



**White paper:  
Identifying and quantifying anticipated  
financial impacts of climate-related  
risks and opportunities**

**By the Climate Disclosures Working Group  
of the New Zealand Society of Actuaries**

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## Climate Disclosures Working Group

This paper was drafted by the Climate Disclosures Working Group (CDWG) of the New Zealand Society of Actuaries (NZSA). The NZSA is the professional body for actuaries practising in New Zealand. The NZSA publishes Thought Leadership papers in areas of public interest.

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This paper is not financial advice, actuarial advice, legal advice, or regulatory guidance. Nor is it an NZSA Professional Standard or Information Note. It does not create any mandatory requirements, nor does it amend or replace any applicable laws, regulations, or climate related disclosure standards.

The paper is intended for informed readers, including entities preparing climate related disclosures, practitioners supporting those entities, policymakers, regulators, and other stakeholders with an understanding of climate related disclosures in New Zealand. Readers should apply the ideas and considerations in this paper using their own judgement, having regard to their specific circumstances and applicable requirements.

## **Section 1: Introduction**

### **Purpose of this paper**

This paper provides practical guidance on how entities can identify and quantify Anticipated Financial Impacts (AFIs) arising from climate-related risks and opportunities (R&Os). AFIs are a required disclosure in many climate reporting frameworks, including the Aotearoa New Zealand Climate Standards (See appendix for requirement in NZ CS 1). They translate climate-related risks and opportunities into financial terms, enabling entities to better understand the potential magnitude, severity, and timing of climate-related impacts on their business.

The purpose of this paper is not to prescribe a single “correct” approach to AFI quantification, nor to create new disclosure requirements. Instead, it aims to support decision-useful, proportionate, and credible approaches to identifying and quantifying AFIs, recognising the deep uncertainty, long time horizons, and data limitations inherent in climate-related financial analysis. Used in this way, AFIs can support both internal and external decision-making, helping entities prioritise actions, allocate resources, and assess strategic resilience.

### **Scope and intended use**

This paper sets out principles, considerations, and illustrative approaches for identifying and quantifying AFIs. It highlights why simplicity, materiality, transparency, and directional accuracy are often more valuable than precision, particularly in the context of climate uncertainty.

The paper does not:

- mandate specific modelling techniques
- require the use of actuarial models or actuaries
- suggest that all entities should quantify AFIs to the same level of detail
- replace the requirements of applicable climate reporting standards.

Entities remain responsible for applying their own judgement, consistent with applicable standards and their specific circumstances.

Readers may use this paper as:

- A conceptual guide to understanding what AFIs are and how they arise from climate-related R&Os
- A practical reference when designing or refining approaches to AFI identification and quantification
- A discussion tool to support internal conversations between boards, management, risk, finance, sustainability, and technical specialists
- A sense check on whether AFI approaches are proportionate, transparent, and decision-useful.

The paper is intended to support iterative improvement over time, rather than a one-off or “perfect” solution.

## Structure of this paper

**Section 3** outlines key principles and considerations for identifying and quantifying AFIs, including materiality, uncertainty, and the treatment of tail risks, and discusses links to financial statement items.

**Section 4** explains how material climate-related risks and opportunities can be translated into AFIs, covering impact pathways, physical and transition risks, and interdependencies.

**Section 5** discusses how models can be used to quantify AFIs, emphasising simplicity, transparency, and iterative improvement, and covering model types, assumptions, governance, and analysis techniques.

## Why has the NZSA written this paper?

The identification and quantification of AFIs has emerged as one of the more challenging aspects of climate-related disclosures, including under the NZ CS. Many entities are grappling with questions such as what level of sophistication is appropriate, how to deal with limited data and uncertainty, and how to avoid AFIs becoming overly complex or misleading.

The New Zealand Society of Actuaries (NZSA) has written this paper to contribute thought leadership to this evolving area. Actuaries have extensive experience in long-term financial modelling, risk assessment, uncertainty management, and translating complex systems into financial insights. These skills are highly relevant to AFI analysis. This paper draws on actuarial principles and practices to help entities approach AFI quantification in a way that is pragmatic, transparent, and fit for purpose.

The CDWG has consulted with the External Reporting Board in preparing this paper. The External Reporting Board (XRB) is an independent Crown entity that develops and issues financial reporting, auditing and assurance, and climate standards for for-profit, not-for-profit and public sector entities. The NZSA is grateful for the contribution and insights that the XRB has provided, however nothing in this paper should be regarded as a requirement or guidance from the XRB.

## Who may find this paper useful?

This paper is written for a broad audience, including:

- Entities required to prepare climate-related disclosures
- Practitioners supporting those entities (including, but not limited to, actuaries)
- Standard setters and regulators interested in how AFIs are being approached in practice
- Other stakeholders seeking to understand AFI concepts and challenges.

While the paper draws on actuarial thinking, it is written to be accessible to non-actuaries involved in climate risk, finance, strategy, and reporting, and focuses on practical principles rather than technical actuarial methods. It assumes familiarity with how climate change gives rise to climate-related risks and opportunities, but not with actuarial modelling techniques.

## Section 2: Executive Summary

Anticipated Financial Impacts (AFIs) translate climate-related Risks and Opportunities (R&Os) into financial terms, enabling entities to better understand the magnitude and severity of potential impacts, and support internal and external decision-making.

