



# Advancing Relevance, Credibility, Legitimacy, and Effectiveness as a Heuristic for Local-Parallel Scenarios

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The parallel scenario process provides a framework for developing plausible scenarios of future conditions. Combining greenhouse gas emissions, social and economic trends, and policy responses, it enables researchers and policy makers to consider global-scale interactions, impacts and implications of climate change. Increasingly, researchers are developing extended scenarios, based on this framework, and incorporating them into adaptation planning and decision-making processes at the local level. To enable the identification of possible impacts and assess vulnerability, these local-parallel scenarios must successfully accommodate diverse knowledge systems, multiple values, and competing priorities including both “top down” modeling and “bottom-up” participatory processes. They must link across scales, to account for the ways in which global changes affect and influence decision-making in local places. Due to the growing use of scenarios, there is value in assessing these developments using criteria or, more specifically, heuristics that may be implicitly acknowledged rather than formally monitored and evaluated. In this Perspective, we reflect on various contributions regarding the value of heuristics and propose the adoption of current definitions for Relevance, Credibility, and Legitimacy for guiding local scenario development as the most useful as well as using Effectiveness for evaluation purposes. We summarize the internal trade-offs (personal time, clarity-complexity, speed-quality, push-pull) and the external stressors (equity and the role of science in society) that influence the extent to which heuristics are used as “rules of thumb,” rather than formal assessment. These heuristics may help refine the process of extending the parallel scenario framework to the local and enable cross-case comparisons.

**Keywords:** boundary work, climate change, cross-scale, integrated assessment models, local-parallel scenarios, multi-scale, research evaluation, SSPs

## INTRODUCTION

The multi-scale and systemic nature of climate risk requires greater consideration of the ways in which responses to climate impacts and anticipated risks can be affected and influenced by conditions at the global, regional, and national scales (Simpson et al., 2021). The parallel scenario framework is a sophisticated, global-scale architecture involving representative concentration pathways (RCPs) of greenhouse gas emissions, shared socio-economic pathways (SSPs), and shared policy assumptions (SPAs) (Ebi et al., 2014). Since 2014 the framework has been used to develop

long-term futures, providing insight into the potential effects of climate change on social-ecological systems, the effectiveness of adaptation and mitigation, and the policies necessary to reduce climate-related risks (O'Neill et al., 2014). The framework provides a set of boundary conditions for constructing internally consistent, plausible representations of diverse futures. Elaborating futures scenarios enables researchers, policymakers, and practitioners to explore interactions and feedback mechanisms between large-scale drivers of global change, and to identify and assess possible pathways for change (O'Neill et al., 2020).

This global scenario architecture provides a versatile and flexible structure that can accommodate diverse applications, at different scales, and provide insight into potential impacts and implications. In this, the three interrelated parallel pathways; the RCPs, SSPs and SPAs explore the impact climate change will have on social-ecological systems, the degree to which mitigation and adaptation policies can avoid and reduce those risks, and the costs and benefits of various policy mixes (Ebi et al., 2014). An emerging trend in impacts, vulnerability, and adaptation research, therefore, is to improve the links between the global and sub-national (hereafter local) level by extending the parallel scenario framework and incorporating outputs into applied adaptation decision-making processes (Campos et al., 2016; Cradock-Henry et al., 2018, 2020; Aguiar et al., 2020; Schmitt Olabisi et al., 2020). Such extended SSPs have been developed for a range of settings and problems, including specific sectors and activities such as agriculture and forestry (Daigneault et al., 2019; Mitter et al., 2020; Lehtonen et al., 2021), and scales and places (Frame et al., 2018; Lino et al., 2019; Chen et al., 2020; Gomes et al., 2020; Pedde et al., 2021).

Extending the basic architecture of the global parallel scenarios developed by the climate change research community to the local level also continues the trend in adaptation research, of researchers working with stakeholders—including communities and regions, policymakers and practitioners—to co-produce knowledge (Bremer and Meisch, 2017). Co-production processes seek to better understand local conditions, assess current and anticipated impacts and implications, and explore adaptation options (Ford et al., 2014; Boon et al., 2019; Cradock-Henry et al., 2020; Hill et al., 2020; Cradock-Henry, 2021). These local-parallel scenarios typically combine elements of top-down and bottom-up data derived from probabilistic or econometric models, or through interviews and other participatory methods, respectively.

