Working Paper 2021/07

Scoping the use of the term ‘climate scenarios’ and other climate-related terms in Aotearoa New Zealand and international literature

MCGUINNESS INSTITUTE
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Contents

1.0 Introduction

1.1 Purpose

The aim of this paper is to: (i) point out the ongoing issue of how climate-related terms are inconsistently defined and used across domestic and international literature, (ii) list all such terms and their various definitions and (iii) develop the McGuinness Institute's climate change glossary.

1.2 Background

The Institute frequently seeks out insights from domestic and international climate literature as part of background research for Project *ClimateChangeNZ*. *Discussion Paper 2021/05 – Establishing reference climate scenarios for Aotearoa New Zealand* and *Report 18: Climate Change Strategy for Aotearoa New Zealand* are the two main publications the Institute has been working on recently for this project.

The Institute has examined domestic and international climate literature, and has found varied uses, definitions and interpretations of climate-related terms and language. Climate-related information must be comparable, and for this reason the language and terminology should be common, clear, concise and easy to understand. This has led to the Institute developing this paper.

The Institute hopes this paper will be useful given the External Reporting Board's development and issuance of climate standards (NZCS1), as well as the recent announcement of the Emissions Reduction Plan. More generally, the Institute hopes that this paper can act as a foundation for the development of consistent thought and a shared understanding of climate-related terminology.

2.0 Methodology

2.1 Method

This section explains the structure of the paper, as well as all methodological decisions that informed its research and writing. In short, this process can be broken down into five steps – search, select, analyse, compare and develop. The Institute elaborates on each step below.

Step 1: Search

The initial stage of this research process was the development of a dataset containing a list of selected publications (see endnotes 1–46). This dataset shaped our thinking and informed our work.

The publications were chosen based upon a methodological decision to include those that were most relevant to the scope of our research projects mentioned in Section 1.2. The Institute focused heavily on domestic and international institutions that have produced past work of interest, as well as recommendations from patrons/collaborators. Additionally, some publications were found via internet searches for key words mentioned in Step 2.

Step 2: Select

The following list of key climate-related terms resulted from the same methodological decision to include terms that were most relevant to the subject matter in the research projects (mentioned in Section 1.2). The selected climate-related terms were:

1. 'Scenario/s' (including 'pathways')
2. 'Reference scenario' (including 'baseline scenario')
3. 'Climate (change) scenario/s' (including 'climate projection' and 'climate prediction')
4. 'Climate model' (including 'regional climate model')
5. '(Scenario) storyline' and 'narrative'
6. Types of climate-related scenarios
7. Types of climate-related pathways

Step 3: Analyse

The selected publications were then analysed to see if any of the key climate-related terms (mentioned below) were included. If so, each publication was checked to see if it included a definition of the key term (as part of a glossary or otherwise). If so, the key term, definition and page number were recorded.

Step 4: Compare

The Institute noted down all definitions associated with each climate-related term (see Section 3).

Step 5: Develop

Finally, the Institute developed a glossary to embed consistency in how climate-related terms are defined and used across future work (see Section 4). The glossary includes terminology (from both domestic and international literature) that the Institute believes is common, clear, concise and easy to understand.

3.0 Climate-related terms in Aotearoa New Zealand and international literature

In this section, the Institute identifies how the same climate-related terms have been defined (and used) differently. The following definitions are a starting point based on what could be found, and the Institute invites comment on, or addition to, this list.

Note: Boxed text indicates that the definition has been derived from a publication produced by an Aotearoa New Zealand-based entity.