Actuaries are well accustomed to modelling and assessing long-term risks, managing uncertainty, and translating complex systems into financial projections. This paper draws on actuarial principles and practices to help entities navigate AFI quantification in a way that is pragmatic, transparent, and fit for purpose.

### Six key considerations when identifying and quantifying AFIs

- Models used can be simple or complex, but simplicity aids understanding and validation
- Prioritise decision usefulness, directional accuracy, transparency and continuous improvement
- Materiality is crucial—focus only on climate-related R&Os that could influence decisions
- Climate change introduces deep uncertainty and long time horizons, making perfect data unattainable; transparent assumptions and expert judgment are essential
- Link AFIs to specific financial statement line items (e.g. revenue, expenses, capital)
- Tail risks and tipping points can have major impacts.

### AFI quantification is built on a foundation of robust R&O analysis

AFI quantification is not a standalone exercise. It depends on robust R&O assessment—identifying material climate-related R&Os and understanding their impact pathways. Entities would likely benefit from explicitly mapping how climate events or trends affect operations and, ultimately, financial metrics. This means considering direct (first order), indirect (second order), and cascading effects, as secondary impacts may drive the largest financial outcomes.

Understanding chronic and acute impacts, as well as the interdependence of R&Os, may enhance AFI quantification. Assessing correlations and R&O combinations helps to avoid underestimating impacts.

### Models are a tool to assess AFIs, but simplicity is best when uncertainty is high

A model is ‘a simplified representation of a system’, can be qualitative or quantitative, and can help turn complex climate uncertainties into financial insights. The goal is usefulness, not precision. There is a balance between selecting a degree of complexity that gives a realistic view of AFIs but is also transparent and easy to understand.

It is usually best to start simple. A simple model that shows significant impacts with sufficient accuracy is preferable to a complex model that is incomplete or is difficult to understand and use. Entities could start by building a model that is easy to use and meets the basic needs of their stakeholders.

As time horizons lengthen, AFIs become increasingly assumption driven. Having well documented rationales and sources help to ensure a strong governance framework.

*“Essentially, all models are wrong, but some are useful.” - British statistician George E. P. Box*

## Section 3: Key Considerations When Identifying and Quantifying AFIs

### A model is a simplified representation of a system

The use of models is an effective way to quantify AFIs.

A 'model' in its broad meaning is 'a simplified representation of a system'. This should not be misconstrued as something inherently complex. A simple model can be more useful than a complex one.

Modelling does not necessarily require sophisticated software. A model can be as simple as a spreadsheet calculation that projects key financial metrics under different assumptions, or as straightforward as quantifying the financial impact of a specific hypothetical event.

A model can also be entirely qualitative, e.g. [the IPCC climate system model diagram](#)<sup>1</sup>, showing interconnections among the atmosphere, oceans, land surface, and human activity.

There is a tension between creating models sophisticated enough to capture material risks and keeping them simple enough to be understood, validated and maintained. A rule of thumb for risk modelling is that when uncertainty is high<sup>2</sup>, simple models tend to be more helpful than complicated ones.

### Delivering value through AFIs: Key focus areas

To unlock the strategic value of AFIs and to produce them efficiently, entities may find it helpful to focus on the following:

- **Decision usefulness:** AFIs support strategic choices. Decision makers should be able to use them to evaluate adaptation or mitigation investments, strategic pivots, or risk mitigation options.
- **Directional accuracy:** The AFIs need to be informed by the material drivers of change, including climate-related R&Os.
- **Transparency:** Modelling and assumption setting that is transparent to allow users to have a clear understanding of the rationale for the entity's approach to modelling.
- **Continuous improvement:** Modelling and assumption setting that continues to adapt to changes in needs, approaches, and the business, physical and economic environments.
- **Internal consistency:** In practice, assumptions are usually internally consistent with each other and set in the context of the relevant Climate Related Scenario (CRS) which is being modelled. Separate assumption combinations will be needed for each CRS.

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<sup>1</sup> Baede et al. The Climate System: an Overview. Figure 1.1 <https://www.ipcc.ch/site/assets/uploads/2018/03/TAR-01.pdf#page=4>,

<sup>2</sup> Trust et al. 2024. Climate Scorpion - the sting is in the tail. <https://actuaries.org.uk/media/g1qevrfa/climate-scorpion.pdf#page=11>

## Materiality: Focus on what truly matters

Entities should consider quantifying the AFIs of climate-related R&Os only where the impacts are expected to be material<sup>3</sup>. Furthermore, the resulting information is only useful if it is relevant for either external (investors) or internal (management) decision-makers. Applying materiality as the guiding lens ensures that attention remains on factors that could reasonably shape decisions, rather than being diluted by immaterial details.

## Climate change: A landscape of deep uncertainty

Climate change represents a fundamental shift without historical precedent. Past data offers limited guidance for future impacts, and simple trend extrapolation is unlikely to produce plausible results. Both the climate system and societal responses involve considerable uncertainty, creating a wide range of possible futures.

This challenge is amplified by the long time horizons involved. AFI projections can extend 10 to 30+ years into the future—far beyond normal business planning cycles. Over such periods, even small changes in assumptions can compound significantly, magnifying uncertainty.

