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Four approaches to anticipatory climate governance: Different conceptions of the future and implications for the present

Karlijn Muiderman^{1,2} | Aarti Gupta¹ | Joost Vervoort^{2,3,4} | Frank Biermann²

¹Environmental Policy Group,
Department of Social Sciences,
Wageningen University and Research,
Wageningen, The Netherlands

²Environmental Governance, Copernicus
Institute of Sustainable Development,
Utrecht University, Utrecht, The
Netherlands

³Environmental Change Institute,
University of Oxford, Oxford, United
Kingdom

⁴Research Institute for Humanity and
Nature, Kyoto, Japan

Correspondence

Karlijn Muiderman, Environmental Policy
Group, Department of Social Sciences,
Wageningen University and Research,
Wageningen, The Netherlands.
Email: karlijn.muiderman@wur.nl

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Abstract

In times of accelerating earth system transformations and their potentially disruptive societal consequences, imagining and governing the future is now a core challenge for sustainability research and practice. Much social science and sustainability science scholarship increasingly engages with the future. There is, however, a lack of scrutiny of how the future is envisioned in these literatures, and with what implications for governance in the present. This article analyses these two aspects, building on the concept of “anticipatory governance.” We understand anticipatory governance to broadly mean *governing in the present to adapt to or shape uncertain futures*. We review perspectives within public policy, futures studies, social–ecological systems, environmental policy and governance, transition studies, science and technology studies, and responsible research and innovation literatures. All these literatures engage explicitly or implicitly with the notion of anticipatory governance, yet from distinct ontological and epistemological starting points. Through our review, we identify *four approaches* to anticipatory governance that differ with regard to (a) their conceptions of and engagement with the future; (b) their implications for *actions to be taken in the present*; and (c) the *ultimate end* to be realized through anticipatory governance. We then map onto these four approaches a diverse set of methods and tools of anticipation that each engages with. In concluding, we discuss how these four approaches provide a useful analytical lens through which to assess ongoing *practices* of anticipatory governance in the climate and sustainability realm.

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anticipation, anticipatory governance, climate change, climate policy, foresight

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1 | INTRODUCTION

In times of accelerating earth system transformations and their potentially disruptive societal and distributional consequences, sustainability research and practice is increasingly focusing on imagining and governing the future (Vervoort & Gupta, 2018). The Paris Climate Agreement's aspirational 1.5° target—to strive to keep average temperature increases to 1.5° above pre-industrial levels—has given further impetus to anticipation processes and tools to explore and realize plausible or desirable “climate futures” (Granjou, Walker, & Salazar, 2017). With the proliferation of anticipation practices in diverse policy arenas, the (sustainable) future of our societies has become a central element in scholarly and policy debate.

Numerous processes and practices are used today to imagine futures, to question assumptions about what futures are possible, and to develop strategies for transformational change (Habegger, 2010). Such anticipation processes often seek to broaden the boundaries of imagination, explore future directions under multiple drivers of change, and guide sustainability transitions and policies under conditions of complexity and scientific uncertainty (Bourgeois, 2012; Habegger, 2010; Pérez-Soba & Maas, 2015; Vervoort & Gupta, 2018)

Most formal approaches to anticipation relate to foresight, including qualitative and quantitative scenario planning, visioning and backcasting, horizon scanning, anticipatory gaming, and other approaches (Swart, Raskin, & Robinson, 2004; Turnpenny, Jordan, Benson, & Rayner, 2015; Wiebe et al., 2018). Other formal anticipation practices include vulnerability and impact assessments. But anticipation also happens without formal methodologies and processes; such informal attempts are also worthy of investigation.

The growing focus on anticipation in sustainability governance points to an important research agenda: to scrutinize the diverse conceptions of the future embedded with diverse perspectives, and how these shape present-day governance and policy choices. While important strands of social science scholarship, including in science and technology studies, responsible research and innovation, geography, environmental governance, and futures studies, have long pointed to anticipatory processes as sites of political negotiation (Anderson, 2007, 2010; Hulme, 2009, 2010; Mittelstadt, Stahl, & Fairweather, 2015; Nordmann, 2014), a comprehensive analysis of distinct perspectives on anticipatory processes, and their role in imagining, interrogating or seeking to realize diverse climate futures, remains timely, and urgent (Vervoort & Gupta, 2018; Pulver & VanDeveer, 2009).

This is the aim of our review. We survey a range of social science and sustainability science perspectives here that engage with conceptions of the future and associated present actions. The organizing concept for our review is the notion of “anticipatory governance,” broadly understood as *governing (or steering) in the present to engage with, adapt to or shape uncertain futures* (Vervoort & Gupta, 2018; see also Boyd, Nykvist, Borgström, & Stacewicz, 2015; Fuerth, 2009b; Guston, 2010, 2012, 2014). We see anticipatory governance as part of long-standing debates on governing for sustainability (e.g., Andonova, Betsill, & Bulkeley, 2009; Biermann, 2007; Bulkeley, 2012; Gupta & Möller, 2018) to which it adds an explicit future-orientation. Understood as such, large swaths of literature in the social and sustainability sciences engage directly or indirectly with anticipatory governance, regardless of whether the term is explicitly used. Our aim here is to critically assess these perspectives, to unearth diverse conceptions of the future and implications for governance in the present.

We proceed as follows: Section 2 describes in some detail the methodology we used to conduct our literature review. In section 3 we highlight how social science and sustainability science scholarship engages, both explicitly and implicitly, with the notion of anticipatory governance. In section 4, we draw on this overview to identify *four distinct approaches to anticipatory governance discernible* in the reviewed literature. Section 5 maps onto these four approaches a range of methods and tools of anticipation that they utilize. In concluding, we highlight how the four approaches to anticipatory governance that we identify in this review provide a useful analytical lens through which to assess the ongoing *practices* of anticipatory governance now underway in the climate and sustainability realm.

2 | METHODOLOGY

We explain here how we identified the literature to be reviewed, and how we conducted our review.

Our dominant methodology was to undertake a narrative-style interpretative review in order to identify diverse perspectives on anticipatory governance in a representative sample of social science and sustainability science literatures that explicitly and implicitly engage with the term. We relied on qualitative methods that are suitable to our aim of describing, synthesizing and furthering conceptual understanding of a key concept (in our case “anticipatory

governance”), rather than undertaking a comprehensive author-centered or article-centered review that draws on quantitative methods to build or test theory (Rowe, 2014).

While concepts such as anticipation, foresight, futures, and forward-looking governance are ever more widely used in social science and sustainability science scholarship, the term “anticipatory governance” is explicitly used by relatively few strands of writing. We thus identified and reviewed studies that explicitly use this term but also those that address related future-oriented governance.

