



## Four propositions to narrow the gap between science and policy for climate change adaptation: Insights and evidence from Aotearoa New Zealand

Angela Halliday<sup>a,\*</sup> , Joanna Fountain<sup>a</sup> , Anita Wreford<sup>a</sup> , Nicholas A. Cradock-Henry<sup>b</sup> 

<sup>a</sup> Faculty of Environment, Society and Design, Lincoln University, PO Box 85084, Ellesmere Junction Road, Lincoln 7647, New Zealand

<sup>b</sup> Earth Sciences New Zealand, PO Box 30-368, Lower Hutt 5040, New Zealand

### ARTICLE INFO

#### Keywords:

Decision-making  
Governance  
Research uptake  
Science-policy interface  
Uncertainty

### ABSTRACT

The scale and complexity of global challenges and the growing pressure on researchers to demonstrate ‘impact’, has prompted considerable investigation into the relationship between science, policy and decision-making. This is especially evident in the field of climate change adaptation, which is characterised by policy relevance, deep uncertainty, and diverse stakeholders, contributing to a highly complex policy and planning landscape. This paper seeks to contribute to the science to policy interface literature by presenting results from case study analysis in Aotearoa New Zealand. In-depth, semi-structured interviews ( $n = 23$ ) with policy practitioners and individuals in related roles and organisations, were used to elicit information about barriers and enablers to research uptake and implementation. Thematic analysis yielded four foundational propositions: Strong relationships enable research to inform policy and decision-making; Interpretations of uncertainty hamper policy-making for adaptation; Competing timeframes and priorities hinder research uptake; and Funding priorities affect research uptake and policy outcomes.

Collectively, these propositions highlight the need to strengthen collaboration between researchers and policymakers by building trust, fostering mutual understanding, and establishing feedback loops between individuals in their respective domains, supported by knowledge translators. The findings have international relevance and utility and can inform the design and evaluation of mission-led science that addresses the complex challenge of climate change adaptation, with an emphasis on enhancing transparency and trust between policymakers and researchers.

### 1. Introduction

Climate change presents growing risks to the health and wellbeing of people and the planet. Adaptation will be required to reduce risk and realise opportunities (Leal Filho, 2024). However, there is a persistent gap between understanding the scale and scope of climate-related risk, and implementing adaptation actions to reduce it (CCC, 2024; Chen et al., 2016; Glavovic et al., 2022; IPCC, 2022; Malik and Ford, 2024). This arises, in part, from the inherent complexity of the adaptation challenge, the needs of policymakers, and the competing priorities and pressures faced by researchers (Arteaga et al., 2023; Eakin and Patt, 2011; Rickards et al., 2024).

Effective governance requires policy-makers to look ahead, set clear priorities, and develop strategies grounded in robust evidence to tackle today’s challenges (Boston, 2017). While linking science and policy may

seem straightforward in theory, it is often far more complex in practice. Evidence and analysis can help define the strengths, weaknesses and unintended consequences of different options. However, complex issues raise the political stakes and introduce dynamics such as uncertainty and competing values, which shape the role of science and research in policy and decision-making (Pielke, 2007).

The complex landscape of climate change adaptation provides fertile ground for studying this science-policy interface. Adaptation aims to reduce vulnerability to current or anticipated impacts of climate change, including extreme weather events, sea-level rise, biodiversity loss, and food and water insecurity (UNDP, 2024). Adaptation must account for multiple factors, including model and decision uncertainty, non-linearity and systemic inertia, which complicate the policy and decision-making context (Colloff et al., 2017; Mach and Kraan, 2021; Stirling, 2010). Consequently, adaptation knowledge production crosses

\* Corresponding author.

E-mail addresses: [angela@cultivatelogic.co.nz](mailto:angela@cultivatelogic.co.nz) (A. Halliday), [Joanna.Fountain@lincoln.ac.nz](mailto:Joanna.Fountain@lincoln.ac.nz) (J. Fountain), [Anita.Wreford@lincoln.ac.nz](mailto:Anita.Wreford@lincoln.ac.nz) (A. Wreford), [n.cradock-henry@gns.cri.nz](mailto:n.cradock-henry@gns.cri.nz) (N.A. Cradock-Henry).

<https://doi.org/10.1016/j.envsci.2025.104239>

Received 10 June 2025; Received in revised form 2 October 2025; Accepted 2 October 2025

Available online 10 October 2025

1462-9011/© 2025 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

traditional disciplinary boundaries and draws on expertise from diverse domains. This landscape is shaped by multiple, often conflicting drivers and stakeholders, alongside a growing recognition of its importance for effective climate change management.

In this paper, we focus on the science-policy context in Aotearoa New Zealand (Aotearoa NZ), where adaptation science and policy have emerged as growing priorities in recent years, following an established focus on mitigation (Cradock-Henry et al., 2019; Lawrence et al., 2025). Drawing on interviews with policy practitioners, the study examines how science is, or is not, incorporated into policy and decision-making processes. To identify barriers to the uptake of adaptation research and explore ways these barriers might be overcome, the study was guided by the following questions:

- What is the current context for policy development and decision-making and the use of research for climate change adaptation policy in Aotearoa NZ?
- How, and to what extent, is climate change adaptation research used to inform policy development and decision-making? and
- What are the barriers to using adaptation research effectively, and the enablers that could address these?

Our findings reveal a rapidly evolving research and policy landscape, driven by recent extreme weather events, an increased awareness and sensitivity to climate change and changing science investment priorities. To address these challenges, we develop and describe four propositions designed to guide future research and support stakeholder engagement and relationships essential to the development and uptake of policy-relevant science. We begin with a review of the literature on the science-policy interface, focussing on values and uncertainty.

### 1.1. Science, policy and decision-making

The relationship between science and policy has received significant attention from scholars in recent decades, driven in part by the increasing scale and scope of the environmental, social, climatic and economic challenges for governance and decision-making (Boston, 2017; Gluckman et al., 2021; Guntzburger and Hadengue, 2025; Jagannathan et al., 2023; Moure et al., 2023). The traditional knowledge pipeline assumes a linear, one-way knowledge transfer from scientific experts to policymakers (Cash et al., 2006; Rogga, 2021). This model has been widely critiqued for oversimplifying the complex, non-linear, and iterative nature of science-to-policy interactions (Cash et al., 2006; Landry et al., 2001; Morgan and Di Giulio, 2018). In its place, scholars have advanced a more nuanced understanding of the science-policy interface, conceptualised as a dynamic, networked space involving multiple actors and feedback loops (Kasperson, 2011). Within this evolving perspective, the concept of 'post-normal' science has emerged, emphasising the importance of uncertainty, value pluralism, and stakeholder engagement (Funtowicz and Ravetz, 1993). Post-normal science has however been criticised for lacking consideration of important governance of problems such as participatory and deliberative democracy (Wesselink and Hoppe, 2011). Building on these insights, (Jasanoff, 2007) argues for 'technologies of humility,' approaches that explicitly recognise uncertainty, value conflicts, and the limits of scientific knowledge in decision-making, highlighting the need for more reflexive and inclusive knowledge practices.

Consequently, co-production and participatory, iterative approaches have gained traction as more effective and responsive alternatives to traditional models of knowledge transfer between research and decision-making (Dilling and Lemos, 2011; Feldman and Ingram, 2009). Co-production is founded on the premise that scientific expertise alone is insufficient to address complex problems and that stakeholder contributions are vital to create knowledge that is both scientifically credible and socially robust. At the same time, co-production is a contested concept: definitions and interpretations vary across disciplines, evidence

on the opportunity costs relative to knowledge use is limited, and there are potential risks, such as privileging familiarity over uncertainty or reinforcing uneven power dynamics that can lead to inequitable outcomes (Durose et al., 2022; Lemos et al., 2018; Turnhout et al., 2020; Wesselink and Hoppe, 2011).

Post-normal science frames scientific practice under conditions of uncertainty, contested values, and urgent decision-making (Funtowicz and Ravetz, 1993; Wesselink and Hoppe, 2011), emphasising the need to broaden what counts as relevant knowledge. Co-production, through its participatory and collaborative processes that aim to integrate different ways of knowing to develop knowledge and contribute to effective solutions for society (Turnhout et al., 2020), can offer a mechanism to bridge science and policy in a post-normal context. Co-production and post-normal science both challenge the traditional linear model of science-policy interaction. Post-normal science primarily offers a diagnostic lens, whereas co-production focuses on the processes of engagement and knowledge production to address complex problems.

Interactions between science and policy are shaped by different values, drivers and operating contexts (Bradshaw and Borchers, 2000). While these differences can sometimes create disconnects, they can also foster complementarities and innovative approaches when effectively managed (Cvitanovic and Hobday, 2018). Government processes are often driven by the need for certainty, rapid decision-making and public accountability. As a result, policymakers and decision-makers are often less tolerant of failure and more wary of new innovations. In contrast, science tends to be more anticipatory and problem-orientated, often accepting uncertainty, complexity and a lack of immediate end users. These differences create tensions particularly around the speed-quality trade-off, where policy demands timely input but rigorous scientific processes require time (Sarkki et al., 2014). Various mechanisms have been proposed to bridge these gaps including the use of knowledge brokers<sup>1</sup> (Gluckman et al., 2021), embedded science advisors (Gluckman, 2017), boundary organisations<sup>2</sup> (Guston, 2001; Lemos et al., 2012; Lidskog, 2014), cross-disciplinary research (Aitsi-Selmi et al., 2016), and participatory co-creation approaches (Barton et al., 2020; Hochrainer-Stigler et al., 2024; Meinke et al., 2006; Morgan and Di Giulio, 2018).