Adding to this complexity, climate-related R&Os do not occur in isolation. Physical and transition climate-related R&Os interact with each other and with broader business risks in intricate ways, creating cascading effects that are difficult to model. These interdependencies mean that understanding climate risk is not just about individual events but about systemic interactions that can reshape financial outcomes.

Given this, it is important to keep in mind that the aim is not perfect prediction but useful insights that help decision makers plan and allocate resources effectively.

## Waiting for perfect data is not a viable strategy

It is very unlikely that high-quality, location-specific climate impact data will be available for entities. Reliance on expert judgment and structured, consistent assumptions is necessary. The longer the projection period, the greater the need for assumptions.

## Linking to financial statement line items

Fundamentally, for a business to operate, it needs capital, positive cashflows, assets and insurance to transfer any risk it cannot mitigate.

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<sup>3</sup> In the context of NZ CS, entities must only disclose information if it is “material”. NZ CS 3 defines material information as “Information is material if omitting, misstating or obscuring it could reasonably be expected to influence decisions that primary users make on the basis of an entity’s climate-related disclosures”.

[XRB Standards Navigator » Standards Navigator](#)

Projecting full financial statements may be very complex. Instead, linking identified impact pathways to specific financial statement line items may be more useful. At a minimum, revenue, expenses and capital expenditure could be considered.

**Revenue impacts could result from:**

- Volume changes (demand increases/decreases)
- Price changes (pricing power, competitive dynamics)
- Product/service mix shifts
- New revenue opportunities from climate-related products/services
- Market share changes.

**Expense impacts could result from:**

- Input cost changes (energy, materials, water)
- Efficiency changes (productivity impacts from weather, equipment performance)
- New costs (carbon pricing, compliance, adaptation measures)
- Labour cost changes (heat impacts on productivity, changing skill needs)
- Research and development related to adaptation or mitigation
- Insurance premium changes.

**Capital expenditure impacts could result from:**

- Adaptation investments (resilience measures, relocated facilities)
- Asset replacements (premature retirement, upgraded specifications, depreciation rate changes)
- Obligations to reinstate environmental damage
- Stranded assets (write-downs of assets made obsolete by transition)
- Potential climate-related litigation
- Growth investments in new low-carbon business lines.

This mapping provides the foundation for building a quantitative model, a view of which financial statement line items are affected and in which direction.

## **The tail risk problem**

Climate change involves potential for extreme outcomes that sit in the "tails" of probability distributions (examples of which include the 2008 global financial crisis and the Covid-19 pandemic). These low-probability, high-impact events can dominate financial risk even if their likelihood seems remote. Using traditional mean-based approaches may significantly understate impacts.

### Figure 1: What is tail risk?<sup>4</sup>

Tail risk refers to the risk of unlikely events occurring, typically in the ‘tails’ of a probability distribution. Such events can be rare but can have significant impacts. Actuaries often pay attention to tail risk as it involves the potential for large losses, which are of particular interest for risk management.

The figure shows a hypothetical probability distribution for an insurance company catastrophe loss event. The 1 in 200-year line is in the tail of the distribution (implying it is a rare event) but results in a significant loss amount. Insurance companies need to be able to withstand tail event losses to pay their policyholders. In this case only considering the mean loss is not helpful.

Figure 2: Hypothetical Probability Distribution for insurance company loss amount



## The tipping point problem

Climate science identifies potential tipping points, thresholds beyond which changes become self-reinforcing and potentially irreversible. Examples include ice sheet collapse, Amazon rainforest dieback, or ocean circulation changes.

The impacts from tipping points are difficult to model due to likely step changes in either physical or transition risks but should be considered due to the severe financial impact these may bring.

Tipping points are different from tail risks as they have a higher likelihood, but the timing is uncertain, and the step change is not a one-off effect.

<sup>4</sup> Trust et al. 2024. Climate Scorpion - the sting is in the tail. <https://actuaries.org.uk/media/g1qevrfa/climate-scorpion.pdf#page=11>