Local scenarios can improve understanding of the types and magnitude of change, explore sensitivities, and evaluate ways of managing risks. Often these scenarios are used as part of an adaptive planning or pathways process that begins with a comprehensive understanding of the current situation, and then bounds future uncertainty within a manageable set of conditions (Cradock-Henry et al., 2018; Frame et al., 2018; Aguiar et al., 2020). However, development of these scenarios assumes seamless ways to coordinate and apply the frameworks from the global through the regional and national to the local while accommodating new directions. However, as O'Neill et al. (2020, p. 1,079) highlight, “At present, there is no commonly

agreed practice regarding methods for downscaling the SSPs” and more detailed Integrated Assessment Models are needed (Pereira et al., 2021; Rosen, 2021).

The rapid growth in the application and development of decision-making tools and processes for adaptation is prompting reflection on the value of heuristics. These are seen as a “branch of study” that seeks to “understand the methods and rules of discovery and invention” (Pólya, 1990). Heuristics can expedite conceptual and methodological development by stimulating thinking. In this essay we use the word “heuristic” to refer to a rule of thumb. Following Starfield et al. (1994), “a heuristic is a plausible or reasonable approach that has often proved to be useful.” In so doing, we build on and extend recent work in the field, focusing on one of the most common heuristics in sustainability and climate science: relevance, credibility and legitimacy.

The relevance, credibility, and legitimacy heuristic (hereafter RCL) has been associated with desired attributes for information at the boundary between science and policy communities. It has been used extensively in the literature on adaptation (and climate change more generally), due in part to its origins in assessing the usability of seasonal climate forecasts for decision-making (Cash et al., 2006). We use RCL as our anchor point from the literature (e.g., Cash et al., 2002, 2003, 2006; Sarkki et al., 2014; Belcher et al., 2016, 2019; Cash and Belloy, 2020). We find this workable in practice at the local level, especially when there is a need for something that, while academically rigorous, can be easily understood by non-technical, on-the-ground practitioners. Or, to phrase it differently, we see the use of a heuristic to be of greater practical benefit than a formal evaluation methodology (Nalau et al., 2021). However, as Elsawah and colleagues point out, while conceptual papers such as that by Cash et al. (2006) are often quoted, their “recommendations are rarely used beyond the point of acknowledging that they exist” (Elsawah et al., 2020, p. 13). Our aim here is to consider the various formulations of criteria and attributes in the literature and propose a simple, reproducible formulation that can be used across local case studies.

In this Perspective we reflect on developing and applying local-parallel scenarios as part of adaptation planning. Findings have been generated inductively based on our own experience, and deductively from a review of the literature. We begin by summarizing the process of nesting the local in the global (section Nesting the Local in the Global), before describing the various RCL formulations (section What Is Meant by Relevance, Credibility, and Legitimacy, and What Is Effective?). In section Tradeoffs and Stressors in Developing Local-Parallel Scenarios we discuss how these criteria can accommodate internal and external stressors when working at the science-policy interface. We conclude by proposing how developing local-parallel scenarios might use these criteria most effectively.

## NESTING THE LOCAL IN THE GLOBAL

There are many examples of adaptation planning and decision-making ranging from adaptation pathways to resilience and vulnerability assessment. Here we restrict ourselves to the

growing use of scenarios at the local level, and the corresponding increase in case studies (Nilsson et al., 2017; Lino et al., 2019; Zandersen et al., 2019; Butler et al., 2020; Lehtonen et al., 2021). Scenarios are narratives describing plausible future worlds. They are a strategic planning method developed to make flexible and robust long-term plans in response to complex and uncertain futures. Scenarios were initially developed by mid-nineteenth century European military intelligence specialists, but since the 1960s they have been used in a variety of contexts and scales, including business and trade (Berkhout et al., 2002), conservation and development (Peterson et al., 2003; Daconto and Sherpa, 2010; Pereira et al., 2021), community development (Rawluk and Godber, 2011), and adaptive infrastructure management (Hamilton et al., 2013). Due to the uncertainties surrounding the magnitude and effects of climate change, natural variability, and the extent to which human societies will adopt mitigation and adaptation, scenarios are used extensively to explore the effects of certain decisions on climate change.