3.1 'Scenario/s' (including 'pathways')

- A **scenario** is 'a plausible representation of an uncertain future, sometimes including the pathway leading to this future, based on assumptions and key parameters that are mutually consistent'.[1]
- A **scenario** is 'a plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about key driving forces'.[2]
- A **scenario** 'is often given other qualifications, such as "emission scenario" or "socio-economic scenario". For the purpose of forcing a global climate model, the primary information needed is the time variation of greenhouse gas and aerosol concentrations in the atmosphere. In New Zealand, the climate impacts community prefers to limit the term "scenario" to describing a storyline consistent with a particular combination of greenhouse gas and socio-economic "pathways". Therefore, with results from climate model simulations, we endeavour to use the term RCP or pathway, rather than scenario.'[3]
- **Scenarios** are 'an alternative set of possible futures. Scenarios say what might happen given a set of observed mega-trends. Scenarios do not predict the future; rather they help to guide our decisions using a qualitative view of what may lie ahead.'[4]
- **Scenarios** are 'stories that describe alternative ways the external environment might develop in the future'.[5]
- A **scenario** is 'a plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (e.g., rate of technological change, prices) and relationships. Note that scenarios are neither predictions nor forecasts but are used to provide a view of the implications of developments and actions.'[6]
- A **scenario** is 'a plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (e.g., rate of technological change (TC), prices) and relationships. Note that scenarios are neither predictions nor forecasts, but are used to provide a view of the implications of developments and actions.'[7]
- A **scenario pathway** 'refer[s] to the political, technological, and economic developments and associated risk drivers (e.g., which sectors and regions bear the most emissions reductions, or which energy technologies win out in different economies) that lead to a particular scenario outcome; there can be distinctively different pathways leading to the same outcome'.[8]
- **Pathways** are the 'temporal evolution of natural and/or human systems toward a future state. Pathway concepts range from sets of quantitative and qualitative scenarios or narratives of potential futures, to solution-oriented decision-making processes to achieve desirable societal goals.'[9]
- **Pathways** are the 'temporal evolution of natural and/or human systems towards a future state. Pathway concepts range from sets of quantitative and qualitative scenarios or narratives of potential futures to solution oriented decision-making processes to achieve desirable societal goals. Pathway approaches typically focus on biophysical, techno-economic, and/or socio-behavioural trajectories and involve various dynamics, goals and actors across different scales.'[10]

3.2 'Reference scenario' (including 'baseline scenario')

- A **reference scenario** is a 'scenario used as starting or reference point for a comparison between two or more scenarios'.[11]
- A **baseline scenario** 'refers to scenarios that are based on the assumption that no emission mitigation policies or measures will be implemented beyond those that are already in force and/or are legislated or planned to be adopted. Baseline scenarios are not intended to be predictions of the future, but rather counterfactual constructions that can serve to highlight the level of emissions that would occur without further policy effort. Typically, baseline scenarios are then compared to emission mitigation scenarios that are constructed to meet different goals for greenhouse gas emissions, atmospheric concentration, or temperature change. The term "baseline scenario" is often used interchangeably with "reference scenario" and "no policy scenario".'[12]
- A **reference scenario** 'is an informed, internally consistent, and policy relevant projection on the future developments of the EU energy system, transport system and greenhouse gas GHG emissions that acts as a benchmark for new policy initiatives'.[13]
- A **reference scenario** is a scenario based on the assumption that no emission mitigation policies or measures will be implemented beyond those that are already in force and/or are legislated or planned to be adopted. Baseline scenarios are not intended to be predictions of the future, but rather counterfactual constructions that can serve to highlight the levels of emissions that would occur without further policy effort.

3.3 'Climate (change) scenario/s' (including 'climate projection' and 'climate prediction')