Underlying these mechanisms is the significant influence of values, which shape research priorities, policy development, and decision-making processes (Heazle, 2010; Jasanoff, 2003; Locatelli et al., 2022; Pulkkinen et al., 2022). Climate change policy illustrates how values can shape decisions, sometimes overriding scientific evidence or using contradictory science to support ideological debates (Gluckman, 2013; Hulme, 2018). The assumed link between knowledge and action has been questioned, with scholars highlighting political and cultural barriers that impede climate action, despite overwhelming scientific consensus (Cologna and Oreskes, 2022; Morgan and Di Giulio, 2018). The values embedded in science itself influence knowledge production, from framing research questions to evaluating models and translating findings into policy (Gluckman et al., 2021; Pulkkinen et al., 2022). Calls for post-normal science recognise the need for diverse perspectives (Funtowicz and Ravetz, 1993), particularly in contested areas such as adaptation. Here, integrating traditional ecological, indigenous or local knowledge alongside Western science is crucial (IPCC, 2023; Taylor et al., 2023). Transformational research and participatory approaches that acknowledge the legacies of colonisation and support decolonisation are increasingly advocated to promote inclusive and effective adaptation policies (Taylor et al., 2023). In Aotearoa NZ, for example, mātauranga Māori offers valuable insights for climate adaptation,

<sup>1</sup> . 'Knowledge brokers are people or organisations that move knowledge around and create connections between researchers and their various audiences' (Meyer, 2010, p. 118).

<sup>2</sup> A boundary organisation is an entity that mediates between two different social 'worlds' typically science and politics (Guston, 2001).

supporting a more holistic, co-governance approach (Hikuroa, 2020; Ihirangi, 2022; Lawrence et al., 2022).

Trust is consistently recognised as a vital component of effective knowledge exchange, particularly in contexts where multiple values, worldviews, and types of knowledge intersect (Cvitanovic et al., 2021; Hewitt et al., 2022; Lemos et al., 2012). Building on the recognition of values and inclusive, participatory approaches discussed above, trust enables collaboration between scientists, policymakers, and communities, supporting the legitimacy, relevance, and uptake of knowledge. However, there is limited guidance on how to build, maintain, or restore trust once it has been damaged (Boschetti et al., 2016). This is particularly important in climate change adaptation, where decisions must be made under high levels of uncertainty and divergent values (Wreford et al., 2020). Traditional planning systems, which assume predictable outcomes, often struggle with such uncertainty, sometimes leading to decision paralysis and creating barriers to adaptation (Morgan and Di Giulio, 2018). A recent systematic review of the intersecting literature on climate change adaptation and uncertainty found that decision-makers are increasingly willing to work with uncertainty rather than delay action (Moure et al., 2023). While some scholars emphasise improving climate models to reduce uncertainty (Shukla et al., 2009), others advocate for adopting more flexible, scenario-based, and robust decision-making frameworks that explicitly embrace it (Aall and Groven, 2022; Lemos and Rood, 2010; Wilby and Dessai, 2010).

## 2. Study setting and methods

Aotearoa NZ is a small, developed economy located in the south-western Pacific. As an island nation, with varied topography and a largely maritime climate, climate change poses significant risks to coastal communities, infrastructure and lifelines with an estimated exposure of NZD\$6.05 billion (USD \$3.5 billion) worth of buildings (replacement value), 409 km of roads and one of its key airports vulnerable to coastal flooding with only 30 cm of sea level rise (Paulik et al., 2019). The country is highly urbanised, however the primary contributors to GDP, including international tourism and agriculture (primarily dairy farming), rely on natural assets, which are exposed to climate change impacts, with further implications for health and well-being (Boston, 2024; CCATWG, 2018; CCC, 2024; Lawrence et al., 2024). In 2023, the country experienced 18 weather-related states of emergency (NEMA, 2024). One of these was an ex-tropical cyclone affecting large areas of the North Island which cost private insurers over NZD \$1.7 billion (USD \$995 million) in claims to date (ICNZ, 2024), with the total cost likely to be exceeded only by the 2010/11 Canterbury earthquake sequence (MFAT, 2023). Such costly events highlight the urgent need for effective governance and proactive adaptation strategies to manage climate risks.

Governance is a critical ‘lever’ for addressing the challenges associated with climate change (IPCC, 2023), but Aotearoa NZ has faced criticism for reactive event-driven adaptation policies (Lawrence et al., 2022). Responsibilities for hazards and climate change adaptation are largely devolved to local government, while central government focuses primarily on mitigation (Archie et al., 2018; Lawrence et al., 2022; Reisinger et al., 2011). Recent policy developments, including the 2020 National Climate Change Risk Assessment (MfE, 2020) and the 2022 National Adaptation Plan (MfE, 2022), aim to strengthen long-term climate adaptation governance. Nonetheless, questions remain about how these strategies are implemented in practice, particularly in a context of overlapping jurisdictions, uneven capacities, and shifting political priorities.

To explore how these governance dynamics play out in practice, this study examined the science-policy interface for adaptation in Aotearoa NZ through in-depth, semi-structured interviews. Participant selection focused primarily on central and local government agencies, with initial participants identified through the authors’ extensive networks within the country’s relatively small adaptation planning community. This was

followed by snowball sampling, a recruitment technique in which current participants recommend others for interviews (Boeije, 2010).

Ethics approval was obtained in advance from Lincoln University (HEC2023-52). Thirty-eight people were approached via email to be involved in the study; 23 of whom agreed to an interview. Participants included those currently or recently employed by central government ( $n = 11$ ), Crown entities<sup>3</sup> or aligned organisations ( $n = 7$ ), local government ( $n = 3$ ) or as consultants ( $n = 2$ ). Participants’ policy-related experience ranged from several years to over two decades.

The interviews aimed to capture a snapshot of the issues present in the current environment, specifically focusing on the uptake of climate adaptation research. Questions were designed to explore participants’ perceptions of the role of science in policymaking, with an emphasis on identifying both barriers and enablers to the use of scientific knowledge in climate adaptation-related policy and decision-making. All interviews were conducted with participants’ permission, recorded, and subsequently transcribed. Following each interview, initial reflections and analytical insights were documented, allowing analysis to begin early, capturing emergent insights in the field, and maintaining close engagement with the data (Lofland, 2006).

The analysis was conducted using a thematic coding process informed by (Braun and Clarke, 2006, 2013) reflexive thematic analysis (TA) approach. Coding was undertaken manually by the researcher in an iterative flexible manner, allowing themes to emerge organically from the data. Both inductive and deductive techniques were employed: inductive coding captured ideas and patterns arising directly from participant responses, while deductive codes were used to reflect concepts from the literature and the study’s conceptual framework.

Key quotations were highlighted throughout to illustrate recurring perspectives, contrasts between participants, and concrete examples of challenges in climate adaptation policy-making. The coding process considered both semantic content (explicit participant statements) and latent meanings (underlying assumptions and framings). Themes were refined through repeated reading and reflection, with selected quotations providing insight into the complexity and diversity of the issues. The resulting themes offer an interpretive account of what shapes the use and uptake of research to climate change adaptation policy in Aotearoa NZ.

**Table 1**  
Decision domain / sector affiliation and job titles for participants.

Sector	Job Title
Central Govt (11)	Policy Analyst, Senior Advisor, Principal Policy Advisor, Principal Advisor, Senior Policy Analyst, Senior Policy Advisor, Policy Manager x 2, Scientist, former Central Government Senior Policy Advisor, former Central Government Principal Advisor
Crown entity, Independent crown entity or Crown aligned organisation (7)	Principal Advisor, Manager x3, Research Manager, Senior Research Officer, Lead Advisor
Local Government (3)	Manager, Principal Strategic Advisor, Senior Analyst and Policy Advisor
Consultancy (2)	Consultant for local and central government, Policy Director – consultancy

<sup>3</sup> Crown entities are publicly funded organisations established by the government of Aotearoa NZ to carry out specific functions, often with a degree of operational independence from direct ministerial control (e.g., research institutes, regulatory bodies).

2.1. Limitations

This research was conducted during an election period marked by contrasting social and political perspectives. These contextual factors should be considered when interpreting the findings. The situation for participants was not ‘business as usual,’ as there was evident nervousness regarding impending changes in political priorities and direction. Interviews also took place after two major extreme weather events. Some reflections were directly influenced by these events and the rapid policy responses that followed, rather than reflecting a more holistic perspective of the policy development process that may have existed prior to these events.

It is also important to acknowledge the potential influence of the primary researcher on both data collection and analysis. In qualitative research, the researcher is the primary instrument, and their positionality, experiences and decisions inevitably shape the outcomes (Babbie, 2021; Mills and Birks, 2014). In this study, the researcher’s role as an ‘insider’, with previous work experience and relationships in the field, may have facilitated rapport and access to participants, but could also have influenced what respondents chose to share (Kerstetter, 2012; Lofland, 2006). To mitigate this potential bias, participants were offered the opportunity to review their transcripts, although most declined. Quotations used in the study were also double-checked with participants. While the researcher’s prior experience and perspective may have introduced bias, strategies such as asking basic, open-ended questions and allowing space for participants’ responses were employed to reduce this influence (Hitchings, 2012). Investigator triangulation between the primary researcher and the research team also added to the credibility and trustworthiness of the study (Denzin, 2017). Key themes and patterns emerging from the data were discussed and refined at each stage of the data collection and analysis process.

Additional limitations relate to sampling and participation, themselves influenced by some of the factors raised above. Recruitment largely relied on the authors’ professional networks and snowballing, which may have constrained the diversity of perspectives included. Furthermore, most interviews were conducted online, which can limit participation for those with restricted digital access and influence the dynamics of interaction compared with in-person settings. Ultimately, while the primary researcher’s insider position may have shaped data collection and interpretation, it also provided valuable insights into the complexities of the interface between climate adaptation research and policy.