2.1 Identifying and selecting literature

We identified the literature to be reviewed in three steps, aiming at a representative sample rather than at comprehensiveness.

First, we searched for articles in the SCOPUS database that explicitly deploy the term “anticipatory governance.” Specifically, we looked for articles that contained the term “anticipatory governance” in the title, abstract, or keywords. We limited this search to journals in the social sciences and environmental sciences, as defined by SCOPUS. This step yielded an initial set of 57 articles. Through scanning the titles and abstracts of these 57 articles, we excluded 10 that were too far removed from the climate and sustainability domain (dealing, e.g., with health or security). This resulted in 47 articles that covered topics such as “anticipatory risk governance,” “anticipatory governance and foresight,” “anticipatory governance for social-ecological resilience,” “anticipatory climate governance,” “anticipatory governance of emerging technologies,” and “anticipatory governance of innovation.” In a second step, we went through the citations and reference lists of these 47 articles, to identify any further articles that explicitly mentioned anticipatory governance (but may not have been captured in our initial search, because they were not categorized as social or environmental sciences within Scopus; Verschuren & Doorewaard, 2010). This process yielded another 24 articles using this term. In a third step, we scanned the references in these 71 articles to identify related literature that engages with future-oriented governance, without explicitly using the term anticipatory governance. Here we looked for terms such as “anticipation,” “anticipatory planning,” “anticipatory knowledge,” “anticipatory democracy” but also “sociology of the future,” “foresight,” and “scenarios.” This yielded another 73 articles, resulting in a set of 144 articles that formed the basis for our review. Through this approach, we sought to identify a broad, representative sample of relevant articles in a large swath of social science and sustainability science scholarship that engages with anticipatory and future-oriented governance.

2.2 Process and method of review

We then analyzed these 144 articles to unpack their understandings of anticipatory governance. We looked, specifically, for three elements that often remain implicit and are under-analyzed in studies on future-oriented governance: (a) diverse *conceptions of and engagement with the future*, including its knowability and manageability; (b) implications for governance and policy *actions to be taken in the present*; and (c) the *ultimate aim* of engaging in anticipatory governance. We had identified the first two elements as important to scrutinize in an agenda-setting article on anticipatory climate governance (Vervoort & Gupta, 2018), which called for conceptual and empirical scrutiny of how often-implicit conceptions of the future influence present-day policy choices. We thus included these two elements in our present review, and added a third important and under-analyzed element, namely the ultimate aim of engaging with anticipatory governance.

In scrutinizing the selected literature to ascertain diverse perspectives on these three component elements, we did not prespecify their possible content. Instead, we read the literature in an open-ended manner, with an eye to identify inductively the range of ways in which the future was being conceptualized and presented; the governance and policy actions in the present to be taken; and the array of possible ends to be realized. Doing so allowed us to identify four main approaches to anticipatory governance in the reviewed literature, with we present and discuss in detail in Section 4, and synthesize in the form of Figure 1.

We also assessed the selected literature against a fourth element: the range of tools and methods of anticipation relied upon in diverse approaches to anticipatory governance, as well as roles proposed for stakeholders. In section 5, we outline diverse anticipatory methods and tools, and their alignment with the four approaches to anticipatory governance identified earlier. Figure 2 synthesizes and presents an overview of this aspect of our analysis.

While broad categorizations are immanent to any literature review, we should note at the outset that our intention here is not to imply strict boundaries between these four approaches. Nor do we seek to rigidly link the four anticipatory governance approaches to specific authors, scholarly articles or research traditions in the social and sustainability sciences. Instead, we view these as ideal-types, with our aim being to critically interrogate and broadly map diverse perspectives on an important phenomenon in the study and practice of sustainability: forward-looking anticipatory governance that engages with diverse visions of sustainable futures. We should also note that not all 144 papers we reviewed are referenced in the article, instead, we chose representative writings to illustrate the four approaches we identify here.

3 | ANTICIPATING AND SEEKING TO GOVERN THE FUTURE: A BRIEF OVERVIEW

Before presenting the four approaches to anticipatory governance in the following section, we first provide here a broad, general overview of how the concept of anticipatory governance is addressed, both explicitly and implicitly, in the reviewed literature. This broad overview provides the context for our more specific discussion of the four approaches to anticipatory governance in Section 4.

3.1 Explicit engagement with the concept of anticipatory governance

To start with the notion of anticipatory governance is explicitly used in four influential strands of social science and sustainability science scholarship.

First, an influential perspective on anticipatory governance has emerged out of a concern with possible disruptive consequences of scientific and technological innovations (Barben, Fisher, Selin, & Guston, 2008; Guston, 2012; Macnaghten et al., 2014; Stilgoe, Owen, & Macnaghten, 2013). This perspective connects science and technology studies, responsible research and innovation, and environmental governance literatures. David Guston, a leading scholar in this tradition, defines anticipatory governance as “a broad-based capacity extended through society that can act on a variety of inputs to manage emerging knowledge-based technologies while such management is still possible” (Guston, 2014, p. 219). In this view, anticipatory governance is a nonpredictive approach to enhance present-day preparedness, including through building capacities in foresight and multi-stakeholder engagement, all to steer away from possible disruptive impacts of novel technologies in the future (Anderson, 2007; Barben et al., 2008; Guston, 2012, 2014; Nielsen, Fredriksen, & Myhr, 2011; Stilgoe et al., 2013). The future is conceived here as being inherently uncertain but which can nonetheless be acted upon in the present, with a focus on building society-wide capacities to anticipate and navigate future trajectories.

Second, anticipatory governance is explicitly addressed in national security policy analyses, particularly in the United States. Anticipatory governance is envisioned here as governance that can manage crises *ex ante* to prevent their destabilizing effects (Boston, 2017; Fuerth, 2009b; Fuerth & Faber, 2013; Ramos, 2014). Building on Toffler's (1970b) notion of anticipatory democracy, some scholars in this tradition argue for developing new forms of representative governance that can operate proactively “in the face of crushing decisional overload, or political future shock” (Toffler, 1970a, p. xii, see also Bezold, 2006, p. 36; Ramos, 2014). Anticipatory governance is seen here as a way to address future challenges posed by the accelerating rate and complexity of social change. Such perspectives on anticipatory governance focus on the adaptive capacity of national planning systems (Fuerth & Faber, 2013), among others regarding climate change. Studies in this tradition imply that the future can be governed and risks prevented as long as anticipatory governance is enabled through “a system of institutions, rules, and norms that provides a way to use foresight, networks, and feedback for the purpose of reducing risk” as a means of engaging with the future (Fuerth, 2009a, p. 29). Thus, the future is conceived of as containing reducible risks, which can be acted upon and mitigated through improved planning processes in the present.