- A **climate change scenario** is 'a scientifically-based projection of one plausible future climate for a region. For guidance on regional impacts of climate change, a range of scenarios is desirable. These can span credible estimates of future greenhouse gas emissions, and the uncertainty range in climate model predictions.'[14]
- A **climate change scenario** 'is the difference between a climate scenario and the current climate'.[15]
- A **climate change scenario** is 'the simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases and aerosols, generally derived using climate models'.[16]
- A **climate scenario** is 'a plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, often serving as input to impact models'.[17]
- A **regional climate scenario** is 'a narrative used to describe how the future might unfold for a region. These are often used to guide impact understanding and adaptation efforts'.[18]
- A **climate prediction** is 'the result of an attempt to produce (starting from a particular state of the climate system) an estimate of the actual evolution of the climate in the future, for example, at seasonal, interannual or decadal time scales'.[19]
- A **climate prediction** is 'an attempt to provide a most likely description or estimate of the actual future evolution of the climate'.[20]
- A **climate projection** is 'a potential future evolution of the climate in response to an emission or concentration scenario of greenhouse gases and aerosols. Often based on a simulation by a climate model.'[21]
- A **climate projection** is a 'simulated response of the climate system to a scenario of future emissions or concentrations of greenhouse gases (GHGs) and aerosols and changes in land use, generally derived using climate models. Climate projections are distinguished from climate predictions by their dependence on the emission/concentration/radiative forcing scenario used, which is in turn based on assumptions concerning, for example, future socioeconomic and technological developments that may or may not be realised.'[22]

3.4 'Climate model' (including 'regional climate model')

- A **climate model** is 'a numerical representation of the climate system based on the physical, chemical, and biological properties of its components, their interactions and feedback processes, and accounting for some of its known properties'.[23]
- A **climate model** is 'a numerical representation (typically a set of equations programmed into a computer) of the climate system. The most complex and complete climate models are known as 'General Circulation Models.'[24]
- A **climate model** is 'a qualitative or quantitative representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes and accounting for some of its known properties. The climate system can be represented by models of varying complexity; that is, for any one component or combination of components a spectrum or hierarchy of models can be identified, differing in such aspects as the number of spatial dimensions, the extent to which physical, chemical or biological processes are explicitly represented, or the level at which empirical parametrisations are involved.'[25]
- A **regional climate model** is a 'climate model at higher resolution over a limited area. Such models are used in downscaling global climate results over specific regional domains.'[26]
- A **regional climate model** is a model that 'run[s] at higher spatial and time resolution than GCMs [global climate models] but over a limited area of the globe. RCMs [regional climate models] take boundary conditions from GCMs, and provide a physically consistent downscaling of the large-scale climate changes simulated by the GCM. They can cater for relatively small-scale features such as New Zealand's Southern Alps.'[27]

3.5 '(Scenario) storyline' and 'narrative'

- A **storyline** is 'a way of making sense of a situation or a series of events through the construction of a set of explanatory elements. Usually it is built on logical or causal reasoning. In climate research, the term storyline is used both in connection to scenarios as related to a future trajectory of the climate and human systems or to a weather or climate event. In this context, storylines can be used to describe plural, conditional possible futures or explanations of a current situation, in contrast to single, definitive futures or explanations.'[28]
- A **scenario** storyline is 'a narrative description of a scenario (or family of scenarios), highlighting the main scenario characteristics, relationships between key driving forces, and the dynamics of their evolution'.[29]
- A **narrative** is 'qualitative descriptions of plausible future world evolution, describing the characteristics, general logic, and developments underlying a particular quantitative set of scenarios'.[30]

3.6 Types of climate-related scenarios

- A **concentrations scenario** is 'a plausible representation of the future development of atmospheric concentrations of substances that are radiatively active (e.g., greenhouse gases (GHGs), aerosols, tropospheric ozone), plus human-induced land cover changes that can be radiatively active via albedo changes, and often used as input to a climate model to compute climate projections'.[31]
- An **emission scenario** is 'a plausible representation of the future development of emissions of substances that are radiatively active (e.g., greenhouse gases, aerosols). It is based on a coherent and internally consistent set of assumptions about driving forces (such as demographic and socioeconomic development, technological change, energy, and land use) and their key relationships. Concentration scenarios, derived from emission scenarios, are often used as input to a climate model to compute climate projections.'[32]
- A **mitigation scenario** is 'a plausible description of the future that describes how the (studied) system responds to the implementation of mitigation policies and measures'.[33]