3. Results and Discussion

The interviews highlighted diverse perspectives on how climate adaptation research informs policy in Aotearoa NZ. Participants’ responses reflected the pervasive impacts of climate change, the challenges of planning under future climate uncertainty, and the various factors that influence the uptake of scientific knowledge in decision-making. The role of research in informing policy at local, regional, and national levels is unclear and contested. Responsibilities shift with government restructures, changing priorities following extreme weather events, and the need to balance adaptation with climate mitigation at the national level. The interviews were conducted against a backdrop of a changing political environment, highlighted by a wave of public sector redundancies following a change in leadership, which concerned many participants. This was followed by shifts in funding structures for research institutions in Aotearoa NZ, leaving many researchers uncertain about their job security under the newly proposed arrangements. This context is important because effective engagement at the research–policy interface requires a stable foundation, enabling both researchers and policy practitioners to anticipate challenges and address the complex issues inherent in climate change adaptation, a task made more difficult when the structures within which they work are constantly in flux.

Table 2 outlines some of the key tensions discussed during the interviews, including a shared discomfort with the use of climate change adaptation research in decision-making contexts due to the inherent uncertainties involved. The propositions outlined in the first column are discussed in more detail below.

3.1. The role of research in policy

Interviewees highlighted the central role of research in shaping climate adaptation policy across Aotearoa NZ, emphasising the need for evidence that is both relevant and actionable. They consistently noted that research must not only identify climate risks but also demonstrate their significance and implications for decision-making. For research to be valuable for policy, it must answer the “so what?” question by providing clear evidence and quantifiable impacts. As one senior research officer from a Crown entity explained:

“It’s why the science, research, data becomes so important .... The more certainty you can provide, the more evidence the more

Table 2  
Research/Policy tensions.

Proposition	Research	Tension/result	Policy
Strong relationships enable research to inform policy and decision-making.	Tends to communicate after research completion; co-development seen as a barrier.	Institutional and individual disconnects, reduce research impact in policy.	Limited time for direct engagement with researchers; turnover affects continuity.
Interpretations of uncertainty hamper policy-making for adaptation.	Uses technical language and complex statistics. Challenges with communicating uncertainty. Acknowledges uncertainty; climate models offer multiple scenarios.	Ineffective communication between researchers and policymakers. Mutual discomfort with uncertainty in decision-making contexts.	Requires well translated, understandable actionable information from research. Prefers deterministic clear-cut data for decision justification.
Competing timeframes and priorities impact research uptake.	Operates under specific project timelines determined through funding, effect of changing political drivers lags due to funding processes. Long research timeframes complicated by publication and peer review process. Acknowledges long-term uncertain impacts of climate change.	Disconnect due to lack of mutual understanding of operational environments/ drivers. Disconnect in timeframes leads to underutilised or outdated evidence informing policy.	Operates in a dynamic political landscape with shifting priorities. Short pressured policy development timeframes.
Funding priorities affect research uptake and policy outcomes.	Influenced by academic or commercial drivers such as publication demands. Prefers strategic, mission-led funding independent of political influence.	Limited implementation of comprehensive long-term strategies; reactive policy-making. Research outcomes may not align with policy needs. Inconsistent funding and support for climate adaptation research.	Focuses on short-term quantifiable outcomes; reactive post-extreme weather events. Driven by political, social and economic factors. Funding priorities change with decisionmakers priorities.

quantifying of the situation ..... That is what speaks to the policy profession .... they are going to ask, for what? Why should we do this? What's the evidence?"

Most participants viewed scientific research as essential for informing ministers and decision-makers, particularly in defining problems, providing context, and outlining potential policy options. As a principal advisor for a Crown entity noted, research plays a crucial role at three key stages of policymaking: "*science should have a role in policy development, in the policy implementation, and in the evaluation of that policy.*" This importance of evidence was reinforced by a consultant working with both central and local government: "*It's so important. It underpins everything we do.*" A central government policy analyst echoed this view: "*Without those insights ... how do we know that the policy is ever going to be effective in driving the change that we need?*" However, a principal strategic advisor from local government cautioned that science is not always valued by decision-makers: "*I think science is not given the respect and the credibility it deserves; it's put aside in the guise of popularity and short-term decision-making.*"

While there was strong consensus on the value of research for informing evidence-based policymaking, several participants stressed that social science, and economic evidence more broadly, is essential for addressing the complexities and impacts of a changing climate. As one central government policy manager explained:

"Social science in my career in the public sector has emerged more and more strongly as something that needs to be considered when we do these things because, of course implementation, that's where the social science plays in."

Several insights emerged from the interviews regarding the use of research in climate adaptation policy. These have been synthesised into four key themes, or 'propositions,' outlined below. The first theme concerns itself with the importance of relationships, trust, and empathy at the interface between research and policy. This theme spans the entire research-to-policy process, highlighting where and when different actors interact and connect. It encompasses concepts such as post-normal science and co-production, while reinforcing the central role of evidence-based policy and decision-making.

The remaining propositions focus on the operational aspects of policy and decision-making. These include how policy can be hampered by interpretations of uncertainty, how competing timeframes influence the uptake of research, and how research funding can affect its influence on policy.

**Proposition 1.** : Strong relationships enable research to inform policy and decision-making.

Participants consistently emphasised that strong relationships between researchers and policymakers are crucial for enabling evidence-based policy. Trusting connections foster open conversations, allowing policymakers to raise difficult or politically sensitive questions without hesitation. A central government scientist described these connections as "*that old-fashioned human verbal transfer of knowledge,*" while a central government policy manager stressed that "*relationships underpin everything.*" These relationships were considered critical for raising awareness of research, enhancing trust, and improving accessibility and translation of findings across central and local government, crown entities and consultants.

Strong, trusting relationships between researchers and policymakers were considered essential for the uptake of research in policy. Aotearoa NZ's small research community was seen as both an advantage and a limitation to relationship building. As a local government manager explained: "*[Aotearoa] New Zealand's really small... if New Zealanders have been involved in that research or are working in that space, then [we] know about it.*" However, a central government scientist warned that this could lead to bottlenecks, as "*you can't talk to everyone because you're only one person.*" This reliance on a small pool of experts not only limits

access to knowledge but also increases the risk that structural changes or disruptions to relationships could significantly impede the flow of research into policy.

Participants acknowledged that while Aotearoa NZ's small size is conducive to close relationships and strong network connections, institutional silos, high staff turnover and limited cross-institutional engagement created barriers. Multiple participants identified institutional silos as a key barrier to research uptake. These silos exist not only between research and policy agencies but also across central government departments, between central and local government, and among Crown entities involved in different aspects of adaptation efforts. Additionally, silos were acknowledged between individual research agencies and among different government institutions responsible for various aspects of climate adaptation policy. This lack of alignment was often beyond individuals' control due to external factors such as time constraints and staff turnover, which led to a loss of institutional knowledge. Furthermore, limited understanding of others' roles, institutional drivers, and priorities created additional barriers, as outlined by a Senior Analyst and Policy Advisor for Local Government,

"I have often been surprised that when you sit down and have a conversation with the scientists about how local government operates, it is a bit of a surprise for them sometimes."

In addition, some researchers were perceived as having "tunnel vision", focusing solely on evidence without accounting for political or societal constraints. A manager from a Crown aligned organisation remarked, "*Anybody who's primarily in one [research or policy domain] is a bit rubbish at talking to the other one.*" A former central government senior policy advisor suggested that hiring practices in government might contribute to the gap, explaining, "*People don't get hired to make decisions in public policy because of research skills. They get hired because they can deliver work programmes and manage people.*"

Policymakers' primary responsibility is to deliver on ministerial priorities. As one central government policy manager explained: "*We're not always looking at the broader picture... society has spoken – it wants these people to make decisions.*" This illustrates a key tension: researchers often take a long-term, evidence-based perspective, while policymakers must respond to immediate political mandates. As a principal advisor for central government noted: "*Scientists might come up with brilliant stuff, but you think, well, that's just not implementable. Basically, it's not politically palatable.*"

Participants identified several strategies to overcome these barriers. Some viewed early involvement in research development as beneficial, to ensure alignment with policy needs. A lead advisor for a Crown entity explained: "*It's most useful getting involved at the front end so that we can say 'yes, this is something that looks like it could get traction and be useful.'*" However, it was acknowledged that central government policymakers often lacked capacity to engage in co-development. Others questioned the effectiveness of co-development, citing resource constraints and inefficiencies. As one central government principal advisor noted, co-development involved "*a lot of resource and wasted time rather than getting on with it.*" This perspective may reflect an underlying preference for a more linear model of science-to-policy, given the time and effort required for relationship building and active involvement in the research process. The tension between the ideal approach to policymaking and the more pragmatic, constrained reality, shaped by tight timeframes, limited information, and political pressures, was evident throughout the interviews and is discussed further below.

Many participants emphasised the need for stronger mutual understanding between researchers and policymakers, although acknowledging that a certain level of mutual awareness between research and policy was evident, likely reflecting the relatively small climate change adaptation communities in Aotearoa NZ, and the fact that some participants had transitioned from science into policy.

Policymakers noted that researchers often lacked awareness of the external pressures shaping policy, including political will, social licence,

and the practical challenges of implementation. As one central government policy manager observed, *“sometimes there isn't the understanding from the science community around the other tensions that have to be considered for policy.”* Participants suggested that more structured knowledge-sharing mechanisms could enhance collaboration and improve the integration of scientific research into policy, particularly in the context of climate change adaptation.

Staff turnover also emerged as a significant challenge, disrupting relationships and causing a loss of institutional memory. At the same time, career and role mobility can be beneficial, fostering awareness, understanding, and empathy for the pressures, drivers, and contexts faced by people across different agencies and roles.

A central government policy analyst shared an example of critical modelling data being overlooked because new staff were unaware of its existence. Turnover in Aotearoa NZ's public sector increased by 14 % between 2020 and 2021, driven by wage freezes and staff movement between agencies (Williams, 2022). More recently, job cuts in central government have raised concerns about further knowledge loss, with nearly 6000 roles eliminated as of June 2024 (McConnell, 2024). A central government senior advisor warned: *“If either of those people [researchers or policymakers] leave that position, then that relationship is broken... you lose knowledge.”* To counteract this, a central government senior policy advisor noted: *“I would rely on someone who's been in that area a long time, who knows the right person to go to for research.”* However, ongoing staff reductions may undermine this strategy, further complicating science-policy integration.