The global-scale parallel scenario framework, however, is unable to model the localized effects of climate change (Ebi et al., 2014; O'Neill et al., 2014). Precipitation, timing, and intensity of weather events, the role of local geography, or the specific socio-economic factors that affect local decisions on adaptation and mitigation in regions and communities therefore need to be elaborated on and bounded in other ways (O'Neill et al., 2020; Pereira et al., 2021).

At the regional or local level climate scenarios have tended to fall into two broad categories. The first involves emulating the parallel process by collecting and refining expert data and projections into relatively complex scenarios for specific regions. These scenarios are then used with planners, policy makers, and others to synthesize large amounts of scientific data, compare and contrast policy options, and inform decision-making. The second approach uses more community-development-type approaches by working with local communities to co-create scenarios that prioritize local knowledge and memories and community aspirations (Mistry et al., 2014). An emerging third way is the use of local socioeconomic and climate scenarios as a tool for exploring plausible future conditions and how these may influence adaptation strategies (Nilsson et al., 2017; Zandersen et al., 2019; Reimann et al., 2021). These local-parallel scenarios use the basic architecture of the global framework to provide a set of boundary conditions. The combination of emissions, policy mixes, and socioeconomic pathways is contextualized for local conditions through stakeholder knowledge and experience. The resulting narratives represent alternative trends, with a loose or soft linkage to national and/or global conditions (Lino et al., 2019).

Developing and applying such scenarios involves developing quite specific artifacts, such as narratives or other representations of plausible future conditions. These, in turn, may challenge established norms and values, and cut across other place-specific issues. For local stakeholders at least, these have as much, if not more, importance in the short-term decision-making on such issues as infrastructure investments, the viability of primary production, and employment (Cradock-Henry et al., 2018). Consequently, for any scenario development process to

be effective at the local scale, it has to successfully engage and negotiate with local concerns (Cradock-Henry et al., 2020; Cradock-Henry and Frame, 2021). Also, as discussed next, useful heuristics are needed that provide guidance on the extent to which this has been achieved.

## WHAT IS MEANT BY RELEVANCE, CREDIBILITY, AND LEGITIMACY, AND WHAT IS EFFECTIVE?

Cash et al. (2002, 2003, 2006) established the key concepts of “credibility, salience and legitimacy” as attributes for information at the boundary between science and policy communities. These acknowledged the science and policy interface as a complex terrain requiring skilful navigation, the dynamics of which, within a rapidly changing world, are becoming increasingly challenging (Cash and Belloy, 2020). The terms evolved as a heuristic means to evaluate the boundary between research and policy without necessarily delving into the politics of the situation, or to challenge underlying assumptions (Preston et al., 2015; Nalau et al., 2021). Such research is effectively transdisciplinary, where high-level modeling is likely to be of limited value and datasets are likely to be incomplete or inconsistent (Carlsen et al., 2016; Bosomworth and Gaillard, 2019; Cradock-Henry et al., 2020).

In other words, “credibility, salience, and legitimacy” provide criteria that link the processes of developing climate change information and its usefulness within the transdisciplinary research world, and that other world experienced by end-users, including policymakers. While the heuristic has been widely used to describe the science–policy boundary (White et al., 2010; Kunseler et al., 2015; Dannevig and Hovelsrud, 2016; Cash and Belloy, 2020), various alternative formulations have been proposed. “Salient” was considered to be analogous to “relevant,” which led to use of the term CRELE (credible, relevant, and legitimate), which has morphed into relevant, credible, and legitimate, resulting in the acronym, RCL. This, as discussed by others, is what appears to be gaining traction and which we adopt as the preferred terminology (Belcher et al., 2016, 2019; Dunn and Laing, 2017).