- A **socioeconomic scenario** is 'a scenario that describes a possible future in terms of population, gross domestic product, and other socioeconomic factors relevant to understanding the implications of climate change'.[34]
- A **socioeconomic scenario** is 'a scenario that describes a plausible future in terms of population, gross domestic product (GDP), and other socio-economic factors relevant to understanding the implications of climate change'.[35]

3.7 Types of climate-related pathways

- A **representative concentration pathway** (RCP) is a scenario that includes 'time series of emissions and concentrations of the full suite of greenhouse gases (GHGs) and aerosols and chemically active gases, as well as land use/land cover'.[36]
- A **representative concentration pathway** (RCP) is a 'concentration scenario identified by its approximate total radiative forcing at 2100 relative to 1750'.[37]
- **Representative concentration pathways** (RCPs) are 'a suite of future scenarios of additional radiative heat forcing at the Earth's surface by 2100 (in Watts per square metre), which is the net change in the balance between incoming solar radiation and outgoing energy, radiated back up in the atmosphere'.[38]
- **Shared socioeconomic pathways** (SSPs) are scenarios that 'have been developed to complement the Representative concentration pathways (RCPs). By design, the RCP emission and concentration pathways were stripped of their association with a certain socioeconomic development. Different levels of emissions and climate change along the dimension of the RCPs can hence be explored against the backdrop if different socioeconomic development pathways (SSPs) on the other dimension in a matrix.'[39]
- **1.5°C pathway** is '[a] pathway of emissions of greenhouse gases and other climate forcers that provides an approximately one-in-two to two-in-three chance, given current knowledge of the climate response, of global warming either remaining below 1.5°C or returning to 1.5°C by around 2100 following an overshoot'.[40]
- **Adaptation pathways** are 'a series of adaptation choices involving trade-offs between short term and long-term goals and values'.[41]
- **Development pathways** are 'trajectories based on an array of social, economic, cultural, technological, institutional and biophysical features that characterise the interactions between human and natural systems and outline visions for the future, at a particular scale'.[42]
- **Emission pathways** are 'modelled trajectories of global anthropogenic emissions over the 21st century are termed emission pathways'.[43]
- **Mitigation pathways** are 'temporal evolution of a set of mitigation scenario features, such as greenhouse gas emissions and socio-economic development'.[44]
- **Transformation pathways** are 'trajectories describing consistent sets of possible futures of greenhouse gas (GHG) emissions, atmospheric concentrations, or global mean surface temperatures implied from mitigation and adaptation actions associated with a set of broad and irreversible economic, technological, societal and behavioural changes. This can encompass changes in the way energy and infrastructure are used and produced, natural resources are managed and institutions are set up and in the pace and direction of technological change.'[45]

4.0 Concluding remarks

This section contains our concluding remarks regarding the subject matter in this paper. The Institute then provides a glossary of working definitions that we (and hopefully others) will use to guide future climate-related work. Through raising this issue, and through the development of this glossary, the Institute can add to the dialogue around the need to create an integrated and consistent framework for dealing with climate-related information.

The McGuinness Institute's climate change glossary includes terminology (both from domestic and international literature) that the Institute believes is common, clear, concise and easy to understand.

4.1 McGuinness Institute's climate change glossary

Adaptation
The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.[46]

Adaptive capacity
The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities or to respond to consequences. The adaptive capacity may increase or decrease over time. This may arise with changes in available resources to conditions in the system of interest, or with cumulative effects of more frequent critical events. A catastrophic event may also permanently reduce the coping range of the system if the system is not able to recover its functionality over time (i.e. it has limited resilience).[47]

Anti-fragile
Anything that has more upside than downside from random events (or certain shocks) is anti-fragile; the reverse is fragile.[48]

Climate information
Information about the past, current state or future of the climate system that is relevant for mitigation, adaptation and risk management.[49]

Climate impacts
The effects of extreme weather, extreme climate events and climate change on natural and human systems.[50]

Climate model
A numerical representation (typically a set of equations programmed into a computer) of the climate system.[51]

Climate prediction
The result of an attempt to produce (starting from a particular state of the climate system) an estimate of the actual evolution of the climate in the future, for example, at seasonal, interannual or decadal time scales.[52]