To improve research translation and communication, participants suggested that knowledge brokering, boundary organisations, and structured knowledge networks could be valuable tools. These suggestions reinforce evidence and claims made in the literature (Aitsi-Selmi et al., 2016; Feldman and Ingram, 2009; Gluckman et al., 2021; Guston, 2001; Lemos et al., 2012; Lidskog, 2014). Some called for greater participation of policymakers in setting research priorities to ensure relevance to policy needs. Others stressed the importance of increasing researchers' understanding of political and operational constraints. A senior analyst and policy advisor from local government explained: *“A lot of it just comes down to understanding how the two institutions work and shaping something up that is fit for purpose”*. Each of these approaches has its strengths and limitations (Karcher et al., 2024). In the Aotearoa NZ context, structured networks such as the newly established Aotearoa Society of Adaptation Professionals (ASAP, 2025) may be particularly relevant. ASAP seeks to connect dispersed expertise through a national practitioner community, while retaining flexibility to respond to locally determined priorities. While boundary organisations and brokers remain valuable, especially for building trust and navigating institutional differences, networks may provide the most scalable and enduring benefits (Muccione et al., 2019; Schneider et al., 2021).

**Proposition 2.** : Interpretations of uncertainty hamper policy-making for adaptation.

While it is widely accepted that climate change adaptation requires policy action, participants noted that uncertainty in climate scenarios can create confusion and challenges. One consultant working with both central and local government explained: *“Yeah ... there is a lot of grey area. And science is never black and white. People find it hard to understand—statistics and probability [are] extremely difficult to grasp for anyone.”* This difficulty in interpreting uncertainty was seen as a barrier for policymakers, who often seek certainty to justify their decisions. As a central government policy analyst reflected: *“I feel like I spent years mulling over uncertainty and I still don't necessarily feel comfortable with it.”*

Another challenge is that current economic and financial models often rely on deterministic assumptions that fail to accommodate the unpredictable nature of climate change. As this manager from a Crown aligned organisation explained: *“Climate is just one of many volatile uncertain drivers which are questioning all of those assumptions and making it more difficult for organisations to rest on their laurels about being*

*deterministic.”* Several participants noted that the uncertainty inherent in climate science can limit its usefulness for policy-making. They also observed the concern researchers had that this uncertainty might lead to their work being dismissed, leading to caution as to how they talk about their science, as a research manager from a Crown entity explained: *“when science involves so much uncertainty that I think [researchers] get worried that the uncertainty is going to be ignored .... because it's too hard to communicate.”*

Another tension between science and policy lies in how uncertainty is managed in decision-making. Policy professionals often seek clear, definitive guidance to minimise uncertainty and enable confident decisions. Several participants highlighted political risk aversion as a barrier to action, noting that it is closely tied to how decisions may affect the electorate. This point was summarised by a senior research officer at a Crown entity: *“I think it's just about burden of proof, and councils always talk about needing to have you know, 98 % certainty or whatever. They're not going to decide based on a 'maybe'...”* Policymakers expressed concern that uncertainty could lead to their decisions being questioned or challenged. They also acknowledged that policy settings need to vary according to the level of uncertainty, particularly when imposing limits on development, as explained by a senior analyst and policy advisor from local government: *“So, the policy settings will vary depending on the degree of certainty .... the amount you might constrain the developments with your policy and rule setting will vary on that.”* According to one Crown entity manager: *“You don't want to admit that you might be wrong. You don't want to admit that it could lead to failure.”* By contrast, researchers are typically reluctant to provide guidance without acknowledging the limitations and uncertainties inherent in their findings. Many participants raised managed retreat as an illustrative example of climate adaptation. Relocating communities away from vulnerable areas demands a high degree of certainty to justify decisions that affect property rights and require a robust legal foundation. Such decisions also carry far-reaching implications for insurance, compensation responsibilities, and the legal standing of both local councils and central government.

Several participants highlighted the need for clear and consistent national-level guidance, to aid local councils in navigating decision-making uncertainty. The presence of multiple (and at times, commercially competing) approaches, together with the related model uncertainty was, in the words of one participant, *“pretty wild west at the moment... There's a lot of providers who are giving a lot of different projections and ensemble modelling.”* For policy professionals with a scientific background, this gap in national direction was a particular source of frustration and anxiety. *“It's not good enough to just have slightly opened outcomes”*, said one senior analyst and local government policy advisor, *“You need to have specific lines in the sand.”* Yet achieving this level of clarity is not straight forward. Integrating climate impact models into local policy decisions was described as particularly challenging especially when assessing future flood risk. Participants noted that inconsistencies between models complicate the development of nationally coherent policies, even as they acknowledged the limitations of applying a uniform approach across Aotearoa NZ's diverse regions. As one central government scientist observed: *“If you do a model for all of New Zealand, it'll be overestimating [climate attributes like heat or rainfall] for some areas and underestimating for others.”* This inherent spatial variability makes it difficult to craft national-level policies, even when those policies are intended as flexible guidelines rather than rigid, numerically based directives.

Calls for stronger national guidance often reflected the difficulties local councils face when making decisions about development in high-risk areas. With each council left to assessing applications independently, often on limited budgets they must rely on scientific evidence that carries inherent uncertainties. This creates costly case-by-case disputes, which consistent national guidance could help avoid. As one consultant explained: *“We're tearing our hair out at the local level, just going, ‘Oh my God... they're going to build that thing over there.’ It's happening all around us, all the time.”*

Some participants, particularly from central government argued that uncertainty need not prevent action, provided it is clearly embedded into policy. “*Good research should definitely cover what the uncertainties and assumptions are,*” explained one central government policy manager. This viewpoint reflects a growing recognition of the need to incorporate uncertainties into policy rather than delaying action (Moure et al., 2023). Doing so however challenges traditional planning systems which assume certainty in outcomes (Kiem et al., 2014; Lawrence and Saunders, 2017), and embracing non-stationarity (Milly et al., 2008). In reality even the best models cannot offer certainty (Ben-Yami et al., 2024), and the expectation of unambiguous data is unrealistic (Janzwood, 2023; Workman et al., 2020). There has been some criticism in the literature regarding the naivety by which climate model outputs are treated as facts and used directly to shape policies (Workman et al., 2020). Yet the persistence of uncertainty continues to foster a risk-averse environment where neither researchers nor policymakers feel comfortable using science in policy and planning (Jebeile and Roussos, 2023).

Findings from these participant interviews and subsequent analysis highlight some potential benefits in greater involvement of knowledge brokers or boundary-spanning experts to support policymakers in interpreting complex data that includes significant uncertainties. Knowledge brokers are particularly valuable because they help translate scientific evidence into policy-relevant insights, build trust between actors and ensure that diverse forms of knowledge are incorporated into decision-making (Cvitanovic et al., 2025). By mediating across institutional and disciplinary boundaries, they can reduce transaction costs for both researchers and policymakers, making engagement more efficient and impactful. Institutions such as Scotland’s ClimateXChange provides an exemplar of these functions, linking research and policy through structured knowledge exchange, and could provide a useful template for Aotearoa NZ (Wreford et al., 2019).

**Proposition 3.** : Competing timeframes and priorities hinder research uptake.

While Proposition 2 highlighted the role of individual knowledge brokers in facilitating understanding of complex and uncertain data, Proposition 3 considers how institutional arrangements can systematically support research translation, balance trade-offs, and maintain credibility and legitimacy.

The limited alignment between research and policy timeframes, particularly in relation to the pressures of election and policy cycles, was frequently cited as a barrier to the consistency and prioritisation of both research and policy efforts. Science and research generally have much longer timelines, potentially leading to the policy being developed without the benefit of research insights; as a Crown entity principal advisor remarked, “*policy is going to be all done and dusted before the research has a chance to be aligned and delivered*”. Similarly, research findings can become outdated by the time they are communicated; a tension highlighted by a central government policy manager: “*Look, research takes time ... you can’t rush it, but we are in a rush for all the other stuff.*”

Aotearoa NZ’s three-year election cycle was described as problematic for developing enduring evidence-based policies due to changing government priorities; “*We go through a switch of government, all of a sudden our priorities are chucked up in the air,*” said one policy analyst. This issue is particularly significant given the long-term nature of climate change adaptation contrasted with the short-term focus and goals of governments. As a former central government principal advisor noted, “*Adaptation is a long-term problem, and potentially changing course every three years, by definition, is misaligned.*” This challenge is not unique to climate change; many long-term issues face similar struggles with political cycles. A central government senior policy advisor acknowledged, “*We’ve got plenty of long-term issues that butt up against political cycles.*” A suggested solution is to develop bipartisan support for adaptation to ensure continuity across election cycles.

Several participants acknowledged that tight policy deadlines could

compromise research quality, running the risk of ill-informed policy decisions. Deadline pressures often limit policymakers’ ability to fully digest and understand available research, particularly on complex topics like climate change adaptation. While these pressures are unlikely to diminish, strategies such as aligning research timelines with policy calendars and providing preliminary research outputs could help mitigate the impact of mismatched timeframes and improve the integration of scientific evidence into policy decisions. As a central government policy manager explained, “*If there’s an opportunity to look at how you might stage some of that research so that you get initial results that you can start feeding into policy, that could be really helpful, because you get a steer on the direction things are headed.*” A central government policy advisor also outlined the importance of having a feedback loop between policymakers and researchers – and the frustration when this did not exist:

“I think at the moment, when you’ve got a short-term bit of policy work ... that feedback loop doesn’t happen. You just have to rely on what you’ve got. I imagine researchers find it really frustrating going to policy people and saying, ‘What can I do that will help inform this?’ We’re like, ‘we don’t know, we haven’t thought about that. We’ll come to you and demand that urgently at some point.’”