A third strand of writing that explicitly engages with the concept of anticipatory governance has emerged in sustainability science, for instance in the area of climate adaptation and resilience (Bates & Saint-Pierre, 2018; Boyd et al., 2015; Hurlbert & Gupta, 2019; Serrao-Neumann, Harman, & Low Choy, 2013). This research engages with extant

notions of anticipatory governance (e.g., Fuerth, 2009b; Guston, 2014; R. Quay, 2010) by seeking to provide “an alternative planning approach to address the adaptation challenge” (Serrao-Neumann et al., 2013, p. 441 see also Boyd et al., 2015). This approach seeks to develop proactive strategies to adapt and build the necessary resilience to contend with uncertain environmental futures (Boyd et al., 2015). The novelty lies in seeking to steer away from short-term decision-making to longer-term policy visioning in ways that can anticipate change and help realize more sustainable futures. Such perspectives also highlight the role played in anticipatory processes by local communities and a diverse array of stakeholders (Boyd et al., 2015; Serrao-Neumann et al., 2013; Tschakert & Dietrich, 2010).

Fourth, there is a more critical line of research with explicit reference to anticipatory governance in global environmental governance and environmental policy literatures (Gupta, 2001, 2004, 2011; Jansen & Gupta, 2009; Mittelstadt et al., 2015; Talberg, Thomas, Christoff, & Karoly, 2018; see also Low, 2017). Anticipatory governance is understood here as the attempt to govern under conditions of extreme scientific uncertainty and normative conflict over the very existence and nature of future environmental and technological risk and harm (Gupta, 2001, 2004, 2013). These studies in global environmental governance emphasize the need for critical scrutiny of anticipatory practices as contested sites of politics.

3.2 Implicit engagement with the concept of anticipatory governance

In addition, three broad fields of study in the climate and sustainability domain engage with processes of anticipation and foresight, without using the term anticipatory governance explicitly.

The first is futures studies with its strong methodological focus on anticipating and imagining futures, including in a sustainability context. While a lack of critical social science scrutiny of future-oriented anticipatory practices, such as scenario building, is noted to be an important research gap (Vervoort & Gupta, 2018), scholars in future studies have spearheaded the study of anticipatory practices and data on which other research communities have relied. Such anticipatory practices are often closely connected to policy to support long-term planning on complex and uncertain issues, such as climate change. Scenario thinking first picked up steam in futures studies in the 1960s, owing to publications such as *The Year 2000* by Kahn and Wiener (Kahn & Wiener, 1967; also Wack, 1985) and the launch of a specialized journal *Futures* in 1968. Since the late 1960s and early 1970s, envisioning environmental futures have been a matter of global concern, due to publications such as *Limits to Growth* by the Club of Rome in 1972 (Meadows, Meadows, Randers, & Behrens, 1972) and the 1972 United Nations Conference on the Human Environment in Stockholm (Granjou et al., 2017). The growing concern with long-term thinking and assessments of futures has also been taken up in fora such as the Intergovernmental Panel on Climate Change Assessment Reports, including its Shared Socio-Economic Pathways (Riahi et al., 2017), as well as in integrated assessment models (O'Neill et al., 2014), UNEP's Global Environmental Outlook, the Millennium Ecosystems Assessment and other assessments (Bell, 2001; Kok, Biggs, & Zurek, 2007; van Vuuren, Kok, Girod, Lucas, & de Vries, 2012).

As a result of decades of such global scientific assessment work, of which scenarios are a key component (Loveridge & Street, 2005; van Notten, Rotmans, van Asselt, & Rothman, 2003; Vervoort, Bendor, Kelliher, Strik, & Helfgott, 2015), futures studies offer extensive research and insights on anticipatory methods to explore climate-impacted futures (Swart et al., 2004). It focuses on imagining and representing multiple alternative climate futures to guide climate mitigation and adaptation decision-making, under conditions of complexity and uncertainty (Sova et al., 2015; Vervoort et al., 2015). All strands of futures studies include anticipatory objectives (Rossel, 2010) but they are characterized by different epistemologies (Ramírez & Selin, 2014; Wilkinson & Eidinow, 2008). Some strands of futures studies are concerned with probabilistic foresight, which assumes that probabilities can be assigned to multiple futures. In this view, by analyzing how present-day driving forces steer future outcomes, one can guide policy planning and determine policy measures and investments. Other strands of futures studies are more concerned with viewing futures and the plausibility assigned to them as socially constructed (Ramírez & Selin, 2014; Wilkinson & Eidinow, 2008)

A second research field can be broadly defined as focusing on transformations and systems resilience (Feola, 2015; Folke, 2006). Within this diverse and interdisciplinary space, anticipation is often seen as a way to advance the transition of complex systems toward more sustainable trajectories (Loorbach, Frantzeskaki, & Avelino, 2017; Rotmans & Loorbach, 2009). Here, anticipatory engagement with potential futures is seen as essential to support sustainability

transitions and transformations (Hansen & Coenen, 2014; Mok & Hyysalo, 2018), where processes of anticipation “act as harbingers of the future” to support pro-active, long-term planning of societal innovation, including through deliberation (Loorbach, 2010; Rotmans & Loorbach, 2009, p. 190). Related literature on resilience sees anticipation as part of proactively governing social-ecological systems towards sustainability (for a review of conceptual approaches to transformations, (Chaffin et al., 2016; see Feola, 2015; Patterson et al., 2017). Also here, anticipation is seen as a prerequisite for transformations. This includes both anticipation of the unintended consequences of social and technical innovation as well as possible opportunities for changing the system (Chaffin et al., 2016; Hebinck, Vervoort, Hebinck, Rutting, & Galli, 2018).

A third, critical domain of thinking on anticipation focuses on interrogating the normative claims underlying anticipatory processes and the potential disconnect between anticipating futures versus making present-day choices in governance. For example, Bell emphasizes that “futurists have done a great deal of practical methodological work on the prediction problem, but they have done less to justify their judgments of preferable futures” (Bell, 2001, p. 72). Recent writings have emphasized how reflexivity about the politics of future-oriented anticipation processes is missing in most futures studies, particularly regarding how the future is framed and what power such frames have over present governance (Vervoort & Gupta, 2018).

