sector impacts.
- The agricultural sector would face significant impacts as a result of shifting temperature distributions. Less frost days, for example, could increase the incidence of agricultural pests and diseases and increased temperatures could impact on water availability.
- Urban settlements and infrastructure would be adversely impacted by increases in coastal, river and pluvial (rain related) flooding resulting in significant economic losses.
- The tourism sector would also face both positive and negative impacts with changes in the number of snow days and a potential increase in the travel season between peak and off-peak known as the "shoulder season" as warmer temperatures are experienced. Rainfall variability could also impact on this sector.
- An increase in hot weather would escalate potential drought risk and increase levels of heat related stress and mortalities in the old and very young.

Understanding Uncertainty

- Although trends in climate change are expected to continue, there is significant uncertainty about the precise rate of change and impact (IPCC, 2013, Working Group I).
- Assessing the different types of uncertainties in order to guide policy-makers and decision-makers is crucial in delivering resilient adaptation options.
- Five principle uncertainty dimensions have been described (Walker, 2003) as follows:
  - **Location**– the part of the problem in which the uncertainty occurs
  - **Level** – classification from "complete ignorance" to "knowing for certain",
  - **Nature** – whether uncertainty is knowledge-based or a direct consequence of inherent variability,
  - **Qualification of knowledge base** – evidence and reliability of information used, and
  - **Value-ladenness of choices** – the extent to which choices made in the assessment, are subjective.
- Drawing on these five uncertainty dimensions confidence in the validity of a finding is expressed qualitatively, based on the type, amount, quality, and consistency of evidence (e.g., mechanistic understanding,

Socioeconomic Scenarios and Uncertainty

- Human populations and economies currently provide some of the main drivers of climate change. Changes in the carbon intensity of our economies and population demographics will have a significant impact on future adaption options.
- It is therefore important to explore a range of future socioeconomic scenarios that may influence our climate in the future differently and hence influence emissions policy decisions and adaptation choices.
- While probabilities associated with each scenario cannot be assigned, scenarios enable policies to be tested for their ability to meet objectives against a range of future conditions and thus enable more robust decision making.

Examining Risk, Uncertainty, Damage and Best Estimates

- Plate A (Figure 3) presents a 'best estimate' of future climate change in terms of degree of temperature changes. For this given 'best estimate' a corresponding damage cost curve is produced.
- In order to include an assessment of risk in the system a probability distribution of future climate change is added on top of the 'best estimate' calculation (Plate B).
- By multiplying probability by consequence, or marginal damage a risk distribution curve can be produced.
- Plate C can therefore be said to capture the risk landscape and thus captures the range of uncertainty associated with future climate change which a single 'best estimate' does not (Figure 3).