Addressing these issues would likely necessitate trade-offs between research time and quality, and between credibility and legitimacy of outputs, especially if findings are rushed for early dissemination (Sarkki et al., 2014). Some participants suggested establishing a non-partisan, dedicated adaptation research centre to consolidate expertise and foster collaboration. Such an initiative might help combat the poor alignment between science and policy, develop a strategic view of research needs and priorities and provide a one-stop shop for community engagement, ensuring policy relevance and scientific, mission-led credibility.

In practice, such a centre could draw on illustrative models like Scotland’s ClimateXChange (Wreford et al., 2019) or the Centre of Expertise for Waters (CREW) (Ferrier et al., 2022). In Aotearoa NZ, potential exemplars already exist, primarily focused on earthquake and seismic hazards. For example, QuakeCORE – a Centre for Research Excellence – and Project AF8 combine boundary-spanning functions with capability and capacity building, but are time-limited and must periodically seek additional funding (Barton et al., 2020; Fox and Keen, 2022; Orchiston et al., 2018). Embedding knowledge brokers or intermediary roles within a more permanent, adaptation-focused centre could further support balancing trade-offs by facilitating timely translation while safeguarding credibility and legitimacy.

**Proposition 4.** : Funding priorities affect research uptake and policy outcomes.

The final proposition highlights how views on research priorities and funding vary significantly depending on participants’ familiarity with the funding process, underscoring difficulties in aligning research with policy needs. Policy professionals without a science background described the funding landscape as complex and opaque, often noting their limited or absent involvement in funding decisions. As a policy director in a consultancy explained: “*If the ultimate users of the research, like a policy person, isn’t informing the decision-making about what’s funded, then to me, that seems like you’re going to get research that’s less policy relevant.*” The importance of strong relationships in bridging this gap was again emphasised by a central government policy manager:

“I think it’s really important that we understand what researchers are saying are the priority areas for investment, but there’s that feedback loop, of what do we need to make evidence-based policy, and being able to have some influence on the system.”

However, achieving this alignment is challenging, as funding priorities often differ. A principal advisor for central government noted: “*It’s always driven by people’s perceptions..... it’s got to be a thing that’s driven by the best and smartest people getting together and a number of them*

covering different aspects of it to get the right balance.”

Participants also highlighted that Aotearoa NZ’s competitive and constrained research funding environment complicates efforts in climate change adaptation, stressing the need for a balanced and comprehensive approach to prioritising research funding, ensuring that studies addressing real-world adaptation challenges are not overlooked.

To address this, participants suggested the need for a national strategy to ensure consistent, stable and co-ordinated research funding which would allow researchers to focus on high impact climate adaptation research. In the absence of such a mechanism, a senior policy advisor for central government believed that government departments would revert to pursuing their own agendas, compounding knowledge gaps and redundancies. Similarly, a local government manager argued that contestable funding hinders longer-term climate change adaptation research: “If we had enduring funding, I think that would probably largely solve that problem because it’s just bid, bid, bid, proposal, proposal, proposal.”

These differing views on funding adaptation research reflect the complexity of both the funding landscape and the nature of climate change adaptation itself. The potential role of policymakers in prioritising funding to align with policy goals was emphasised, along with the need for closer collaboration between researchers and practitioners to ensure research addresses local needs. However, some participants were sceptical about co-developing projects through transdisciplinary approaches and embracing post-normal science. They questioned the value of these methods given the significant costs, time, and effort required to make them successful. Critics also pointed to a lack of clear examples where such approaches have worked well in practice, particularly in the context of climate change adaptation. In general, co-development was viewed as aspirational but not practical, given already busy schedules. Further work may be warranted to determine if this scepticism is specific to climate change adaptation science in Aotearoa NZ or applies to other complex value-laden issues in research and policy in other contexts.

Some participants cautioned that closely aligning research funding priorities with political agendas may hinder adaptation efforts due to the rapid shifts in political focus. However, they also acknowledged the potential benefits of involving policymakers in co-developing research questions, even though this approach may not always be practical. These findings highlight the central role of funding structures in shaping the science-policy interface. Competitive and short-term funding models can undermine research continuity and relevance, particularly for long-term challenges such as climate change (cf. Gluckman, 2018; Sarkki et al., 2014). International experience suggests that more coordinated strategies, including dedicated adaptation research centres or long-term mission-led programmes, can help reconcile policy relevance with scientific independence (Pitt et al., 2018). While closer involvement of policymakers in setting priorities may increase uptake, safeguards are needed to avoid capture by short-term political agendas. Ultimately, funding mechanisms that combine stability, inclusiveness, and transparency are likely to be most effective in supporting credible and policy-relevant climate adaptation research (Thompson et al., 2017).

#### 4. Conclusion

The interviews reveal a rapidly evolving research and policy landscape, shaped by recent extreme events, growing awareness, and shifting science investment priorities. The four propositions we discuss operate at different levels of the research–policy interface for climate change adaptation. Proposition 1 concerns the importance of trust and relationships, which directly and indirectly affect the other propositions.

Proposition 2 addresses uncertainty. Policymakers and decision-makers face pressure to make the “right” decisions, and strong relationships with researchers can help them understand uncertainty and adopt decision-making frameworks that accommodate it. Honest, open conversations about politically sensitive or controversial policy decisions require trust and mutual respect, which take time to develop.

Proposition 3 relates to timeframes. Our findings indicate that empathy and understanding of each other’s drivers, as well as the external pressures and contexts they operate within, can improve the uptake of research into policy in a timely manner. Participants noted that this is not always achieved, as some researchers were surprised when policymakers explained the harsh realities of their operating context. However, most policymakers in the study came from diverse backgrounds, including scientific ones, and generally appreciated the time required for a robust research process.

Proposition 4 is particularly relevant in the current context of climate change adaptation policy and research in Aotearoa NZ, as it concerns funding. Recent changes to science funding, coupled with widespread public sector redundancies, have made it difficult to sustain high-level, conceptual discussions about how researchers and policymakers might best work together. Many participants expressed concern about the implications of these shifts for adaptation policy. While the politics of funding are beyond the scope of this article, it is clear that changes to funding structures have disrupted relationships, with cascading effects that influence the other propositions outlined above.

That said, the small size of the climate change adaptation research and policy community in Aotearoa NZ presents both advantages and disadvantages, echoing Gardiner et al.’s (2023) inclusivity/exclusivity paradox of informal networks. Its relatively flat, non-hierarchical structure makes it easier to identify key people and access needed information, fostering strong and trusting relationships. At the same time, these dynamics can entrench power imbalances and restrict diversity of thought, potentially constraining research, policy development, and decision-making.

Participants offered several aspirational and practical suggestions for addressing the issues raised in the four propositions. These included funding dedicated roles or organisations responsible for translating scientific findings to prevent misunderstandings; developing a shared set of definitions to ensure clear and consistent communication; and including key findings and high-level summaries in reports, often accompanied by visual aids such as graphs or maps.

While each of these suggestions has merit, funding remains a key consideration (SSAG, 2024; Truax et al., 2025). Power imbalances may be amplified depending on which institution funds a translation or liaison role, while trust-building can be undermined if such roles are independently funded or isolated from existing networks.

Developing a shared set of definitions was also seen as important, as terms such as “risk” and “vulnerability” can be interpreted differently depending on one’s professional background or operating context. Similarly, the suggestion of providing high-level summaries highlighted a tension: participants sought clear, robust evidence to inform complex decisions, but simultaneously expressed reluctance to engage with lengthy reports. High-level summaries, often prepared due to time constraints, cannot fully convey the nuance and uncertainty inherent in climate change adaptation research.

Although there is no clear pathway to a seamless science–policy interface for climate change adaptation in Aotearoa NZ, several issues stand out. A key recommendation for both researchers and policymakers is to explicitly attach funding to building trust and relationships across the interface. These take time to cultivate but are essential for mutual understanding of priorities and constraints. Past efforts have focused mainly on embedding science into policy; equal attention is needed on how policy contexts are communicated to researchers to avoid a one-sided interface.

Building researchers’ social and communication skills and empowering them to engage directly with policymakers without institutional constraints would be beneficial. Future research should expand to include both researchers and those responsible for science funding in Aotearoa NZ, examining how the small, flat, non-hierarchical structures of research and policy institutions can both facilitate and hinder the uptake of science for climate change adaptation. Finally, clearly documented examples of successful research–policy collaboration could

motivate policymakers to invest in relationship-building and co-development, yet few such cases currently exist. Capturing them would provide valuable lessons for future practice.

Taken together, these findings echo many of the intended outcomes of co-production and post-normal science, particularly trust, mutual understanding, and recognition of diverse perspectives. Our results suggest that the promise of co-production lies less in applying a single model, and more in matching the process to context and remaining agile in response to shifting policy and funding environments (Chambers et al., 2021, 2022). For Aotearoa NZ, this points to the value of flexible, context-sensitive approaches to collaboration that can adapt to both the opportunities and constraints of a small, interconnected research-policy community. Explicitly linking co-production to these local dynamics may help strengthen the science-policy interface and guide future institutional arrangements.

While this study focuses on Aotearoa NZ, many of the challenges and insights identified have relevance for climate change adaptation policy globally, including the importance of trust, strong relationships, and mutual understanding between researchers and policymakers. Ensuring that scientific knowledge is effectively translated into action requires not only robust evidence but also the time and resources to cultivate collaborative relationships, navigate uncertainty, and reconcile differing priorities. By investing in these social and institutional capacities, all those facing complex climate risks can enhance the impact of research on policy and decision-making. Ultimately, building a resilient and responsive science-policy interface is critical not only for addressing immediate adaptation needs but also for supporting long-term, equitable and evidence-informed responses to the accelerating challenge of climate change adaptation.