## Section 4: From Risks and Opportunities to AFIs

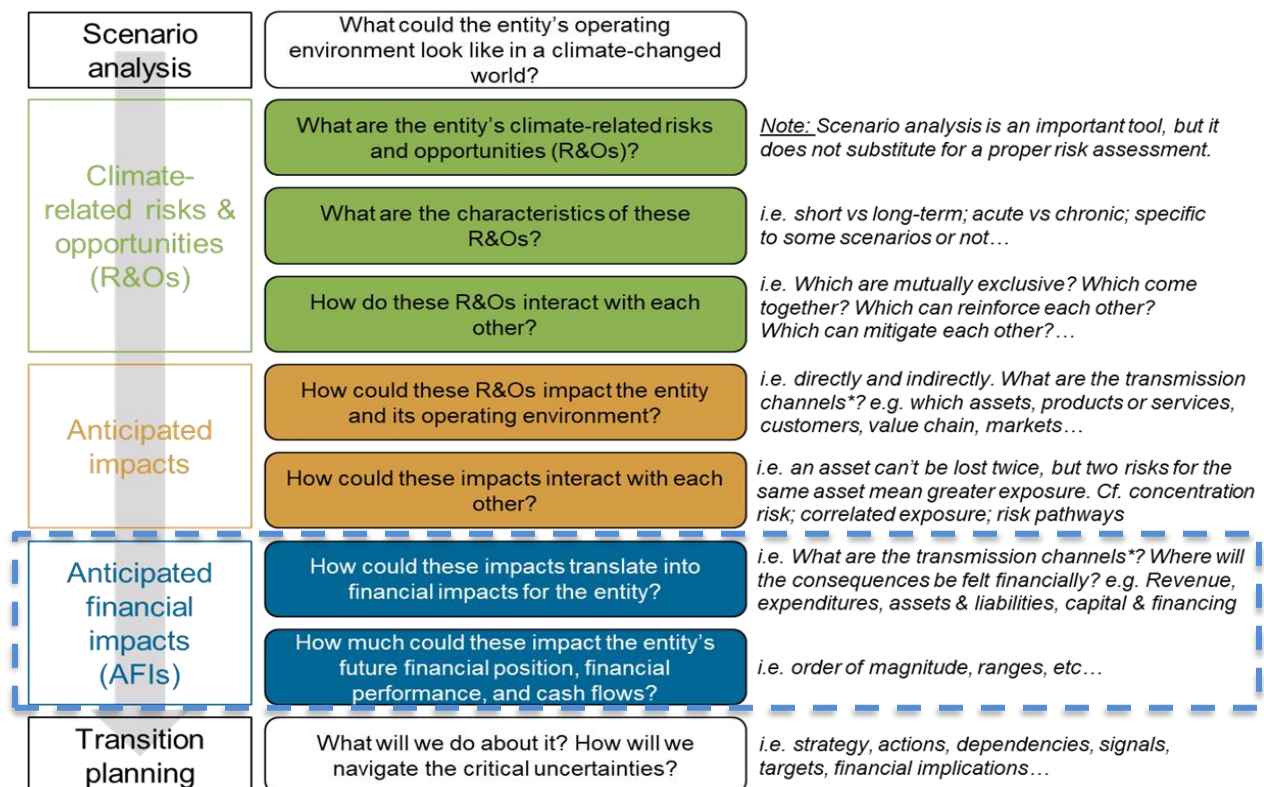
### The identification and quantification of AFIs is not a standalone exercise

Figure 2 below illustrates a series of steps XRB guidance suggests entities should go through before identifying and quantifying AFIs. This illustrates the overall logic from the identification of material climate-related R&Os to anticipated impacts, then translating into AFIs.

A robust assessment to identify material climate-related R&Os is a necessary precursor to quantifying AFIs. If this step is poorly executed—through incomplete or inaccurate identification, or by failing to understand the underlying hazard, exposure, and vulnerability of each risk—the resulting AFIs may lack credibility. Poor inputs lead to poor outputs, and in some cases, the absence of specificity may make quantification impossible. This underscores the need for disciplined processes and clear materiality criteria to ensure useful outcomes.

An integrated and iterative process is likely to be useful. Understanding anticipated impacts and AFIs helps determine which climate-related R&Os are truly material. In turn, transition planning informed by these insights can mitigate certain risks.

**Figure 2 – Steps for exploring an entity’s climate-related R&Os**



Source: External Reporting Board, Staff guidance Anticipated financial impacts, Framing internal conversations. July 2025.

<https://www.xrb.govt.nz/dmsdocument/5557/>. \* Transmission channels are the causal chains that explain how climate drivers give rise to

impacts on an entity, directly or indirectly through their counterparties, the assets they hold and their operating environment. For example, see the Bank for International Settlement (BIS) publication on [climate-related risk drivers and their transmission channels](#).

## Understand how material climate-related R&Os translate into anticipated financial impacts

The key challenge is translating the anticipated impacts of climate-related R&Os into anticipated financial impacts. This requires an intermediate step: understanding how climate events affect the entity's operations, value chain and/or strategies.

Entities may find it helpful to start by understanding their environment, industry and unique characteristics, including:

- The parts of the business most exposed to climate R&Os
- The climate impacts most material to the financial position and performance
- Understanding the value chain and how the R&Os interact through this
- The level of reporting required for external stakeholder needs and internal decision-making.

For physical risks, flooding or extreme heat could affect production, logistics, and the workforce. For transition risks, carbon pricing, regulation, or customer demand shifts could flow through to revenue and costs.

Entities could consider building an explicit translation layer that is specific to them, rather than jumping directly from climate science to profit and loss impacts. An impact pathway is a useful tool to trace how a climate event or trend could affect the entity and ultimately its finances:

**CLIMATE EVENT/TREND → ANTICIPATED BUSINESS IMPACT → ANTICIPATED FINANCIAL IMPACT**

For example: Increased flood frequency → Facility damage/downtime → Increased CapEx + Lost revenue

For each material climate-related R&O identified in the climate risk assessment, mapping the specific pathways through which it affects finances is a valuable analytical step.

## Consider both physical and transition risks and opportunities

Depending on an entity's unique business model and strategy, both physical and transition climate-related R&Os may be material. The approach may be different for each, given the fundamental differences between them.

Local physical risks are more straightforward to model as there is typically a direct linkage between changes in weather patterns and potential physical impacts. These are first order effects (see below).

Transition risks and opportunities may have more complexity given the range of possible interactions between societal, economic, and government factors. They are typically second order effects or may have a cascading effect (see below).