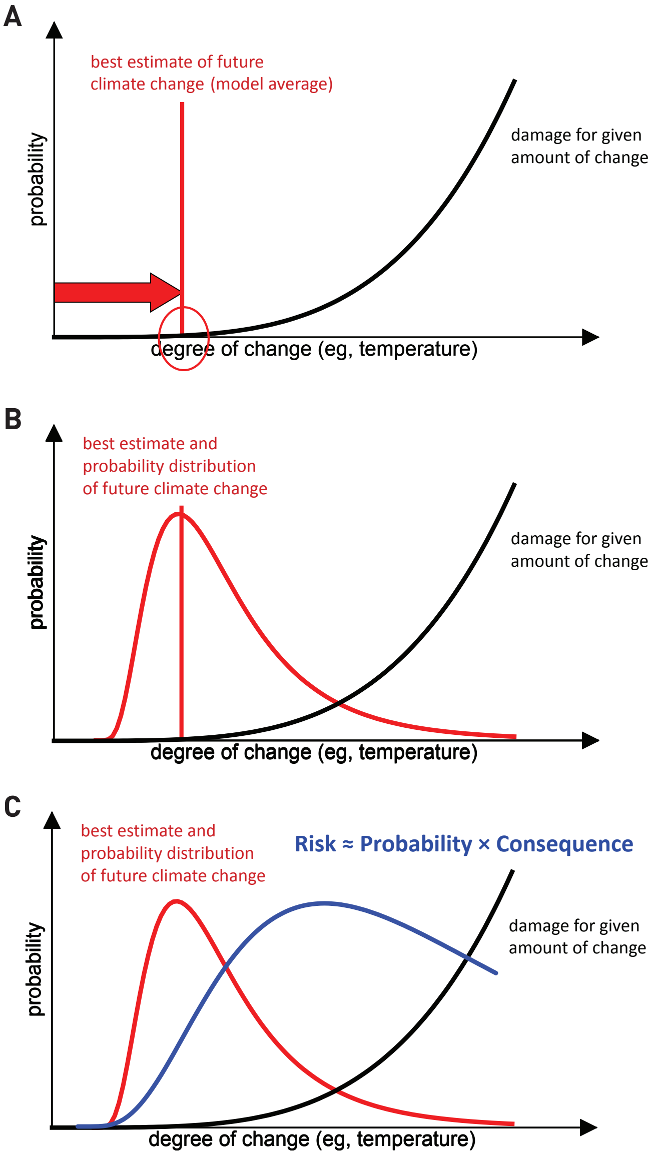

Figure 3: Examining risk, uncertainty and damage (Source Reisinger and Lawrence 2016).

A Note on Damage Cost Curves

The slope profile of a damage cost curve can vary greatly between economic sectors, depending on their unique sensitivities. When assessing sectoral dependent adaptation actions, the shape of the relevant damage cost curve is a significant consideration.

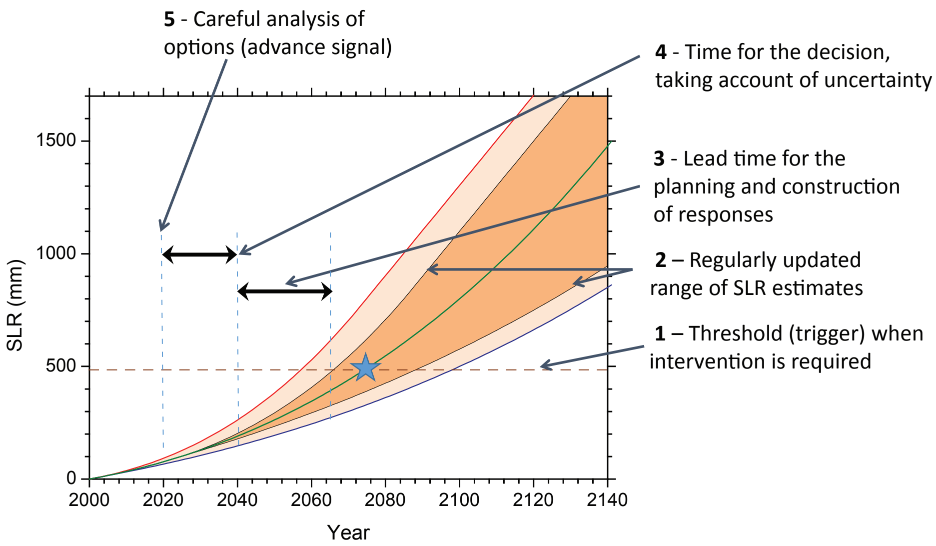

Figure 4: Thresholds, interventions and adaptation planning (Source: Adapted from Reeder and Ranger 2010).

Figure 4 is a schematic illustration of the considerable lead time necessary for identifying decision-relevant thresholds, analysis of adaptive options and for their implementation. This can take decades and underscores the importance of proactive adaptive management over long timeframes. The example relates to making adaptive choices for managing sea-level rise (SLR).