#### CRedit authorship contribution statement

**Angela Halliday:** Writing – review & editing, Writing – original draft. **Anita Wreford:** Writing – review & editing, Supervision. **Nicholas A. Cradock-Henry:** Writing – review & editing, Supervision. **Joanna Fountain:** Writing – review & editing, Supervision.

#### Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Angela Halliday reports financial support was provided by Resilience to Nature's Challenges National Science Challenge. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

#### Acknowledgements

The authors would like to thank the handling editor and two anonymous reviewers for their constructive feedback, which improved the manuscript. We also thank the research participants for their time and sharing their insights and experiences working at the boundary between adaptation research and policy. Funding for the research was provided by the Resilience, Policy and Governance Programme, Resilience to Nature's Challenges National Science Challenge through the NZ Ministry for Business Innovation and Employment.

#### Data availability

The data that has been used is confidential.

#### References

Aall, C., Groven, K., 2022. The unpredictable truth: a proposed road map for a Reflect-Then-Act approach to climate uncertainties and lessons learned from Norwegian

- municipalities. *Weather Clim. Soc.* 14 (1), 337–347. <https://doi.org/10.1175/WCAS-D-21-0078.1>.
- Aitsi-Selmi, A., Blanchard, K., Murray, V., 2016. Ensuring science is useful, usable and used in global disaster risk reduction and sustainable development: a view through the sendai framework lens. *Palgrave Commun.* 2 (1), 16016. <https://doi.org/10.1057/palcomms.2016.16>.
- Archie, K.M., Chapman, R., Flood, S., 2018. Climate change response in New Zealand communities: Local scale adaptation and mitigation planning. *Environ. dev.* 28, 19–31. <https://doi.org/10.1016/j.envdev.2018.09.003>.
- Arteaga, E., Nalau, J., Biesbroek, R., Howes, M., 2023. Unpacking the theory-practice gap in climate adaptation. *Clim. Risk Manag.* 42, 100567. <https://doi.org/10.1016/j.crm.2023.100567>.
- ASAP. (2025). Elevating Climate Change Adaptation Practice in Aotearoa New Zealand. Aotearoa Society of Adaptation Professionals. Retrieved 30 September from (<http://asap.org.nz/>).
- Babbie, E.R., 2021. *The Practice of Social Research* (Fifteenth ed.). Cengage Learning.
- Barton, T.M., Beaven, S.J., Cradock-Henry, N.A., Wilson, T.M., 2020. Knowledge sharing in interdisciplinary disaster risk management initiatives: cocreation insights and experience from New Zealand. *Ecol. Soc.* 25 (4). <https://doi.org/10.5751/ES-11928-250425>.
- Ben-Yami, M., Morr, A., Bathiany, S., Boers, N., 2024. Uncertainties too large to predict tipping times of major earth system components from historical data. *Sci. Adv.* 10 (31), ead14841. <https://doi.org/10.1126/sciadv.ad14841>.
- Boeije, H., 2010. *Analysis in Qualitative Research*. SAGE.
- Boschetti, F., Cvitanovic, C., Fleming, A., Fulton, E., 2016. A call for empirically based guidelines for building trust among stakeholders in environmental sustainability projects. *Sustain. Sci.* 11 (5), 855–859. <https://doi.org/10.1007/s11625-016-0382-4>.
- Boston, J., 2017. *Safeguarding the Future: Governing in an Uncertain World*. Bridget Williams Books Limited.
- Boston, J., 2024. *A Radically Different World; Preparing for Climate Change*. Bridget Williams Books Limited.
- Bradshaw, G.A., Borchers, J.G., 2000. Uncertainty as information: narrowing the Science-policy gap. *Conserv. Ecol.* 4 (1). <https://doi.org/10.5751/es-00174-040107>.
- Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. *Qual. Res. Psychol.* 3 (2), 77–101. <https://doi.org/10.1191/1478088706qp0630a>.
- Braun, V., & Clarke, V. (2013). *Successful qualitative research: A practical guide for beginners*.
- Cash, D.W., Borck, J.C., Patt, A.G., 2006. Countering the Loading-Dock approach to linking science and Decision-making: comparative analysis of el Niño/Southern oscillation (ENSO) forecasting systems. *Sci. Technol. Hum. Values* 31 (4), 465–494. <https://doi.org/10.1177/0162243906287547>.
- CCATWG. (2018). *Adapting to climate change in New Zealand: Recommendations from the Climate Change Adaptation Technical Working Group*.
- CCC. (2024). 2024 report assessing progress on implementation and effectiveness of the first adaptation plan. ([https://www.climatecommission.govt.nz/public/Monitoring-and-reporting/NAPPA-2024/CCC-NAPPA\\_bookmarked2.pdf](https://www.climatecommission.govt.nz/public/Monitoring-and-reporting/NAPPA-2024/CCC-NAPPA_bookmarked2.pdf)).
- Chambers, J.M., Wybom, C., Klenk, N.L., Ryan, M., Serban, A., Bennett, N.J., Brennan, R., Charli-Joseph, L., Fernández-Giménez, M.E., Galvin, K.A., Goldstein, B. E., 2022. Co-productive agility and four collaborative pathways to sustainability transformations. *Glob. Environ. Change* 72, 102422. <https://doi.org/10.1016/j.gloenvcha.2021.102422>.
- Chambers, J.M., Wybom, C., Ryan, M.E., Reid, R.S., Riechers, M., Serban, A., Bennett, N. J., Cvitanovic, C., Fernández-Giménez, M.E., Galvin, K.A., Goldstein, B.E., 2021. Six modes of co-production for sustainability. *Nat. Sustain.* 4, 983–996. <https://doi.org/10.1038/s41893-021-00755-x>.
- Chen, C., Doherty, M., Coffee, J., Wong, T., Hellmann, J., 2016. Measuring the adaptation gap: a framework for evaluating climate hazards and opportunities in urban areas. *Environ. Sci. Policy* 66, 403–419. <https://doi.org/10.1016/j.envsci.2016.05.007>.
- Colloff, M., Martín-López, B., Lavorel, S., Locatelli, B., Gordard, R., Longaretti, P.-Y., Walters, G., van Kerkhoff, L., Wybom, C., Coreau, A., Wise, R., Dunlop, M., Grantham, H., Overton, I., Williams, R., Doherty, M., Capon, T., Sanderson, T., Murphy, H., 2017. An integrative research framework for enabling transformative adaptation. *Environ. Sci. Policy* 68, 87–96. <https://doi.org/10.1016/j.envsci.2016.11.007>.
- Cologna, V., Oreskes, N., 2022. Don't gloss over social science! a response to: Glavovic et al. (2021) 'the tragedy of climate change science'. *Clim. dev.* 14 (9), 839–841. <https://doi.org/10.1080/17565529.2022.2076647>.
- Cradock-Henry, N., Flood, S., Buelow, F., Blackett, P., Wreford, A., 2019. Adaptation knowledge for New Zealand's primary industries: known, not known and needed. *Clim. Risk Manag.* 25, 100190. <https://doi.org/10.1016/j.crm.2019.100190>.
- Cvitanovic, C., Hobday, A.J., 2018. Building optimism at the environmental science-policy-practice interface through the study of bright spots. *Nat. Commun.* 9 (1), 3466. <https://doi.org/10.1038/s41467-018-05977-w>.
- Cvitanovic, C., Karcher, D.B., Breen, J., Badullovich, N., Cairney, P., Dalla Pozza, R., Duggan, J., Hoffmann, S., Kelly, R., Meadow, A.M., Posner, S., 2025. Knowledge brokers at the interface of environmental science and policy: a review of knowledge and research needs. *Environ. Sci. Policy* 163, 103973.
- Cvitanovic, C., Shellock, R.J., Mackay, M., van Putten, E.L., Karcher, D.B., Dickey-Collas, M., Ballesteros, M., 2021. Strategies for building and managing 'trust' to enable knowledge exchange at the interface of environmental science and policy. *Environ. Sci. Policy* 123, 179–189. <https://doi.org/10.1016/j.envsci.2021.05.020>.
- Denzin, N.K., 2017. *The Research Act: A Theoretical Introduction to Sociological Methods*. Routledge.