Other terms have also been proposed and include, for example, iterativity (Lemos and Morehouse, 2005; Dilling and Lemos, 2011), defined as “a continuous multi-directional interaction that goes beyond simple repetition, building on previous practices, learning from success and failure, and fostering evaluation itself among all participants at the interface and between science-policy interfaces and external audiences” (Sarkki et al., 2015, p. 507) which led to CRELE + IT. While this is useful in terms of transdisciplinary research, it can, for use in local scenarios, be seen as an essential requirement absorbed into the overall concept of effectiveness, as discussed later. Dunn and Laing (2017) suggested that CRELE is not suitable to describe policymakers’ needs because it is more focused on information supply rather than information demand. They recommended the use of applicability, comprehensiveness, timing, and accessibility. This, and to a lesser extent CRELE, was criticized by Tangney

(2017) as flawed, though with the latter acknowledging the criteria that should be prioritized for the use of evidence in decision-making (Hansson and Polk, 2018).

To this lexicon, Maier et al. (2016) added terms to describe multiple plausible futures: deep uncertainty, global/local uncertainty and volatility, uncertainty, complexity, and ambiguity. Interestingly, with reference to the development and application of the parallel scenarios, O'Neill et al. (2020) use the term “credible, reproducible, and consistent methods for the use of the SSPs across scales” (p. 6), which perhaps lacks enough rigor. All of this suggests that a formal and broadly accepted formulation would be helpful as the process of extending scenarios gains momentum globally.

The systematic review by Belcher et al. (2016), and its subsequent refinement (Hansson and Polk, 2018), led to definitions for the principles and criteria for assessing the quality of transdisciplinary research. We propose the use of their working definitions for the development of extended parallel scenarios at the local level, as follows:

- **Relevance:** the importance, significance, and usefulness of the research problem, objectives, processes, and findings to the problem context
- **Credibility:** the research findings are robust and the sources of knowledge are dependable—this includes clear demonstration of the adequacy of the data and the methods used to procure the data, including clearly presented and logical interpretation of findings
- **Legitimacy:** the research process is perceived as fair and ethical—this encompasses the ethical and fair representation of all involved, and the appropriate and genuine inclusion and consideration of diverse participants, values, interests, and perspectives.

Belcher et al. (2016) also included the principle of effectiveness. This is, in this case, an assessment criterion to be considered *ex ante* at the proposal stage, with actual effectiveness determined *ex post* through the use of appropriate assessment tools. Thus, effectiveness defines the extent to which research generates knowledge and stimulates actions that address the problem and contribute to solutions and innovations. As a result, Belcher et al. (2019) placed this effectiveness heuristic outside the bounds of the adaptation processes, and we do not include effectiveness to assess adaptation processes prior to their application.

## TRADEOFFS AND STRESSORS IN DEVELOPING LOCAL-PARALLEL SCENARIOS

### Internal Tradeoffs

Sarkki et al. (2014) used empirical data to identify and explore four internal trade-offs at the science-policy interface, which they described as:

- The *personal time* trade-off between the commitment required by those involved to cover the highly complex, multi-faceted terrain of adaptation vs. commitment to an existing discipline or process

- The *clarity-complexity* trade-off between simple, strong, clear messages (relevance) vs. thorough treatment of uncertainties and systemic dimensions (credibility and legitimacy)
- The *speed-quality* trade-off between timely and rapid responses to policy needs (relevance) vs. time-consuming quality assessment (credibility) and/or consensus building (legitimacy)
- The *push-pull* trade-off between following strong policy demand (relevance) and more supply-oriented research strategies to enable identification of emerging issues or development of innovative solutions (credibility and legitimacy).

Sarkki et al. (2014) also identified issues relating to trust and inclusion of other worldviews, which are considered as external stressors.

### External Stressors

Cash and Belloy (2020) describe four external stressors in the global context which address criticism that RCL does not fully address socio-political aspects, distributive justice, and the rapidly changing knowledge-action landscape. First there is the challenge of engaging with quite different forms of knowledge when working across scales, and the need to ensure trust is created in the process. Second there are equity issues, which are both urgent and complex and include ethical dimensions, populations with existing vulnerabilities, issues of privilege, as well as historically disadvantaged populations. Third there is the degradation of the role of science in society and the trust placed in science in the “post-truth” world where trust in science has become corroded with an increasing emphasis on personal or political preferences. This is most clearly exhibited through perspectives such as climate change denialism and resistance to evidence-based responses to the COVID-19 pandemic (Jasanoff, 2021). Finally, there are issues related to the production of knowledge through digital technologies across multiple platforms, including ease of access to shared information, which blurs the citizen-science boundary, and the ways in which social media is used by institutions, community groups, and businesses to influence opinions.