Developing Dynamic Adaptive Policy Pathways

- In order to carry out effective adaptation actions an iterative risk management approach is needed such as the Dynamic Adaptive Policy Pathways approach (Figures 5 and 6).
- This approach begins with the identification of objectives, constraints, and uncertainties that are relevant for decision-making.
- Scenarios are then used to compare the policy options to determine which may be needed in the future when current policy actions fail to meet objectives.
- In subsequent steps, these actions are used to produce an assembly of adaptation pathways. The performance of each of the actions and pathways is assessed according to defined objectives to determine their adaptation tipping point.
- Once a set of actions is deemed adequate, potential pathways (a sequence of actions) can be constructed, and subsequently one or more preferred pathways can be selected as input for a dynamic robust plan.
- The plan is then monitored using signals and triggers designed to anticipate a tipping point when the options no longer meet the objectives and when adjustments to another pathway can take place

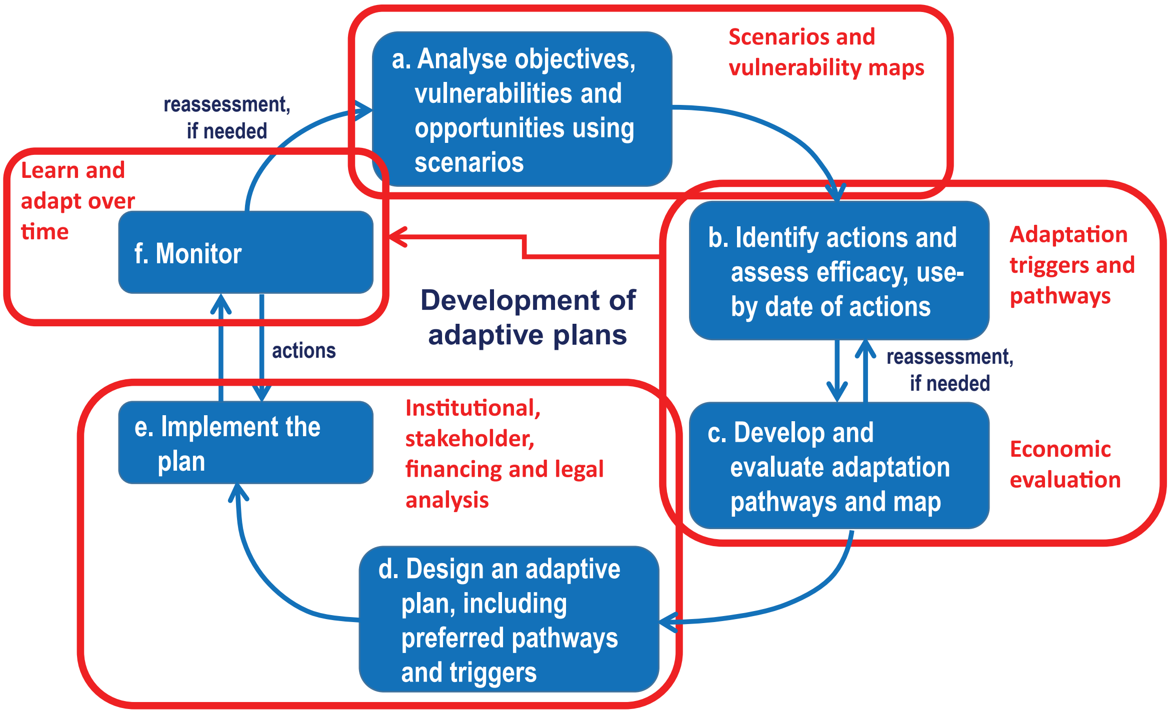

Figure 5: Development of Dynamic Adaptive Policy Pathways (Source: After Haasnoot et al. 2013).