Such critical thinking on anticipation is also a mainstay of research in science and technology studies, sociology of the future, and responsible research and innovation (Bellamy, 2016; Jasanoff & Kim, 2015; Jasanoff & Markle, 2008; Nordmann, 2014; Selin, 2008). A key focus in such writings is on how practices of anticipation—and the ideas of the future expressed therein—are sites of political conflict and negotiation. For example, Selin (2008, p. 1892) suggests that “as social scientists begin to weave their own accounts of futures, they should pay attention to the politics of such rendering.” Writings in this vein also engage with the notion of “sociotechnical imaginaries” by Jasanoff and Kim (2009, 2015), who define such imaginaries as “collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order, and attainable through, and supportive of, advances in science and technology” (Jasanoff & Kim, 2015, p. 4). This line of research then interrogates how such sociotechnical imaginaries frame the possibilities for action in the present and have performative effects by casting some futures as more desirable, attainable, or even imaginable than others. For example, Esguerra (2019) investigates the socio-material politics of different “future objects.” Anderson (2010) offers an analysis from the perspective of geography about how the future is problematized as indeterminate or uncertain, and investigates different ways of engaging with such “problematic” futures, including through reliance on, inter alia, pre-emption, precaution, and preparedness.

4 | FOUR APPROACHES TO ANTICIPATORY GOVERNANCE: DIVERSE CONCEPTIONS OF THE FUTURE, ACTIONS IN THE PRESENT, AND ULTIMATE AIMS

With this broad overview of both explicit and implicit understandings of anticipatory governance in the literature, we now turn to distill similarities and differences across them, in terms of: the conceptions of the future, implications for present actions, and ultimate aims to be realized. This allows us to delineate four distinct approaches to anticipatory governance in the reviewed literature.

In distilling diverse *conceptions of the future*, we scrutinized assumptions about the knowability and manageability of the future. Our review yielded four (ideal-typical) ways in which the future is being conceptualized and engaged with in the literature: (a) assessing *probable (and improbable)* futures; (b) contending with multiple *plausible* futures; (c) imagining diverse *pluralistic* futures; and (d) scrutinizing the *performative* potential of future imaginaries.

In distilling associated *actions in the present*, we inductively identified four ideal-typical categories of present-day actions flowing from diverse conceptions of the future. These included: (a) formal planning and strategy development; (b) building broad-based societal preparedness and capacities; (c) mobilizing diverse actors; and (d) interrogating discursive and material effects in the present.

Finally, with regard to *ultimate aims*, we inductively identified the following four ideal-typical ends to be realized through engaging with anticipatory governance: (a) to mitigate or reduce future risk; (b) to reflexively navigate diverse

uncertain futures; (c) to imagine and co-create new futures; and (d) to shed light on the political implications in the present of speculative future imaginaries.

Through combining these diverse ways of engaging with the future, associated present actions, and ultimate aims, we distill four broad approaches to anticipatory governance discernible in social and sustainability science scholarship. We describe these below and summarize them also in Figure 1.

4.1 Approach 1: Probable futures, strategic planning, and risk reduction

The first approach to anticipatory governance that we identify here assesses probable and improbable futures and prioritizes strategic planning in the present, with the ultimate aim of future risk reduction. This approach is most clearly discernible in perspectives in the public policy and planning literature that explicitly deploy the notion of anticipatory governance as well as in some probabilistic futures studies. There are some similarities between this and the second approach, namely that both see futures as complex and uncertain; however, proponents of Approach 1 predominantly argue that future risks can be prevented and future opportunities can be shaped.

Conception of the future: This first approach to anticipatory governance is concerned with identifying and assessing the probability of different futures. It assumes that future risks and uncertainties can be made partially knowable and manageable and that such knowledge can be gained by reducing scientific uncertainty and complexity regarding the directions of future change. In this approach, probable futures are identified by analyzing patterns of the past, which can shed light on and help to explore future trends and their probabilities (see e.g., Börjeson, Höjer, Dreborg, Ekvall, & Finnveden, 2006; Cuhls, 2003). At the same time, there is also a concern with exploring improbable/low-likelihood futures that may have a high impact on society. Part of the rationale for exploring improbable futures is to develop knowledge infrastructures for detecting early warnings of low-probability but high-impact contingencies (Fuerth, 2009a; Fuerth & Faber, 2013).

Actions in the present: Flowing from the manner of engaging with the future as above, this approach to anticipatory governance focuses on prioritizing “mission-oriented” policy action in the present, through analyzing the policy consequences of futures with different probabilities (Fuerth & Faber, 2013). In this view, scientists, engineers, and policymakers, or policymakers in whole-of-government approaches, can strategically prioritize and plan the future in the present, pre-empt future threats (Fuerth & Faber, 2013; Stockdale, 2013) and protect long-term societal interests and future investments (Boston, 2017). According to Fuerth, anticipatory governance “improves the capacity to organize planning and action in ways that mobilize the full capacities of governments, and... speed [s] up the process of detecting error and propagating success” (Fuerth, 2009b, p. 31). Thus, the future is conceived as containing reducible risks, which can be acted upon in the present through improved knowledge infrastructures and strategic planning processes.

Ultimate aim: The aim here is to reduce future risks, by strategically designing policy trajectories that minimize and steer away from high-risk scenarios (Kuzma, Romanchek, & Kokotovich, 2008), stay ahead of destabilizing developments (Cuhls, 2003; Fuerth, 2009a) and thereby “win the future” (Fuerth, 2009b; Fuerth & Faber, 2013) and “safeguard the future.” In this view, expert-driven strategic planning can help to steer toward a more desired future in which risks are reduced and opportunities are seized.

4.2 Approach 2: Plausible futures, enhanced preparedness, and navigating uncertainty

The second approach to anticipatory governance we identify here envisions multiple plausible futures, and calls for enhancing preparedness and building capacities in the present to be able to reflexively navigate diverse (uncertain) futures. This approach is discernible in writings on responsible research and innovation and some strands of climate policy and governance literatures, as well as anticipation-focused scholarship in the interdisciplinary transitions and transformations literature. Thematic foci here include future environmental and societal impacts of climate change as well as governance of novel technologies, such as nanotechnology, biotechnology, or geoengineering (see

e.g., Douglas & Stermerding, 2014; Fonseca & Pereira, 2014). Even though some similarities exist with Approach 1, this approach emphasizes the need to enhance preparedness to reflexively steer sociotechnical developments in mitigating potential future harms.

Conception of the future: This approach sees more fundamental and irreducible uncertainties in the future. This makes multiple future trajectories possible that are all plausible and that cannot be ranked or reduced to one single most likely future (Guston, 2014; Michelson, 2016; see also Selin, 2011). Considering that multiple plausible futures exist, and that plausibility itself is considered a matter of individual and group subjectivity (Ramírez & Selin, 2014), their content can only be legitimately envisioned through broad deliberation (Boyd et al., 2015; Guston, 2014; Rotmans & Loorbach, 2009).