While these originated through consideration of global developments, we seek here to consider them specifically in relation to local scenario processes. That is to say, we consider the use of the RCL heuristics primarily through the first of these dynamics—working across scales. We then look at how this affects issues of equity and science in a post-truth society and with digital transformations only playing a relatively minor role. We do so based on our experiences with impacts, vulnerability, and adaptation at the local level in Aotearoa—New Zealand (New Zealand) that will be highly contextual and place-specific, but also seek to provide a more general perspective (Cradock-Henry et al., 2018, 2020; Frame et al., 2018; Ausseil et al., 2019; Cradock-Henry and Frame, 2021).

### Equity

Cash and Belloy (2020) describe four aspects of inequity in contemporary society: historically disadvantaged populations;

those with existing vulnerabilities; those in post-disaster recovery; over-arching ethical considerations of human and non-human ecology. Of these, the historically disadvantaged and those with existing vulnerabilities are, currently, the most pertinent to our discussion. In the New Zealand context we propose that the first relates solely to the indigenous population, with the latter covering other disadvantaged groups.

Aotearoa—New Zealand is a bi-cultural nation, with indigenous Maori retaining governance rights and management responsibilities for ancestral land through Te Tiriti o Waitangi (the Maori version of the Treaty of Waitangi, 1840)—New Zealand's founding document, framing the relationship between Maori and the Crown. In addition to their lands, many iwi (Maori tribes) have commercial agribusiness and forestry interests. They also live in or near coastal margins, which are likely to be exposed to the effects of climate change. Ideally, scenarios would be developed using kaupapa-based Māori methodologies (Smith, 2012); i.e., designed by and for Māori, addressing Māori concerns, conducted predominantly by Māori researchers and based on Māori cultural values. In practice, available technical capability and capacity can, currently, be a limiting factor. To ensure a Māori perspective, any local consultation process must involve iwi or hapu as an equal partner. This cannot be considered an optional add-on but must be seen as a central component. If this is not undertaken in a sincere and comprehensive manner, then success in achieving a legitimate result is greatly diminished.

Our experience also suggests it is both critical and difficult to negotiate and balance the power dynamics between ostensibly equal stakeholders (Cradock-Henry et al., in press). As with geopolitics, there are strong players and silent players. For example, there can be wealthy landowners with extensive business interests, positions in local-body politics, and strong, long-term family connections who may be able to exert a disproportionate influence on decision-making processes (sometimes over-stated as “oligarchs”). This authority needs to be made relatively transparent and the opportunity for alternative perspectives enabled.

If “oligarchs” are potentially over-privileged, then there is an equal risk of under-privileging local, “silent,” voices. These are groups or individuals who are potentially less able to form coherent and consistent opinions than those endowed with politically relevant resources. Exclusion of silent voices reduces the relevance and legitimacy of local scenarios. Consideration therefore also needs to be given to how participatory scenario processes unfold; for example, who participates, and to what extent local hierarchies of social difference (age, gender, class, ethnicity, etc.) shape how scenarios are facilitated, and the actions that emerge out of them (Stirling, 2008).

## Science in Society

Expert-led scenario development tends to prioritize the knowledge and involvement of professionals over local communities and is usually expensive and resource intensive. However, experts can introduce information and identify opportunities not readily available to local communities. Nonetheless, scenarios can be perceived as derived from and

delivered by experts telling local people what they need to do. In other words, the role of the external knowledge provider is perceived as privileged, with the potential to dominate the local. While this has been a topic within the science and technology studies field for several decades (e.g., Wynne, 1991, 1992), it is not always widely understood in practice by biophysical researchers or local authorities. Failure to accommodate this, or to have resources available to address this, could lead to early failures, which then place climate change as even less of a legitimate issue. This is exacerbated in the post-truth world, as highlighted through populist campaigns such as climate change denialism (Harvey et al., 2018; Bloomfield and Tillery, 2019; Bowden et al., 2019; Kovaka, 2021) and resistance to immunization programmes for the COVID-19 virus (Jaiswal et al., 2020; Uscinski et al., 2020).