## Climate-related R&Os have first-order, second-order, and cascading effects

The complexity of quantifying AFIs is exacerbated due to risks and opportunities not being independent of each other. As such, entities will likely need to consider:

- **First-order effects:** Direct, immediate impacts on operations or assets (e.g., physical damage from an extreme weather event, direct cost increase from carbon pricing, immediate operational disruption)
- **Second-order effects:** Indirect impacts through the value chain, market dynamics, or customer behaviour (e.g., supplier disruptions, market demand shifts, insurance availability changes, competitive advantage from early adaptation)
- **Cascading effects:** Impacts that trigger multiple downstream consequences or amplify over time (e.g., facility damage that disrupts production, affects customer relationships, requires supply chain reconfiguration, impacts brand reputation, and necessitates strategic restructuring).

The most material financial impacts may come from second-order and cascading effects. For example, the 2011 floods in Thailand caused severe physical damage estimated at around USD 15 billion, but the economic losses far exceeded this at USD 46 billion, with far-reaching effects on the global supply chain of hard drives.<sup>5</sup>

However, second-order effects are also typically harder to quantify. Before modelling is started, it is suggested that entities consider cascading effects when assessing risks and opportunities, with the most material risks and/or chain of risks brought forward for modelling.

## Physical risk is two-fold: Chronic versus acute

Chronic risks relate to longer shifts in climate patterns, e.g., sea level rise. Whereas acute risks relate to climate events, e.g., increased frequency or intensity of flooding. The distinction is important.

Chronic and acute risks should be considered separately. For example, chronic risks may lead to sea level rise, which may not be able to be mitigated, e.g. locations on the coast where it is not economical to build a sea wall or relocate assets. Whereas, acute risks may be able to be mitigated economically, e.g. by improving the resilience of physical assets to climate events.

## Interdependence matters

Identified risks and chains of risks are unlikely to occur in isolation. For example:

- Drought might coincide with heatwaves.
- Rapid decarbonisation policies might emerge alongside continued physical climate risks.
- Economic disruption from transition could affect the capacity to invest in physical resilience.

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<sup>5</sup> <https://www.swissre.com/risk-knowledge/mitigating-climate-risk/decade-on-thailand-devastating-2011-floods.html>

Recognising the correlation between risks is essential for impact assessment. Treating related risks as fully independent may significantly understate the potential impacts of climate-related R&Os, given correlated risks are likely to occur together in the future. They could occur simultaneously, or one could trigger another.

A simple correlation assessment may usefully guide model design. Assessing key risks on a qualitative scale (low/medium/high) will help to show how likely they are to occur together.

It is also worth noting that some risks are negatively correlated, i.e., the occurrence of one risk may make another less likely. For example, a business that is heavily invested in renewable energy may benefit from increases in carbon pricing.

### **Risk amplification**

Using the example of drought and flooding: After a drought, the ground is dry and compacted. When heavy rain arrives, it cannot be absorbed quickly, causing a greater proportion of the water to run off the surface, leading to floods that have a greater impact than normally.

Understanding the co-occurrence of these two risks can help inform an entity's decision-making (e.g. how high should we build our new asset?).

### **Compounding effects of multiple risks**

More generally, the co-occurrence of several risks deemed as non-material individually can compound in material impacts when put together. e.g. A building occupancy or customers' frequentation can be impacted by many different risks, each of these having minor inconvenience to the business, but the accumulation can result in a material impact.

This also applies to opportunities, as the convergence of several opportunities could result in snowballing potential, and new strategic opportunities for the entity.

### **Understanding when impacts are compounding or limited**

Some effects have no obvious apparent causal link but can happen concurrently. For example, drought and flooding can both be experienced in the same year in the same location.

Understanding this co-occurrence is important when assessing potential impacts, if parts of an operation or supply chain are impacted by both risks.

In some cases, this co-occurrence would result in lower AFIs (e.g. if a crop is destroyed in a drought, the same crop cannot then be destroyed in a flood that follows soon after).

In some cases, this would result in higher AFIs (e.g. an orchard being successively impacted by drought and flood could lead to high tree mortality rate, on top of the year's production losses).

Mapping the co-occurrence of opportunities is also likely to be of strategic value for the entity, and useful for AFIs assessment.

For example: In a given year, the contraction of a market could concur with the growth of another one, balancing the overall AFIs.

## Section 5: Using Models to Quantify AFIs

### Use of Models:

- A 'model' in its broad meaning is 'a simplified representation of a system'.
- This should not be misconstrued as something inherently complex.
- A simple model can be more useful than a complex one.
- Modelling does not necessarily require sophisticated software.
- A model can also be entirely qualitative.
- A rule of thumb for risk modelling is that when uncertainty is high, simple models tend to be more helpful than complicated ones.

### Why models can be useful

Modelling can help turn complex climate uncertainties into useful financial insights. Climate-related R&Os affect costs, revenues, and asset values in ways that are hard to predict. By modelling, entities can test assumptions, estimate potential impacts, and identify areas of greatest exposure or advantage. This supports informed decisions on investment, resilience, and resource allocation through credible analysis.

For the quantification of AFIs, a "model" might range from a simple spreadsheet projecting key impacts under different assumptions and parameters to sophisticated simulation models. All are valid. The appropriate choice depends on the specific circumstances, materiality of climate-related R&Os and available resources.