Actions in the present: An engagement with the future that recognizes multiple plausible future trajectories then calls for the development of adaptive capacities and a state of preparedness in the present, to navigate diverse future trajectories. Such preparedness should involve a broad range of actors in reflexive modes of future-making as well as futures-based decision-making (Guston, 2014; Sadowski & Guston, 2016). Guston (2014), for example, highlights the need for reflexivity in contemplating technological trajectories and progress, such that contingencies and possible disruptions can be better anticipated and prepared for *ex ante*. Future stakes should be brought into a reflexive conversation in dialogic spaces that include scientists, engineers, and policymakers (Davies & Selin, 2012; Wiek, Guston, van der Leeuw, Selin, & Shapira, 2013).

The call for upstream public engagement (Fuller, 2009; Macnaghten, 2009; Macnaghten et al., 2014) is hence critical for this second approach. It is seen as important to include the concerns and hopes of lay publics who can support more socially robust technological development or climate adaptation planning (Lister, Brocki, & Ament, 2015; Nykvist, Borgström, & Boyd, 2017; Serrao-Neumann et al., 2013). Anticipatory methods are used to exchange knowledge between experts and lay people, with anticipation understood here as being more about “practicing, rehearsing or exercising a capacity in a logically, spatially, or temporally prior way, than it is about divining a future” (Guston, 2014, p. 226).

Ultimate aim: Whereas in the first approach, anticipatory governance aims at reducing future risks, this second approach focuses on preparedness to adapt to technological innovation and socio-ecological change, with the ultimate aim being to reflexively navigate uncertain futures (see also Pickering, 2019).

4.3 Approach 3: Pluralistic futures, societal mobilization and co-creating alternatives

The third approach to anticipatory governance that we identify here is concerned with imagining diverse pluralistic futures, to mobilize societal actors in the present to co-create desired futures. It draws primarily on perspectives in futures studies and views on anticipation and anticipatory governance in the sustainability sciences. From these perspectives, the socially constructed nature of futures means that all notions of plausibility are subjective: different futures are more or less believable for different audiences. This approach is thus most concerned with collectively imagining radical futures with the aim of co-creating transformative futures.

Conception of the future: This third approach is similar to the second approach inasmuch as it also sees the future as having multiple trajectories that are largely unknowable. It adopts, however, a more explicitly transformative stance. This approach reacts in particular to probability-based and plausibility-based concepts of the future that are seen as too limiting since plausibility is still defined in terms of how futures relate to the present. Ramírez and Selin (2014) for example propose to open up the exploration of future worlds beyond the limiting ideas of plausibility that are tied to the present. Since all knowledge about the future is shaped by interaction and depends on interpretations of the world, different societal notions of the future represent fundamentally pluralistic future worlds (Patterson et al., 2017; Robinson & Herbert, 2004; Zehfuss, 2002). Vervoort et al. (2015) hence tie this fundamental plurality of futures to a plurality of societal presents and pasts.

Actions in the present: Scholars in these traditions thus reject the duality between present and future, expressing a postmodern ontology that prioritizes interaction between multiple presents and future worlds that can be co-created and mobilized through collective action. In this perspective, actions in the present call for prioritizing the imagining and development of pluralistic and actionable pathways to change that can bring together and mobilize societal actors in novel configurations (Swart et al., 2004). All assumptions for change processes can be investigated and all action trajectories can be tested to make them socially robust under various future conditions. Rossel (2010, p. 74) explains, furthermore, that, “robust does not mean ‘true’ nor ‘definitively ascertained’,” but “recognized, shaped, used and perceived as relevant by a variety of social constituencies,” as opposed to one expert or interest group. The collective imagination of new and more sustainable futures is seen as a first step to realizing and achieving alternative futures (Hajer & Pelzer, 2018; Hajer & Versteeg, 2019). One way to do so is to bring societal actors together to imagine new futures through new pathways for change, which can be acted upon in the present (Robinson, Burch, Talwar, O’Shea, & Walsh, 2011). Anticipation in this approach is thus about mobilizing stakeholders to imagine futures and bring these futures to life. It is about co-creating desirable futures through social processes, but also about which future challenges to engage with (Vervoort et al., 2015).

Ultimate aim: This approach makes the closest connection between futures and anticipation on the one hand, and sustainability transformations and transitions on the other (Hajer & Versteeg, 2019; Hebinck et al., 2018). Thus, scholars investigate anticipation here in contexts where new configurations of societal actors are brought together for radical change (Bennett et al., 2016), with the ultimate aim of co-creating new and more transformative futures (Bendor, 2018; Hajer & Pelzer, 2018; Robinson & Herbert, 2004; Sova et al., 2015).

4.4 Approach 4: Performative futures, critical interrogation, and political implications

The fourth approach to anticipatory governance we identify here engages with the future primarily to emphasize the performative power of future imaginaries, in shaping present-day choices and governance trajectories. This perspective is thus most concerned to interrogate and shed light on these performative effects, to reveal their political implications for and in the present. This approach is most fully articulated in writings in science and technology studies, sociology of the future, and critical (global) environmental governance. There are certain similarities between this and the preceding two approaches, including seeing the future as unknowable and calling for opening decision-making to lay public. However, this approach is most fundamentally concerned with interrogating the performative power and politics of engaging with and imagining the future.

Conception of the future: In this fourth approach, the future is marked by irresolvable uncertainties and unknowns. Any attempt to reduce it to something that is manageable inevitably privileges particular ways of thinking and specific priorities. All claims about the future are seen here as political interventions, as representations or “fabrications of the future” (Jasanoff & Kim, 2015, p. 337) that have performative effects in the present (Anderson, 2010; Selin, 2008) all claims about the future, even when developed through deliberative processes, have the power to call into being specific futures by shaping present-day choices. This could be, for example, through limiting future climate mitigation and adaptation possibilities to the pragmatism of current regimes (Pulver & VanDeveer, 2009; Sarkki et al., 2017; Sova et al., 2015), or shaping how novel climate engineering technologies are conceptualized and de facto governed in the present (Gupta & Möller, 2018; see also Talberg et al., 2018). Frames about the future can include both utopian and dystopian visions that create distorted images of social realities and “colonize” the future (Selin, 2007, p. 197). For example, the framing of “climate emergencies” may legitimize and prioritize the development of socially and politically problematic technological solutions in the present (Bellamy, 2016; Gupta, 2019; see also Macnaghten et al., 2014).