In the context of developing local scenarios through participatory and co-production processes, this can result in the wider project being perceived by some locals as an extension of “government,” with researchers being seen as “suits from the city.” This has led, in our experience, to being advised against mentioning specific topics (in the rural New Zealand context this includes the use of toxins for predator management and proposed bans on fossil fuel mining) that can be particularly contested and divisive. Until recently, work on adaptation in New Zealand—particularly with farming communities—was fraught, with stakeholders’ conflating mitigation and adaptation (Reisinger et al., 2011; Cradock-Henry, 2017) and opposition to taxes on carbon or greenhouse gas emissions (Cooper and Rosin, 2014). Attitudes, trust in science, and knowledge sharing have become politically polarized, with people rejecting scientific evidence that misaligns with their personal or political preferences, requiring greater sensitivity and diplomacy when managing participatory deliberation and analysis. It is essential therefore, to acknowledge and reflect on one’s role in the scenario process. Assuming the role of the “honest broker” (Pielke, 2007; Sarkki et al., 2020) in scenario development can help navigate the tension between scenario types: what *could* happen vs. what *should* happen (Börjeson et al., 2006).

Participatory scenario development processes are more likely to reflect local people’s experiences and aspirations. These should include important knowledge missed by experts, and include multiple stressors, and through this process build local agency to enact appropriate and socially acceptable solutions (Bohunovsky et al., 2011; Mistry et al., 2014; Wesche and Armitage, 2014; Flynn et al., 2018; Guaita García et al., 2020). However, they are often not spatially explicit, can miss important expert knowledge, are not robust enough and connected to national/global drivers, and can be resource intensive for participants (Guaita García et al., 2020). This tension between local and professional knowledges and experiences needs to be carefully facilitated.

## CONCLUDING COMMENTS

Climate change adaptation processes are one possible intervention in the complex assemblage of climate risk management. However, they are deeply enmeshed in wider

social contexts, including the exercise of authority and agency, irrespective of scale. The arguments about this at the global and national level are well-rehearsed (O'Neill et al., 2020; Rosen, 2021) and we propose, these are equally valid at the local level.

For the global parallel-scenario process to connect to local contexts in culturally meaningful ways, scenarios should be formally reviewed during their development to assess the extent to which they are relevant, credible, and legitimate for local stakeholders, and not just for researchers. They need to be made relevant by ensuring expert knowledge is contextualized for local concerns, conflicts, and aspirations. The processes cannot privilege the expert over the local and must provide credible and legitimate ways in which the future can be plausibly negotiated. We propose that the consistent use of heuristics, rather than formal definitions, for assessment criteria are important, and that the definitions produced by Belcher et al. (2016) and restated earlier provide a means of creating consistency between case studies. Inevitably these will be subject to review over time, as they have already. However, a consistency of approach in practical examples appears the most useful next step.

It is the local's inherent complexity that makes the political so critical to an overarching understanding of adaptation options. Accommodation of this complexity must address not just the rigors of sound research but also the trade-offs and stressors described. While absolute definitions for criteria have an obvious attractiveness, the dynamic around the terms used and the concerns their use seeks to address (see Cash and Belloy, 2020 for a deeper discussion) reinforce that these should be seen as heuristics which, as demonstrated so clearly by Nalau et al. (2021) must retain a high degree of flexibility. That does not, however,

imply a casual approach. Only by consistently applying these heuristics can we counter Elsawah et al.'s critique (Elsawah et al., 2020, p. 13) that such concepts are developed but not used.

## DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

## AUTHOR CONTRIBUTIONS

NC-H and BF: conceptualization, writing—reviewing, and editing. NC-H: funding acquisition. All authors contributed to the article and approved the submitted version.

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**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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