A simple, transparent model that captures material impacts well is better than a complex, opaque model that obscures key assumptions. A simple model can be improved over time.

### What characterises a model

- **Abstraction:** Selecting what matters most for a given question. Models deliberately simplify reality to focus on the most important relationships, e.g. understanding the entity's material drivers and outputs.
- **Representation:** Identifying and setting out the key relationships among elements of a system being modelled. For example, this could be mathematical equations or logical rules.
- **Application:** Applying the model to simulate, forecast or test decisions. The decision maker's requirements shape the appropriate level of complexity.
- **Validation:** Assessing outputs from the model relative to observed reality, to assess reliability where available. This includes back testing, sensitivity analysis and peer review. In the absence of firm data, there is a need to conduct a common-sense evaluation of the model outputs.

## **There are different types of models**

### **Qualitative models**

This approach describes qualitative (i.e. non-numerical) relationships between observed variables. They can also include conditions under which these relationships are true. They often focus on the ‘how’ and the ‘why’ rather than the ‘how much’.

### **Mean deterministic model**

This approach is a simple deterministic model where projections are based on mean (average) values or assumptions. This approach is commonly associated with budget modelling.

This kind of model is simple and transparent. However, it will probably produce a relatively smooth projection of results and is likely to understate the real risks faced by entities, as the tail risk is largely ignored.

### **Deterministic model**

This approach builds on a mean deterministic model by adding specified events that represent plausible tail climate-related and tipping point R&Os. This model may not produce a smooth projection but will be subject to spikes, troughs and step changes when an event occurs. While that may be more realistic, it depends heavily on the judgement made around the timing and impact of events.

### **Stochastic model**

This model uses a probabilistic approach to climate-related R&Os, where it projects events based on the likelihood (probability) of occurrence each year.

One advantage of this type of model (known as a Monte Carlo simulation) is that it can be run many times to build up a picture of the underlying variability in a projection. This can help provide a clearer understanding of the impact of tail climate-related R&Os. However, a disadvantage is that these models are reasonably complex to implement, requiring technical expertise and significant judgement. The results are also heavily dependent on the underlying probability functions chosen.

## **Model selection: Start simple**

Entities are likely to benefit by starting with a simple model and progressively building in more sophistication as confidence and understanding grow. For example, an entity might first use a mean-based projection to establish baseline impacts. Then develop tail-risk projections to test what happens under plausible combinations of events.

A spreadsheet-based model that projects a few key financial impacts under different parameters and assumptions, incorporating identified impact pathways, is a viable starting point towards useful AFI quantification.

Once an entity is mature in the use of probabilistic distributions, they can consider using a stochastic model to enhance their modelling after using deterministic models.

Where complex models are adopted, a parallel simplified model could also be used to validate any output.

## **Key modelling components**

Every AFI model requires a range of inputs that fall into multiple categories. Some of these may have already been collected for the work on anticipated impacts. The inputs for AFIs will be specific to each business and for each Climate Related Scenario (CRS) being considered. The assumptions for each CRS need to be internally consistent. Examples might include:

### **Climate measures:**

- Temperature projections
- Precipitation changes
- Sea level rise
- Flood mapping
- Extreme event frequency/severity.

### **Global/country/regional assumptions:**

- Population change
- Economic activity
- GDP change
- International and local government policy settings.

### **Transition assumptions:**

- Carbon pricing trajectories
- Policy implementation timelines
- Technology cost curves
- Market demand shifts
- Changes in legislation and regulation.

### **Business parameters:**

- Current operations data
- Asset characteristics and locations
- Supply chain structure
- Cost structures and margins
- Management expectations for the future.

### **Financial parameters:**

- Cost and availability of capital
- Future investment returns
- Cost and availability of insurance.

Depending on the location of the entity's supply chain and markets, both a domestic and global view may be required.

Clear documentation of input information, i.e., the source of data and the rationale for selecting assumptions and parameters, will improve the model's credibility. This is essential for model transparency, future refinement, and support of applicable regulatory requirements.

Distinguish between:

- **Observed data** - historical performance, current operations
- **External projections** - climate models, economic forecasts
- **Expert judgement** - where data is unavailable
- **Assumed relationships** - how climate variables affect operations and/or strategies.

## The importance of transparent assumptions

### Data versus assumptions

As time horizons extend, the modelling of AFIs will transition from being data-driven to being assumption-driven and the uncertainty will also increase. The credibility and transparency of assumptions matter.

Transparency about which inputs are data-driven, and which are assumed is important for credibility. Document the basis for assumptions, whether from expert judgement, analogous events or entities, or extrapolation from trends.

### Assumption setting

A clear framework is needed for assumption setting and adoption. This will be key for entities to unlock the strategic value that comes from this long-term modelling.

This process typically involves:

- Documenting the rationale and sources for key assumptions
- Where possible, reconciling to actual data or research
- Monitoring and validating regularly in a systematic way
- Establishing governance for assumption review and updates.

The choice of assumption and the rationale should be well understood by the entity's decision makers.

### Be clear about uncertainty

Uncertainty in data, assumptions and modelling is often disclosed to support appropriate interpretation of results. Presenting assumption ranges, rather than relying solely on single-point estimates, better reflects the inherent uncertainty in AFI modelling. Uncertainty itself does not undermine the value of the outcomes.