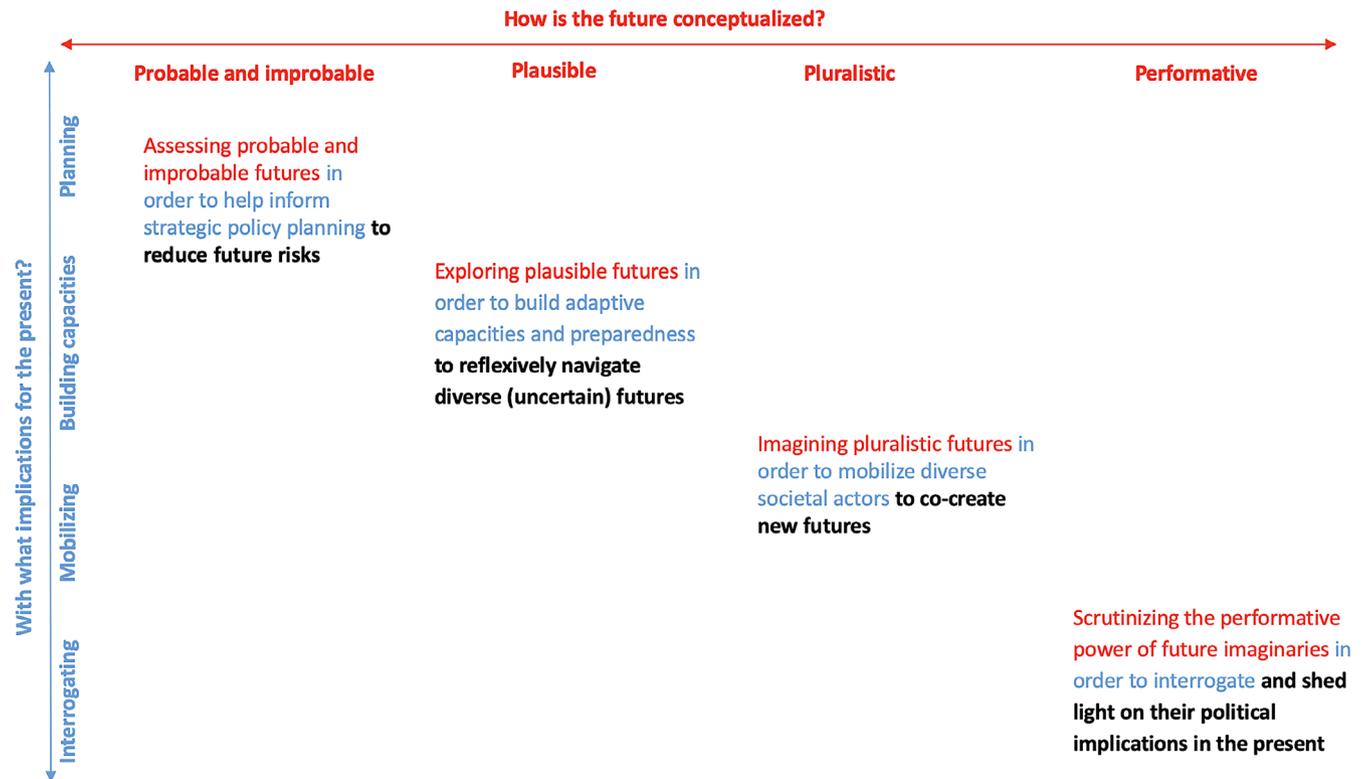
Actions in the present: Given its focus on the performative power of future imaginaries, this approach is most interested in interrogating the discursive and political implications and consequences of such imaginaries for present-day choices (Esguerra, 2019). A key concern is the power of expert knowledge and scientific expertise in calling into being, and engaging with, diverse futures. In discussing the role of science in responses to climate change (Hulme, 2010), climate engineering (Gupta & Möller, 2018; Low, 2017), or other domains of sustainability, such an

approach to anticipation questions whether expert-driven visioning is merely a technical process that can objectively and neutrally engage with the future (see also Mittelstadt et al., 2015). In this view, claim-making about the future must instead be analyzed as a site of political negotiation and conflict (Gupta, 2011; see also Jansen & Gupta, 2009; Talberg et al., 2018). The key focus is to identify the discursive effects of frames or fabrications of the future as they are generated and advanced through practices of anticipation; and to study how these exert power over the present. A priority is to interrogate and be cognizant of how claim-making about the future can hold the present hostage (Nordmann, 2014).

Ultimate aim: In this approach, the ultimate aim of engaging with anticipatory governance and critically interrogating future visions and imaginaries, is to shed light on their performative effects and political implications in the present, including how future imaginaries benefit or exclude certain policy choices, trajectories, sectors, investments, or interests of actors. This approach hence seeks to bring attention back to the present and to the difficult political choices and trade-offs that require redressal now, rather than in an imagined future (Nordmann, 2014).

In Figure 1, we map and visualize these four approaches to anticipatory governance. On the horizontal axis, we illustrate the continuum of views on conceptions of the future that we have discussed above. The vertical axis shows the continuum of views on implications for actions in the present. The four boxes capture the key elements of the four approaches, with the conception of/engagement with the future in red text, the actions to be taken in the present in blue, and the ultimate aim in black.

As we discuss in the conclusion, this mapping of anticipatory governance approaches also serves as an analytical lens through which to further explore the nature and implications of ongoing practices of anticipatory governance, as they are now underway around the world.



Key: Red: what conception of/engagement with the future; blue: how these intersect with actions to be taken in the present; black bold: why/to what end: the desired ends of engaging in/with anticipatory governance
 Source: Developed by the authors

FIGURE 1 Approaches to anticipatory governance: Diverse conceptions of the future and actions in the present

5 | METHODS AND TOOLS OF ANTICIPATION: OVERLAPPING USE AND VARYING ENDS

Having described four approaches to anticipatory governance, we now discuss the tools and methods of anticipation used within, but also across, these four approaches. The reason for this separate section is that the four approaches to anticipatory governance, and methods used herein, are not straightforwardly aligned. Although certain tools and methods align more with a given approach, similar methods and tools can also be used by distinct approaches to anticipatory governance. Furthermore, a single anticipation process can use multiple mechanisms, methods, and tools (Vervoort et al., 2014). For example, one can combine quantitative models with participatory scenario or visioning processes to gain insights into future drivers that may be difficult to imagine (Mason-D'Croz et al., 2016). The purpose of this section, however, is not to explain the use of diverse methods of anticipation in anticipatory processes, but rather to analyze which methods align with which approach to anticipatory governance, and whether some methods are used across different approaches. We conclude our discussion by presenting an overview, in Figure 2, of how tools and methods of anticipation map onto the four approaches to anticipatory governance.

5.1 Anticipatory tools and methods to assess *probable and improbable* futures (Approach 1)

Two sets of anticipatory tools are referred to most often by those subscribing to the first approach to anticipatory governance that we identified, given its focus on calculating probabilities of future risks and on hypothesizing alternative courses of action. These include tools that extend the horizon of awareness to detect risks in the future, as well as tools that set short-term policy priorities based on long-term strategizing (Fuerth, 2009b).