- Dilling, L., Lemos, M.C., 2011. Creating usable science: opportunities and constraints for climate knowledge use and their implications for science policy. *Glob. Environ. Change* 21 (2), 680–689. <https://doi.org/10.1016/j.gloenvcha.2010.11.006>.
- Durose, C., Perry, B., Richardson, L., 2022. Is co-production a 'good' concept? Three responses. *Futures* 142, 102999. <https://doi.org/10.1016/j.futures.2022.102999>.
- Eakin, H., Patt, A., 2011. Are adaptation studies effective, and what can enhance their practical impact? *Wiley Interdiscip. Rev. Clim. Change* 2, 141–153. <https://doi.org/10.1002/wcc.100>.
- Feldman, D.L., Ingram, H.M., 2009. Making science useful to Decision-makers: climate forecasts, water management, and knowledge networks. *Weather Clim. Soc.* 1 (1), 9–21. <https://doi.org/10.1175/2009WCAS1007.1>.
- Ferrier, R.C., Helliwell, R.C., Jones, H.M., Dodd, N.H., Beier, M.S., Akoumianaki, I., 2022. Supporting Evidence-Based water and climate change policy in scotland through innovation and expert knowledge: the centre of expertise for waters (CREW). In: Biswas, A.K., Tortajada, C. (Eds.), *Water Security Under Climate Change*. Water Resources Development and Management. Springer, Singapore. [https://doi.org/10.1007/978-981-16-5493-0\\_9](https://doi.org/10.1007/978-981-16-5493-0_9).
- Fox, M., Keen, J., 2022. Industry Impact of Quakecore Flagship Programme 4. *Bull. N. Z. Soc. Earthq. Eng.* 55 (1), 58–63. <https://doi.org/10.5459/bnzsee.55.1.58-63>.
- Funtowicz, S.O., Ravetz, J.R., 1993. Science for the post-normal age. *Future J. Policy Plan. Future Stud.* 25 (7), 739–755. [https://doi.org/10.1016/0016-3287\(93\)90022-L](https://doi.org/10.1016/0016-3287(93)90022-L).
- Glavovic, B.C., Smith, T.F., White, I., 2022. The tragedy of climate change science. *Clim. Dev.* 14 (9), 829–833. <https://doi.org/10.1080/17565529.2021.2008855>.
- Gluckman, P., 2013. The Role of Evidence in Policy Formation and Implementation. Office of the Prime Minister's Chief Science Advisor, Wellington.
- Gluckman, P. (2017) Enhancing evidence-informed policy-making. (<https://www.dpmc.govt.nz/sites/default/files/2021-10/pmcsa-17-07-07-Enhancing-evidence-informed-policy-making.pdf>).
- Gluckman, P., 2018. The role of evidence and expertise in policy-making: the politics and practice of science advice. *J. Proc. R. Soc. New South Wales* 151, 91–101.
- Gluckman, P.D., Bardsley, A., Kaiser, M., 2021. Brokerage at the science-policy interface: from conceptual framework to practical guidance. *Humanit. Soc. Sci. Commun.* 8 (1), 1–10. <https://doi.org/10.1057/s41599-021-00756-3>.
- Guntzburger, Y., Hadengue, M., 2025. Providing a comprehensive thematic review of the Science-Policy interface (SPI): a probabilistic topic modeling approach. *Environ. Sci. Policy* 163, 103966. <https://doi.org/10.1016/j.envsci.2024.103966>.
- Guston, D.H., 2001. Boundary organizations in environmental policy and science: an introduction. *Sci. Technol. Hum. Values* 26 (4), 399–408. <https://doi.org/10.1177/016224390102600401>.
- Heazle, M., 2010. Uncertainty in policy making : value and evidence in complex decisions. *Earthscan*.
- Hewitt, J.E., Lundquist, C.J., Pilditch, C.A., Thrush, S.F., Ulrich, S., 2022. Barriers to coastal planning and policy use of environmental research in Aotearoa-New Zealand. *Front. Mar. Sci.* 1–13. <https://doi.org/10.3389/fmars.2022.898109>.
- Hikuroa, D., 2020. Hendtlass, C., Morgan, S., Neale, D. (Eds.), *Mātauranga Māori and its role in coastal management*. Zealand Coastal Society, New.
- Hitchings, R., 2012. People can talk about their practices. *Area* 44 (1), 61–67. <https://doi.org/10.1111/j.1475-4762.2011.01060.x>.
- Hochrainer-Stigler, S., Deubelli-Hwang, T.M., Parviainen, J., Cumiskey, L., Schweizer, P.-J., Dieckmann, U., 2024. Managing systemic risk through transformative change: combining systemic risk analysis with knowledge co-production. *One earth*. <https://doi.org/10.1016/j.oneear.2024.04.014>.
- Hulme, M., 2018. Gaps in climate change knowledge: do they exist? Can they be filled? *Environ. Humanit.* 10 (1), 330–337. <https://doi.org/10.1215/22011919-4385599>.
- ICNZ. (2024). North Island Weather Events Claims 96% Settled. Insurance Council of New Zealand. Retrieved 8 August from (<https://www.icnz.org.nz/industry/media-releases/north-island-weather-events-claims-96-settled/>).
- Ihirangi, 2022. Exploring an indigenous worldview framework for the national climate change adaptation plan. *National Iwi Chairs Forum*.
- IPCC. (2022). Climate change: a threat to human wellbeing and health of the planet: Taking action now can secure our future. Retrieved 30 June 2023 from (<https://www.ipcc.ch/2022/02/28/pr-wgii-ar6/>).
- IPCC. (2023). Summary for Policymakers. (Climate Change 2023: Synthesis Report. A Report of the Intergovernmental Panel on Climate Change. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Issue.
- Jagannathan, K., Emmanuel, G., Arnott, J., Mach, K.J., Bamzai-Dodson, A., Goodrich, K., Meyer, R., Neff, M., Sjöstrom, K.D., Timm, K.M., 2023. A research agenda for the science of actionable knowledge: drawing from a review of the most misguided to the most enlightened claims in the science-policy interface literature. *Environ. Sci. Policy* 144, 174–186.
- Janzwood, S., 2023. Confidence deficits and reducibility: toward a coherent conceptualization of uncertainty level. *Risk Anal.* 43 (10), 2004–2016. <https://doi.org/10.1111/risa.14008>.
- Jasanoff, S., 2003. (No?) Accounting for expertise. *Sci. public policy* 30 (3), 157–162. <https://doi.org/10.3152/147154303781780542>.
- Jasanoff, S., 2007. Technologies of humility. *Nature* 450 (7166), 33. <https://doi.org/10.1038/450033a>.
- Jebeile, J., Roussos, J., 2023. Usability of climate information: toward a new scientific framework. *Wiley Interdiscip. Rev. Clim. Change* 14 (5), e833. <https://doi.org/10.1002/wcc.833>.
- Karcher, D.B., Tuohy, P., Cooke, S.J., Cvitanovic, C., 2024. Knowledge exchange at the interface of marine science and policy: a review of progress and research needs. *Ocean Coast. Manag.* 3, 107137. <https://doi.org/10.1016/j.ocecoaman.2024.107137>.
- Kasperson, R.E., 2011. Characterizing the Science/practice Gap. In: Routledge, pp. 23–40. <https://doi.org/10.4324/9781849775458-8>.
- Kerster, K., 2012. Insider, outsider, or somewhere in between: the impact of researchers identities on the community-based research process. *J. Rural Soc. Sci.* 27 (2), 99–117.
- Kiem, A.S., Verdon-Kidd, D.C., Austin, E.K., 2014. Bridging the gap between end user needs and science capability: decision-making under uncertainty. *Clim. Res.* 61 (1), 57–74. <https://doi.org/10.3354/cr01243>.
- Landry, R., Amara, N., Lamari, M., 2001. Utilization of social science research knowledge in Canada. *Res. Policy* 30 (2), 333–349. [https://doi.org/10.1016/S0048-7333\(00\)00081-0](https://doi.org/10.1016/S0048-7333(00)00081-0).
- Lawrence, J., Anita, W., Paula, B., David, H., Alistair, W., Shaun, A., E, L.M., Cate, M.-N., Susan, W., Joanna, F., John, C.M., E, A.A.-G., S, W.M., M, D, S, A, C.-H, N, Christian, Z., Milfont, T.L., 2024. Climate change adaptation through an integrative lens in aotearoa New Zealand. *J. R. Soc. New Z.* 54 (4), 491–522. <https://doi.org/10.1080/03036758.2023.2236033>.
- Lawrence, J., Gallop, S., Marquardt, L., Bell, R., Blackett, P., Craddock-Henry, N., Wreford, A., 2025. Dynamic adaptive pathways planning for adaptation: lessons learned from a decade of practice in aotearoa New Zealand. *J. Integr. Environ. Sci.* 22. <https://doi.org/10.1080/1943815X.2025.2451424>.
- Lawrence, J., Saunders, W., 2017. The planning nexus between disaster risk reduction and climate change adaptation. In: *First ed.* Routledge, pp. 418–428. <https://doi.org/10.4324/9781315684260-39>. 1 ed.
- Lawrence, J.H., Wreford, A., Allan, S., 2022. Adapting to avoidable and unavoidable climate change: what must aotearoa New Zealand do? *Policy Q.* 18 (2), 51–60. <https://doi.org/10.26686/pq.v18i2.7575>.
- Leal Filho, W., 2024. *Planetary Health and Climate Change: Understanding the Impacts of Climate Change to the Well-being of Our Planet*. Springer Nature.
- Lemos, M., Arnott, J., Ardoin, N., Baja, K., Bednarek, A., Dewulf, A., Fieseler, C., Goodrich, K., Jagannathan, K., Klenk, N., Mach, K., Meadow, A., Meyer, R., Moss, R., Nichols, L., Sjöstrom, D., Stults, M., Turnhout, E., Vaughan, C., Wyborn, C., 2018. To co-produce or not to co-produce. *Nat. Sustain.* 1. <https://doi.org/10.1038/s41893-018-0191-0>.
- Lemos, M.C., Kirchhoff, C.J., Ramprasad, V., 2012. Narrowing the climate information usability gap. *Nat. Clim. Change* 2 (11), 789–794. <https://doi.org/10.1038/nclimate1614>.
- Lemos, M.C., Rood, R.B., 2010. Climate projections and their impact on policy and practice. *Wiley Interdiscip. Rev. Clim. Change* 1 (5), 670–682. <https://doi.org/10.1002/wcc.71>.
- Lidskog, R., 2014. Representing and regulating nature: boundary organisations, portable representations, and the science-policy interface. *Environ. Polit.* 23 (4), 670–687. <https://doi.org/10.1080/09644016.2013.898820>.
- Locatelli, B., Laurenceau, M., Chumpisuca, Y.R.C., Pramova, E., Vallet, A., Conde, Y.Q., Zavala, R.C., Djoudi, H., Lavorel, S., Colloff, M.J., 2022. In people's minds and on the ground: Values and power in climate change adaptation. *Environ. Sci. Policy* 137, 75–86. <https://doi.org/10.1016/j.envsci.2022.08.002>.
- Lofland, J., 2006. *Analyzing social settings: a guide to qualitative observation and analysis*. Fourth ed. Wadsworth/Thomson Learning.
- Mach, K.J., Kraan, C.M., 2021. Science-policy dimensions of research on climate change and conflict. *J. Peace Res.* 58 (1), 168–176. <https://doi.org/10.1177/0022343320966774>.
- Malik, I.H., Ford, J.D., 2024. Addressing the climate change adaptation gap: key themes and future directions. *Climate* 12 (2), 24. <https://doi.org/10.3390/cli12020024>.
- McConnell, G. (2024). Public service job cuts: What ministries are proposing. <https://www.stuff.co.nz/politics/350220974/public-service-job-cuts-what-ministries-are-proposing>.
- Meinke, H., Nelson, R., Kocic, P., Stone, R., Selvaraju, R., Baethgen, W., 2006. Actionable climate knowledge: from analysis to synthesis. *Clim. Res.* 33 (1), 101–110. <https://doi.org/10.3354/cr033101>.
- Meyer, M., 2010. The rise of the knowledge broker. *Sci. Commun.* 32 (1), 118–127. <https://doi.org/10.1177/1075547009359797>.
- MFAT. (2023). *Cyclone Gabrielle's impact on the New Zealand economy and exports*. (<https://www.mfat.govt.nz/en/trade/mfat-market-reports/cyclone-gabrielles-impact-on-the-new-zealand-economy-and-exports-march-2023/>).
- MfE. (2020). National Climate Change Risk Assessment for New Zealand – Arotakena Tūraru mō te Huringa Āhuarangi o Aotearoa: Method report – Pūrongo whakararangi. Wellington.
- MfE. 2022. Aotearoa New Zealand's first national adaptation plan. Ministry for the Environment, Wellington.
- Mills, J., Birks, M., 2014. *Qualitative methodology: a practical guide*. SAGE.
- Milly, P.C.D., Betancourt, J., Falkenmark, M., Hirsch, R.M., Kundzewicz, Z.W., Lettenmaier, D.P., Stouffer, R.J., 2008. Stationarity is dead: whither water management? *Science* 319 (5863), 573–574. <https://doi.org/10.1126/science.1151915>.
- Morgan, E.A., Di Giulio, G.M., 2018. Science and Evidence-Based climate change policy: collaborative approaches to improve the Science-Policy interface. In: Serrao-Neumann, In.S., Coudrain, A., Coulter, L. (Eds.), *Communicating Climate Change Information for Decision-Making*. Springer International Publishing AG, Switzerland, pp. 13–28. [https://doi.org/10.1007/978-3-319-74669-2\\_2](https://doi.org/10.1007/978-3-319-74669-2_2).
- Moore, M., Jacobsen, J.B., Smith-Hall, C., 2023. Uncertainty and climate change adaptation: a systematic review of research approaches and People's Decision-Making. *Curr. Clim. Change Rep.* 9 (1), 1–26. <https://doi.org/10.1007/s40641-023-00189-x>.
- Muccione, V., Huggel, C., Bresch, D.N., Jurt, C., Bresch, D.N., Jurt, C., Wallimann-Helmer, I., Mehra, M.K., Caicedo, J.D.P., 2019. Joint knowledge production in