Climate projection
The simulated response of the climate system to a scenario of future emissions or concentration of greenhouse gases and aerosols, generally derived using climate models.[53]

Climate system
The highly complex system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the lithosphere and the biosphere, and the interactions between them.[54]

Climate change scenario
A scientifically based projection of one plausible future climate for a region.[55]

Downscaling
Deriving estimates of local climate elements (e.g, temperature, wind, rainfall) from the coarse resolution output of global climate models.[56]

Emission scenario
A plausible representation of the future development of emissions of substances that are radiatively active (e.g, greenhouse gases, aerosols). It is based on a coherent and internally consistent set of assumptions about driving forces (such as demographic and socioeconomic development, technological change, energy and land use) and their key relationships. Concentration scenarios, derived from emission scenarios, are often used as input to a climate model to compute climate projections.[57]

Narrative
Qualitative descriptions of plausible future world evolution, describing the characteristics, general logic and developments underlying a particular quantitative set of scenarios.[58]

Mitigation scenario
A plausible description of the future that describes how the (studied) system responds to the implementation of mitigation policies and measures.[59]

Pathways
The temporal evolution of natural and/or human systems toward a future state. Pathway concepts range from sets of quantitative and qualitative scenarios or narratives of potential futures, to solution-oriented decision-making processes to achieve desirable societal goals. Pathway approaches typically focus on biophysical, techno-economic, and/or socio-behavioural trajectories and involve various dynamics, goals and actors across different scales. Types of pathways include adaptation pathways, development pathways, emissions pathways, mitigation pathways, overshoot pathways, non-overshoot pathways, representative concentration pathways, shared socioeconomic pathways and transformative pathways.[60]

Qualitative scenario analysis
Analysis that focuses on trend identification and the overarching narratives of the scenarios, often providing insight into less quantifiable company characteristics such as strategy, agility, philosophy, vision and culture. This kind of analysis can weave together multiple trends of various scales and complexity into a narrative to provide context relevant to a company's strategy.[61]

Quantitative scenario analysis
Analysis that refers to the use of quantified information within a scenario. It can take many forms, from numerical descriptions of trends and other factors, to the use of techniques such as trend analysis, sensitivity analysis, and modelling of a company's climate related risks.[62]

Reference scenario
Refers to the latest scenario designed specifically with New Zealand in mind and published by NIWA (see Figure 4). The reference scenario is one of two scenarios that must be used by preparers of Climate Statements.[63]

Regional climate scenario
A narrative used to describe how the future might unfold for a region. These are often used to understand impacts and guide adaptation efforts.[64]

Representative concentration pathways (RCPs)
A 'scenario that includes time series of emissions and concentrations of the full suite of greenhouse gases (GHGs) and aerosols and chemically active gases, as well as land use/land cover'.[65]

Risk
The potential for adverse consequences where something of value is at stake and where the outcome is uncertain, recognising the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur.[66]

Regional climate model (RCM)
A climate model at higher resolution over a limited area. Such models are used in downscaling global climate results over specific regional domains.[67]

Resilience
The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure while also maintaining the capacity.[68]

Scenarios
Refers to probable, possible and preferred descriptions of how the future may develop based on a coherent and internally consistent set of assumptions about driving forces and key relationships.[69]

Shared socioeconomic pathways (SSPs)
Scenarios that 'have been developed to complement the representative concentration pathways (RCPs). By design, the RCP emission and concentration pathways were stripped of their association with a certain socio-economic development. Different levels of emissions and climate change along the dimension of the RCPs can hence be explored against the backdrop if different socio-economic development pathways (SSPs) on the other dimension in a matrix.'[70]

Socioeconomic scenario
A scenario that describes a possible future in terms of population, gross domestic product and other socioeconomic factors relevant to understanding the implications of climate change.[71]

Scenario outcome
The endpoint of a scenario, usually whether or not a temperature target is reached, such as limiting the level of temperature rise by 2100 to 2°C.[72]