In the first category are tools such as Delphi methods, horizon scanning or future commissions, all of which are intended to enhance the capacity of planners to monitor future events, analyze potential implications, simulate alternative courses of action, ask unasked questions, and issue timely warnings (Boston, 2019; Fuerth & Faber, 2013; Li & Porter, 2018). Additional methods relevant here include cost-minimizing scenarios, forward-looking information services, econometric model calculations, technological forecasting, climate statistics, impact assessments, time series analyses, and trend analyses (Bradfield, Wright, Burt, Cairns, & van der Heijden, 2005; Edwards, 2010; van Notten et al., 2003).

In the second category are tools that set short-time policy priorities *based on long* term strategizing. These include *policy analysis*, *budget analysis*, *organizational crowdsourcing*, *public learning*, *online community tools*, *risk assessment*, and *scenario analysis* (Bezold, 2006; Fuerth, 2009a, 2009b; Ramos, 2014). The envisioned role of science, including social science, and scientific methods is to guide expert-analytical processes and to identify probable future pathways; the role of lay publics is often limited (Cuhls, 2003).

5.2 Anticipatory tools and methods to explore *plausible* futures (Approach 2)

Numerous tools are used in exploring multiple plausible futures, the focus of Approach 2. Some are generally more associated with probabilistic foresight, such as simulation modeling and weak signal-type approaches. However, one can apply the modeling approaches and weak signal approaches to sets of scenarios that are not ordered by likelihood but include a range of futures that are considered plausible (Sampson, Quay, & White, 2016; Quay, 2015; Wender, Foley, Guston, Seager, & Wiek, 2012), therefore still falling within a “plausibility envelope.” Other methods common to both Approaches 1 and 2 include strategic visioning and backcasting, combined with tools to assess risks, vulnerabilities, and monitor changing climate conditions (Boyd et al., 2015; Dougill, Fraser, & Reed, 2010; Fazey et al., 2015; Nicholls, Wong, Burkett, Woodroffe, & Hay, 2008; Rogers, 2011; Wardekker, de Jong, Knoop, & van der Sluijs, 2010). Methods that are prioritized here include those designed to transfer knowledge from experts to local knowledge holders and facilitate bottom-up community involvement in decision-making. Thus, similar methods as used in Approach 1 are used in Approach 2 as well, but are intended to strengthen the anticipatory capacity of governing stakeholders and the agency of vulnerable groups (Boyd et al., 2015; Nuttall, 2010; Tschakert & Dietrich, 2010).

Vulnerable groups in developing countries are of particular concern here, given that access to information, knowledge networks, and learning tools is perceived to be scarce at the community level. Thus, in Approach 2, participatory methods—

including participatory vulnerability mapping, participatory modeling, and participatory scenario explorations—are seen as pivotal to facilitating knowledge transfer from experts to lay groups and for adapting livelihoods, institutions, and ecosystems to uncertain futures (Dougill et al., 2010; Ostrom, 2010; Tschakert & Dietrich, 2010; Voinov & Bousquet, 2010). Equally important for the use of such methods is the balancing and combining of scientific knowledge with citizen knowledge by engaging a variety of stakeholders, such as local governments, scientists, corporations, community networks, and governmental organizations (Boyd et al., 2015; Dougill et al., 2010; Nuttall, 2010). The focus is on building anticipatory capacities in a deliberative fashion (Wiek, Guston, van der Leeuw, Selin, & Shapira, 2013).

Finally, consensus conferences, citizens' juries, deliberative mapping, and deliberative polling and focus groups are also used to explore plausible futures (Bellamy, Chilvers, Vaughan, & Lenton, 2012; Chilvers, 2010; Stilgoe et al., 2013). These tools can stimulate expert-driven interaction between scientists and engineers (Harvey & Salter, 2012; Sadowski & Guston, 2016) but also bring in the public through “upstream public engagement” (Conca, 2019; Guston, 2014; Macnaghten, 2009). Such methods can also improve interaction between scientists and publics, which is seen as crucial for a better mutual understanding of values and goals (Guston, 2010) and the sharing of positive lessons, securing legitimacy and realizing socially robust technologies (Anderson, 2007; Macnaghten, 2009; Stilgoe et al., 2013).

Similar methods are also proposed in the more constructivist futures studies and critical social science literatures that underpin Approaches 3 and 4 (as discussed further below). There, they might be deployed to mobilize diverse actors, thus aligning with the third approach, or to critically interrogate frames of the future, thus aligning with the fourth approach.

5.3 Anticipatory tools and methods to imagine *pluralistic* futures (Approach 3)

In this approach, participatory futures methods and tools are used to mobilize stakeholders to collectively imagine pluralistic transformative pathways. Various methods for the development of participatory futures are used with the understanding that multiple scenarios represent multiple incommensurable future worlds. This differs from the, often implicit, understanding most common in the second approach: that there is a single, shared reality from which multiple future trajectories are possible within the boundaries of plausibility (Vervoort et al., 2015). These innovations and experiments are ideally employed to “embrace uncertainty, discomfort and knowledge gaps, and the connected need to capture and make productive fundamental plurality among understandings of the future” (Vervoort et al., 2015, p. 62). Visions, scenarios, and back-casted pathways are intended to mobilize collective action towards more desired futures (Bennett et al., 2016; Kok et al., 2007; Robinson et al., 2011; Sova et al., 2015; Vervoort et al., 2014) and for “thinking beyond positioned views on today's desirable state” (Sarkki et al., 2017, p. 559). Simulation gaming plays an increasingly important role among the tools associated with this approach (Vervoort, 2019). Methods and tools also include other forms of community dialogues, training, education, and experimentation (Garb, Pulver, & vanDeveer, 2008; Karlsen, Øverland, & Karlsen, 2010; Mayer, 2009). Although a number of these methods overlap with the second approach, the focus here is on creating new shared futures with the purpose of realizing them, as distinct from the focus in Approach 1 on navigating uncertain futures in a more adaptive mode.

Notably, because of the interest in imagining and realizing pluralistic futures, there is a stronger focus within this Approach 3 on methods that allow for the creation of future visions and scenarios that can be engaged with as fully embodied and realized experiences. Such “experiential futures” methods (Candy & Dunagan, 2017) include turning scenarios into interactive theater (Baena, 2017); creating exhibitions (Hajer & Versteeg, 2019; Bendor, Maggs, Peake, Robinson, & Williams, 2017) and design workshops; various experientially focused games from VR games to live-action role-playing games (Vervoort, 2019); and integrating futures into present-day environments such as cityscapes (Candy & Dunagan, 2017). Such methods can and sometimes are used for futures developed from Approach 2 as well, but the match between experiential futures and Approach 3 is more common because of the explicit interest in bringing new desired futures to life.