## Present value considerations

Actuaries regularly use and are comfortable with a discounted cashflow approach to value assets and liabilities.

A discounted cashflow projection estimates present value by projecting future cashflows and then discounting them to their present values. Modelling of discounted cashflow AFIs could be considered to both enable comparison across time horizons and serve as a proxy for future organisation value impact for decision-making.

Discounted cashflow projections serve two purposes in AFI assessment:

1. They provide a consistent way to compare impacts across time horizons. A \$1M impact in 2050 needs to be compared appropriately with a \$1M impact in 2030.
2. They can serve as a proxy for the potential impact on enterprise value of an organisation at different points in the future—helping decision makers understand how climate-related R&Os might affect business value if left unmanaged.

### Discount rate considerations:

- Risk-free component reflecting the time value of money
- Risk premium reflecting uncertainty and business risk, depending on whether an asset or a liability
- Whether climate risks warrant specific risk adjustments.

### Inflation assumptions:

- Distinguish between general inflation and sector-specific pricing pressures
- Climate impacts may affect relative prices, e.g., energy, water, food.

A significant limitation of this approach is that it puts less weight on longer-term cashflows, which could understate the importance of material long-term risks. Regardless of this limitation, discounted cashflows provide a mechanism to assess relativities between different strategies or time periods.

It is imperative that any impact in the future be included at a value appropriate to that time period and not a current value. For example, if a plant is at risk of being damaged in 10 years, then the cost of repair should be the cost in 10 years, not the current cost.

While disclosures could be on a discounted cashflow basis, it may be worth considering undiscounted AFIs to understand long-term climate-related R&Os.

## Building confidence in results

### Sensitivity analysis: Understanding what drives results

Test how AFI estimates change when key assumptions vary. This reveals which inputs drive results and where additional effort to refine assumptions would be most valuable.

### Approach:

- One-way sensitivity analysis involves varying each key assumption individually to isolate its effect.
- Stress testing involves examining combinations of assumptions to understand compound effects.

### Document sensitivity analysis

It demonstrates rigour and helps stakeholders understand uncertainty ranges. It also guides where to focus efforts on refining assumptions in future iterations.

### Explaining differences between climate-related scenarios (CRS)

At a high level, differences between CRS should be able to be reconciled and validated and easily explained to decision makers.

Baseline assumptions provide the comparison to CRS assumptions. AFIs can be determined by taking the difference between model results between CRS assumptions and baseline assumptions. Explaining what drives differences between each CRS helps identify which risks matter most and informs strategic priorities.

The following is an approach that could be considered:

- Decompose total impact differences by driver (physical vs transition, revenue vs costs)
- Understand which pathways contribute most to different AFIs under each CRS
- Use this attribution to inform strategic responses.

This variance analysis can help to prioritise adaptation and mitigation investments.

### Transparency about limitations

Every AFI model has limitations. Being transparent about them builds credibility.

Explanation of the following should be considered:

- Where material climate-related R&Os are excluded due to quantification challenges
- Use of proxies for data gaps
- Which key assumptions have high uncertainty
- Interconnected aspects of climate-related R&Os not fully captured
- Model simplifications and their potential impacts.

Presenting these limitations alongside results allows decision makers to interpret AFIs appropriately, rather than over-relying on potentially false impressions of precision.

### Model governance essentials

Strong model and assumption governance ensures reliability and enables efficient iteration as the approach matures.

This includes:

- **Documentation:** An audit trail documenting data sources, assumption rationale, modelling approach, checks etc

- **Version control:** Document changes between model versions and reasons for changes
- **Peer review:** Independent review of assumptions and logic by qualified personnel
- **Validation:** Testing against benchmarks if possible, e.g. testing recent climate impacts if data exists
- **Model integrity:** Regular testing to ensure that calculations are performing as intended
- **Continuous improvement:** Planned cycles or predefined thresholds for updating data, assumptions, and approach.

Models will typically evolve as understanding improves. Early versions may be simple, but the structure should ideally accommodate future enhancements without complete rebuilds. If models are modular enhancements or greater understanding of one area do not require a complete overhaul.

## The iterative approach

AFI quantification can be viewed as an iterative process, not a one-time exercise. Each reporting cycle provides opportunities to refine assumptions, improve models, and incorporate new information.

Beyond the entity's experience, peer disclosures, emerging data sources, and evolving methodologies, including international developments are all useful inputs. A clear audit trail documenting the approach, key assumptions, and the rationale for changes over time supports both credibility and continuous improvement.

Perfection in year one is unlikely to be realistic. Meaningful improvement year over year is a more realistic and valuable measure of progress. This supports both internal learning and external credibility.

## Actual versus expected analysis

As time progresses, comparing actual outcomes to projections validates assumptions and demonstrates the disciplined continuous improvement central to actuarial practice. It should be noted that this process may emerge over relatively long time periods (years rather than months).

This helps validate assumptions, identify areas needing refinement, and build confidence in the approach. For example, if a physical risk materialises, assess whether its impact was consistent with assumptions.

Capturing lessons learned and updating the approach accordingly is central to the disciplined control cycle.