Scenario pathways
The political, technological, and economic developments and associated risk drivers (e.g, which sectors and regions bear the most emissions reductions, or which energy technologies win out in different economies) that lead to a particular scenario outcome; there can be distinctively different pathways leading to the same outcome.[73]

Scenario storyline
A narrative description of a scenario (or family of scenarios), highlighting the main scenario characteristics, relationships between key driving forces, and the dynamics of their evolution.[74]

Storyline
A way of making sense of a situation or a series of events through the construction of a set of explanatory elements. In climate research, the term 'storyline' can be used either in connection to scenarios related to a future trajectory of climate and human systems, or to a scenario related to a particular weather or climate event. In this context, storylines can be used to describe plural, conditional possible futures or explanations of a current situation, in contrast to single, definitive futures or explanations.[75]

Stranded assets
Assets exposed to devaluation or conversion to 'liabilities' because of unanticipated changes in their initially expected revenues.[76]

Uncertainty
A state of incomplete knowledge that can result from a lack of information or from disagreement about what is known or even knowable.[77]

Appendix 1: Climate scenario bibliography

Appendix 1 contains a list of publications more specifically related to climate scenarios.

The Institute compiled this list (including the brief synopses) prior to the discussion event held in August 2021– 'Establishing Reference Climate scenarios'. This bibliography was given to participants to familiarise them with examples of climate scenarios.

1. OECD, *Global Scenarios 2035: Exploring Implications for the Future of Global Collaboration and the OECD.*[78]

   This report 'uses a strategic foresight approach to inform reflection on how best to prepare the OECD to meet the needs of a highly unpredictable future. It was developed by the OECD's Strategic Foresight Unit to demonstrate how navigating the future of global collaboration and the Organisation's role within it will require ongoing exploration and dialogue about what may be possible, and desirable, in the future.'

2. Shell, *Sky – Meeting the Goals of the Paris Agreement.*[79]

   This is 'an ambitious scenario to hold the increase in the global average temperature to well below 2°C'. It is a well thought-out and executed scenario developed by one of the largest petroleum companies in the world.

3. CIFOR, *Climate scenarios: What we need to know and how to generate them.*[80]

   This report 'provides some overviews on the roles of climate scenarios in adaptation planning and what should be considered in using and generating climate scenarios, in a frequently ask questions style. Specifically, this book tries to answer questions commonly addressed by non-climatologists when they want to address climate scenario in adaptation plans.'

4. NIWA, 'Climate change scenarios for New Zealand'.[81]

   This webpage offers a range of material regarding climate change scenarios from an Aotearoa New Zealand-based perspective. The material is based on the RCP scenarios (similar to our TCFD exercise) from the IPCC's 5th Assessment report.

5. McGuinness Institute, *Four Possible Futures for New Zealand in 2058.*[82]

   This report uses the issues of climate change and genetic modification to explore four scenarios based on whether or not the world manages itself well and whether or not Aotearoa New Zealand manages itself well. These four scenarios illustrate why small countries have such a vested interest in international affairs.

6. McGuinness Institute, 'TCFD exercise'.[83]

   This exercise was developed by the Institute to use while hosting the 2019 TCFD workshops. The detailed exploration of Core Element 2 (Strategy) was supported by this exercise, where attendees explored a variety of scenarios based on climate change models of representative concentration pathways (RCPs) for 2.6, 6.0 and 8.5. In the second part of the exercise, attendees practised testing existing climate change and business strategies of Aotearoa New Zealand organisations against each of the scenarios and then making corresponding TCFD disclosures.

7. TCFD, *Technical Support: The Use of Scenario Analysis in Disclosure of Climate-Related Risks and Opportunities.*[84]

   This report assists 'organisations in using climate-related scenario analysis to support the development of disclosures consistent with the Recommendations of the Task Force on Climate-related Financial Disclosures'.