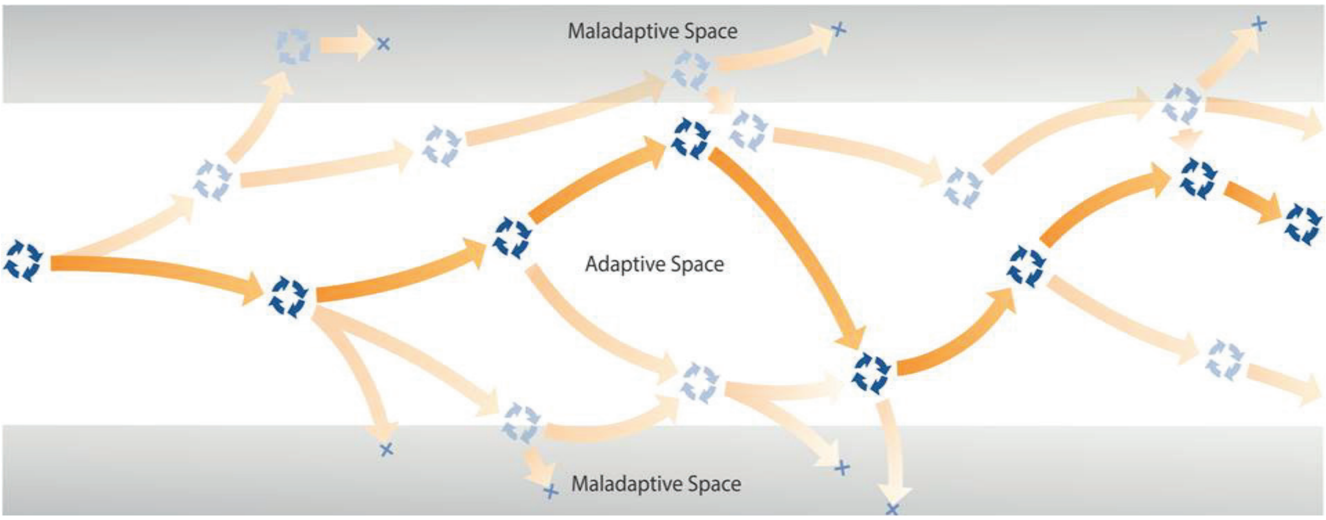

Figure 6: Adaptation Pathways (Source: Reisinger 2014).

Realising Resilient Climate Adaptation

That the majority of policy-makers and decision-makers are much more comfortable making decisions based on single numbers that have the appearance of certainty associated with them, is unsurprising given the expectations of communities and the institutional frameworks within which decisions are taken. However, the nature of changing climate set out in this note means that creating certainty in this way can be highly misleading. For decisions to be robust over a range of future conditions tools that embody uncertainty are essential. This is not a case for delay. Rather it is a case for identifying those decisions that are climate change-sensitive using a range of tools that can do this including scenarios analysis and staging those decisions over time that enables course correction over time as the conditions change and the actions no longer meet the objectives.

This note provides an overview of how risk and uncertainty can be conveyed in order to make effective decisions over time on climate change adaptation options/pathways and policies.

An application of the Dynamic Adaptive Policy Pathways planning approach in a New Zealand real-life decision process can be found at http://www.deepuncertainty.org/2016/12/14/what-it-took-to-catalyse-uptake-of-dynamic-adaptive-pathways-planning-to-address-climate-change-uncertainty-2016/" (Lawrence & Haasnoot 2016).

Further detail can be accessed in the references and resources below.

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Resources

Ministry for the Environment. 2017 Coastal Hazards and Climate Change: Guidance for Local Government. Wellington: Ministry for the Environment.

Ministry for the Environment. 2010. Tools for estimating the effects of climate change on flood flow: A guidance manual for local government in New Zealand.

http://www.mfe.govt.nz/publications/climate/climate-change-effects-on-flood-flow/tools-estimating-effects-climate-change.pdf

Decision Simulation Games – www.deltares.nl/en/software/sustainable-delta-game/#1

Access to the New Zealand tailored River and Coastal Games is through Dr Judy Lawrence at the New Zealand Climate Change Research Institute, Victoria University of Wellington judy.lawrence@vuw.ac.nz