- climate change adaptation networks. *Curr. Opin. Environ. Sustain.* 39, 147–152. <https://doi.org/10.1016/j.cosust.2019.09.011>.
- NEMA. (2024). Declared States of Emergency. Civil Defence National Emergency Management Agency. Retrieved 8 August from (<https://www.civildefence.govt.nz/resources/previous-emergencies/declared-states-of-emergency>).
- Orchiston, C., Mitchell, J., Wilson, T., Langridge, R., Davies, T., Bradley, B., Johnston, D., Davies, A., Becker, J., McKay, A., 2018. Project AF8: developing a coordinated, multi-agency response plan for a future great alpine fault earthquake. *New Z. J. Geol. Geophys.* 61 (3), 389–402. <https://doi.org/10.1080/00288306.2018.1455716>.
- Paulik, R., Stephens, S., Wadhwa, S., Bell, R., Popovich, B., & Robinson, B. (2019). Coastal Flooding Exposure Under Future Sea-level Rise for New Zealand, (Prepared for the Deep South National Science Challenge). (<https://deepsouthchallenge.co.nz/wp-content/uploads/2021/01/Exposure-to-Coastal-Flooding-Final-Report.pdf>).
- Pielke, R.A., 2007. *The Honest Broker: Making Sense of Science in Policy and Politics*. Cambridge University Press.
- Pitt, R., Wyborn, C., Page, G., Hutton, J., Sawmy, M.V., Ryan, M., Gallagher, L., 2018. Wrestling with the complexity of evaluation for organizations at the boundary of science, policy, and practice. *Conserv. Biol.* 32 (5), 998–1006. <https://doi.org/10.1111/cobi.13118>.
- Pulkkinen, K., Undorf, S., Bender, F., Wikman-Svahn, P., Doblas-Reyes, F., Flynn, C., Hegerl, G.C., Jönsson, A., Leung, G.-K., Roussos, J., Shepherd, T.G., Thompson, E., 2022. The value of values in climate science. *Nat. clim. change* 12 (1), 4–6. <https://doi.org/10.1038/s41558-021-01238-9>.
- Reisinger, A., Wratt, D., Allan, S., Larsen, H., 2011. *The Role of Local Government in Adapting to Climate Change: Lessons from New Zealand*. Springer Netherlands, Dordrecht, pp. 303–319. [https://doi.org/10.1007/978-94-007-0567-8\\_22](https://doi.org/10.1007/978-94-007-0567-8_22).
- Rickards, L.A., Alexandra, J., Denham, T., Sanders, A., 2024. Five tensions in climate adaptation research. *Front. Clim.* 5, 1215171. <https://doi.org/10.3389/fclim.2023.1215171>.
- Rogga, S., 2021. Transcending the loading dock Paradigm—Rethinking Science-Practice transfer and implementation in sustainable land management. In: Weith, T., Barkmann, T., Gaasch, N., Rogga, S., Strauß, C., Zscheischler, J. (Eds.), *Sustainable Land Management in a European Context: A Co-Design Approach*. Springer International Publishing, pp. 249–265. [https://doi.org/10.1007/978-3-030-50841-8\\_13](https://doi.org/10.1007/978-3-030-50841-8_13).
- Sarkki, S., Niemelä, J., Tinch, R., van den Hove, S., Watt, A., Young, J., 2014. Balancing credibility, relevance and legitimacy: a critical assessment of trade-offs in science-policy interfaces. *Sci. Public Policy* 41 (2), 194–206. <https://doi.org/10.1093/scipol/sct046>.
- Schneider, F., Tribaldos, T., Adler, C., Biggs, R., de Bremond, A., Buser, T., Krug, C., Loutre, M.-F., Moore, S., Norström, A.V., Paulavets, K., Urbach, D., Spehn, E., Wülser, G., Zondervan, R., 2021. Co-production of knowledge and sustainability transformations: a strategic compass for global research networks. *Curr. Opin. Environ. Sustain.* 49, 127–142. <https://doi.org/10.1016/j.cosust.2021.04.007>.
- Shukla, J., Hagedorn, R., Hoskins, B., Kinter, J., Marotzke, J., Miller, M., Palmer, T.N., Slingo, J., 2009. Revolution in climate prediction is both necessary and possible: a declaration at the world modelling summit for climate prediction. *Bull. Am. Meteorol. Soc.* 90 (2), 175–178. <https://doi.org/10.1175/2008BAMS2759.1>.
- Stirling, A., 2010. Keep it complex. *Nature* 468 (7327), 1029–1031. <https://doi.org/10.1038/4681029a>.
- Taylor, J.E., Poleacovschi, C., Perez, M.A., 2023. Climate change adaptation trends among Indigenous peoples: a systematic review of the empirical research focus over the last 2 decades. *Mittig. adapt. strateg. glob. change* 28 (6), 29. <https://doi.org/10.1007/s11027-023-10063-8>.
- Thompson, M.A., Owen, S., Lindsay, J.M., Leonard, G.S., Cronin, S.J., 2017. Scientist and stakeholder perspectives of transdisciplinary research: early attitudes, expectations, and tensions. *Environ. Sci. Policy* 74, 30–39. <https://doi.org/10.1016/j.envsci.2017.04.006>.
- Truax, O., Penney, C., MacDonell, S., 2025. Indirect costs: the perverse consequences of aotearoa New Zealand's research overheads system. *New Z. Sci. Rev.* 80. <https://doi.org/10.26686/nzsr.v80.9848>.
- Turnhout, E., Metz, T., Wyborn, C., Klenk, N., Louder, E., 2020. The politics of co-production: participation, power, and transformation. *Curr. Opin. Environ. Sustain.* 42, 15–21. <https://doi.org/10.1016/j.cosust.2019.11.009>.
- UNDP. (2024). What is climate change and why is it so crucial? (<https://climatepromise.undp.org/news-and-stories/what-climate-change-adaptation-and-why-it-crucial>).
- Wesselink, A., Hoppe, R., 2011. If Post-Normal science, is the solution, what is the problem?: the politics of activist environmental science. *Sci. Technol. Hum. Values* 36, 389–412. <https://doi.org/10.2307/41149060>.
- Wilby, R.L., Dessai, S., 2010. Robust adaptation to climate change. *Weather* 65 (7), 180–185. <https://doi.org/10.1002/wea.543>.
- Williams, K. (2022). Heavy job churn in public sector amid pay freezes, cost of living crisis. *Stuff*. (<https://www.stuff.co.nz/national/politics/129723607/heavy-job-churn-in-public-sector-amid-pay-freezes-cost-of-living-crisis>).
- Workman, M., Dooley, K., Lomax, G., Maltby, J., Darch, G., 2020. Decision-making in contexts of deep uncertainty - an alternative approach for long-term climate policy. *Environ. Sci. Policy* 103, 77–84. <https://doi.org/10.1016/j.envsci.2019.10.002>.
- Wreford, A., Dittrich, R., Zammit, C., Renwick, A., & Collins, D. (2020). Robust adaptation decision-making under uncertainty: Real Options Analysis for water storage.
- Wreford, A., Peace, S., Reed, M., Bandola-Gill, J., Low, R., Cross, A., 2019. Evidence-informed climate policy: mobilising strategic research and pooling expertise for rapid evidence generation. *Clim. Change* 156 (1-2), 171–190. <https://doi.org/10.1007/s10584-019-02483-w>.