8. Network for Greening the Financial System (NGFS) – *Guide to climate scenario analysis for central banks and supervisors.*[85]

   This guide 'provides practical advice on using scenario analysis to assess climate risks to the economy and financial system. It is based on the initial experiences of NGFS members and observers, and also aims to progress discussion on the methodologies used. While mainly aimed at central banks and supervisors, many aspects of the Guide might also prove informative to the wider community.'

9. United Nations Principles of Responsible Investment, 'Climate scenario analysis'.[86]

   This webpage contains a list of climate scenario tools that 'make it easier for investors to implement a key recommendation of the TCFD – scenario planning'.

10. IPCC, *AR6 Climate Change 2021: The Physical Science Basis.*[87]

    This report 'addresses the most up-to-date physical understanding of the climate system and climate change, bringing together the latest advances in climate science, and combining multiple lines of evidence from paleoclimate, observations, process understanding, and global and regional climate simulations'.

11. Anderson, B., et al., *Modelled response of debris-covered and lake-calving glaciers to climate change, Kā Tiritiri o te Moana/Southern Alps, New Zealand.*[88]

    This paper uses a glacier model and future climate scenarios from six different climate models to investigate how glaciers might change in the future in the Aoraki/Mt Cook region (where ~54% of New Zealand glacier ice is). RCP 2.6 suggests that by 2099, 50% of ice will be lost relative to 2005. RCP 8.5 suggests that by 2099, 92% of ice will be lost relative to 2005.

12. UK Climate Resilience Programme, 'Products of the UK-SSPS Project'.[89]

    This webpage gives an overview of the various products of the UK-SSPS project, including: UK-SSP narratives & systems diagrams, semi-quantitative trends, quantified projections, interface for exploring and accessing UK-SSP products, and other relevant publications.

13. Frame, B., et al., *Adapting global shared socio-economic pathways for national and local scenarios.*[90]

    This report explains how 'socio-economic scenarios enable us to understand the extent to which global-, national- and local-scale societal developments can influence the nature and severity of climate change risks and response options'.

14. Cradock-Henry, N., et al., *Dynamic adaptive pathways in downscaled climate change scenarios.*[91]

    This report observes how parallel scenario process enables characterisation of climate-related risks and response options to climate change under different socioeconomic futures and development prospects.

    The authors discuss 'the need for a stronger recognition of such national-scale characteristics to make climate change scenarios more relevant at the national and local scale, and propose ways to enrich the scenario architecture with locally relevant details that enhance salience, legitimacy, and credibility for stakeholders'.

15. Te tai pari o Aotearoa, 'Future sea level rise around New Zealand's dynamic coastline'.[92]

    The article was written for a 'general' audience and offers an example of the type of information we aim to produce for all of the coastline around Aotearoa.

Endnotes

1 See Colin, A., et al. (November 2019). *Understanding transition scenarios: Eight steps for reading and interpreting these scenarios.* Institute for Climate Economics, p. 56. Retrieved 14 December 2021 from https://www.i4ce.org/download/understanding-transition-scenarios-eight-steps-for-reading-and-november-2019-interpreting-these-scenarios

2 See Mullan, B., et al. (May 2008). *Climate Change Effects and Impacts Assessment: A Guidance Manual for Local Government in New Zealand, 2nd Edition*. Ministry for the Environment, Wellington, p. 110. Retrieved 14 December 2021 from https://environment.govt.nz/publications/climate-change-effects-and-impacts-assessment-a-guidance-manual-for-local-government-in-new-zealand

3 See Ministry for the Environment (MfE). (2018). *Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from the IPCC Fifth Assessment, 2nd Edition*. Ministry for the Environment, Wellington, p. 126. Retrieved 14 December 2021 from https://environment.govt.nz/publications/climate-change-projections-for-new-zealand

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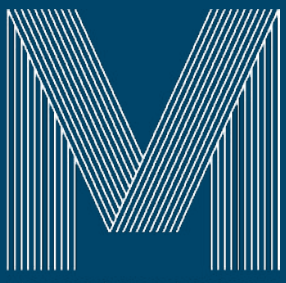

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