The actual experience with climate impacts may help inform and validate the forward-looking AFI assumptions.

## Glossary

### **Acute physical risk**

Climate-related physical risks arising from discrete, short-term events, such as floods, storms, heatwaves, or wildfires.

### **Anticipated Financial Impacts (AFIs)**

The expected effects of climate-related risks and opportunities on an entity's financial position, performance, or cashflows. AFIs translate climate-related impacts into financial terms and may relate to revenues, expenses, capital, assets, or liabilities.

### **Cascading effects**

Impacts that trigger a sequence of downstream consequences over time or across different parts of an entity or its value chain, potentially amplifying the overall financial impact.

### **Chronic physical risk**

Climate-related physical risks arising from longer-term shifts in climate patterns, such as sea level rise, increasing average temperatures, or changing precipitation patterns.

### **Climate-Related Scenario (CRS)**

A plausible future state describing how climate-related risks and opportunities may evolve over time, typically incorporating assumptions about physical climate outcomes, transition pathways, and socio-economic responses. Climate-related scenarios are used to explore uncertainty rather than to forecast outcomes.

### **Climate-related Risks and Opportunities (R&Os)**

Potential adverse (risks) or beneficial (opportunities) effects on an entity arising from climate change. These may be physical (e.g. extreme weather) or transition-related (e.g. policy, market, or technology changes).

### **Compounding effects**

The combined impact of multiple risks or opportunities that, when occurring together or sequentially, result in a greater overall effect than when considered individually.

### **Deep uncertainty**

A situation where decision-makers do not know, or cannot agree on, the appropriate models, probabilities, or outcomes for future states of the world. Climate change is characterised by deep uncertainty due to long time horizons, complex systems, and evolving societal responses.

### **Deterministic model**

A model in which outcomes are fully determined by the inputs and assumptions, with no explicit representation of randomness. Running the model multiple times with the same inputs will produce the same result.

### **Discounted cashflow (DCF)**

A valuation approach that estimates present values by projecting future cashflows and discounting them back to today using an appropriate discount rate. In the context of AFIs, DCF analysis can help compare impacts across different time horizons.

### **First-order effects**

Direct and immediate impacts of climate-related risks or opportunities on an entity, such as physical damage to assets or direct cost increases.

### **Impact pathway**

A causal chain describing how a climate-related driver or event leads to business impacts and, ultimately, financial impacts (e.g. climate event → operational disruption → financial loss).

### **Interdependence**

The degree to which climate-related risks and opportunities are correlated or connected, such that the occurrence of one may influence the likelihood or severity of another.

### **Materiality (climate-related)**

Information is material if omitting, misstating, or obscuring it could reasonably be expected to influence decisions that primary users make on the basis of an entity's climate-related disclosures.

### **Mean deterministic model**

A deterministic model that uses average or central assumptions to project outcomes, often producing smooth results that may understate extreme or tail outcomes.

### **Model**

In this paper, a simplified representation of a system used to explore how climate-related risks and opportunities may affect financial outcomes. Models may be qualitative or quantitative and are intended to support insight rather than precise prediction.

### **Qualitative model**

A non-numerical model that explains how and why climate-related risks and opportunities may affect an entity, often by describing relationships, conditions, and impact pathways rather than estimating magnitudes.

### **Return period**

A statistical measure describing the average time between events of a given severity (e.g. a "1-in-100-year" flood). Return periods do not imply events occur at regular intervals and may change over time due to climate change.

### **Second-order effects**

Indirect impacts arising through supply chains, markets, customer behaviour, or other intermediaries, rather than from direct exposure to a climate-related hazard.

### **Sensitivity analysis**

An analysis that examines how model outputs change when key assumptions or inputs are varied, helping to identify which factors drive results.

**Stochastic model**

A model that incorporates randomness and probability to generate a distribution of possible outcomes rather than a single result. Stochastic models are often used to explore variability and tail risks.

**Stress testing**

An analysis that evaluates outcomes under severe but plausible combinations of assumptions or events, often used to understand exposure to extreme climate-related risks.

**Tail risk**

The risk of low-probability, high-impact events that lie in the extreme ends (“tails”) of probability distributions and can dominate financial outcomes.

**Tipping point**

A threshold beyond which changes in a system become self-reinforcing and potentially irreversible, leading to step changes in physical or transition risks.

**Transmission channels**

The causal mechanisms through which climate-related drivers give rise to impacts on an entity, directly or indirectly, through assets, operations, counterparties, or the broader economy.

## Appendix: New Zealand AFI Disclosure Requirements

New Zealand AFI disclosure requirements are described in *Aotearoa New Zealand Climate Standard 1: Climate-related Disclosures* (NZ CS 1), paragraphs 15(b)–(d). Paragraph 15 is copied below for reference.

*An entity must include the following information when describing the anticipated impacts of the climate-related risks and opportunities it has identified (see paragraph 11(d)):*

- a) The anticipated impacts of climate-related risks and opportunities reasonably expected by the entity*
- b) The anticipated financial impacts of climate-related risks and opportunities reasonably expected by an entity*
- c) A description of the time horizons over which the anticipated financial impacts of climate-related risks and opportunities could reasonably be expected to occur*
- d) If an entity is unable to disclose quantitative information for paragraph 15(b), an explanation of why that is the case.*

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