5.4 Assessing how imagined futures are *performative* (Approach 4)

Methods and tools deployed in critical strands of scholarship on anticipatory governance are, to some extent, similar to those used in other approaches as well, including future scenarios, technology assessment, integrative deliberation, and

vision assessments. However, here such methods are either the subject of, or used for, critical interrogation (Bellamy et al., 2012; Fonseca & Pereira, 2014; Mittelstadt et al., 2015; Selin, 2007, 2008). An example of such critical application is analysis of future narratives and images, which is used to question the limiting assumptions about what futures are possible, to open up dialogue for exploring novel and alternative pathways, and to interrogate the political implications of future visions and pathways for the present (Selin, 2008). Anticipation tools serve here as a heuristic device to identify diverse futures (Sarkki et al., 2017; Talberg et al., 2018) and to democratize anticipatory knowledge production. Here, anticipation mechanisms are primarily investigated as future framings with important political implications in the present (Biermann & Gupta, 2011; Vervoort & Gupta, 2018), rather than as a proxy for merely knowing futures. In this view, participatory and inclusive anticipation practices are vehicles to interrogate and open up dominant framings of the future.

In this section, we discussed methods and tools that are used in and across four approaches to anticipation and anticipatory governance. Figure 2 maps these methods and tools onto our continuum of four approaches to anticipatory governance. The boxes detailing the four approaches are not repeated here again, to improve the readability of the figure. As Figure 2 illustrates many of these methods overlap and can be used across these continua and approaches. The crucial distinction lies thus not so much in type of method used in the four approaches—these can be similar—but in the ends they serve. These ends can vary significantly, as can the associated perceptions of the future and actions in the present (for a recent extensive review of anticipatory tools and methods in envisioning climate engineered futures, see Low & Schäfer, 2019).

Our analysis supplements hence the insight of Anderson (2007, p. 158), who argues that different methods and tools of anticipation “produce different epistemic objects through which future possibilities and potentialities are disclosed, objectified, communicated, and rendered mobile, through the very way in which they are employed.” As our analysis suggests, even if the anticipatory methods are similar, the ways they are employed can vary because of the diverse conceptions of the future they take as a starting point, the actions to be taken in the present that they prioritize, and the end they seek to achieve.

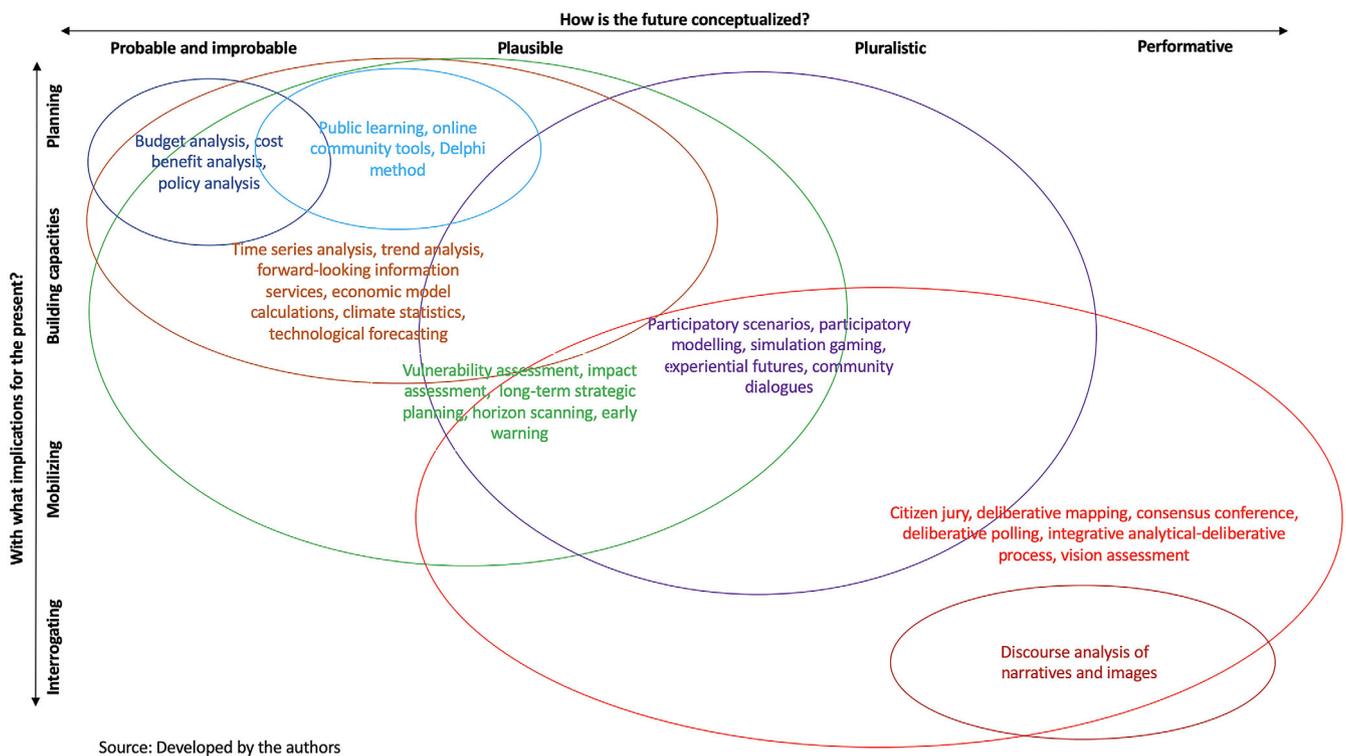


FIGURE 2 Engaging with the future, acting in the present: Diverse tools and methods of anticipation

6 | CONCLUSION

This article has reviewed scholarly writings on anticipation and anticipatory governance in the social science and interdisciplinary sustainability science literatures. Our focus on explicit and implicit notions of anticipatory governance across a wide range of research fields makes our analysis different both in scope and intent from existing typologies of engagements with the future, particularly in futures studies research, which have focused more narrowly on futures methods and content (see, e.g., Bradfield et al., 2005; van Notten et al., 2003; Wilkinson & Eidinow, 2008). We have identified four approaches to anticipatory governance here, each of which embodies different conceptions of the future and actions to be taken in the present, to realize different ends. Divergences across these elements allowed us to identify and map four distinct and internally coherent approaches to anticipatory governance.

Approach 1 to anticipatory governance takes as a starting point that futures are scientifically uncertain and complex, but still assessable in terms of probable and improbable future risks. The role of anticipation is to assess these risks, to inform strategic policy trajectories on how to minimize future risks.

Approach 2 takes as its starting point that the future contains irreducible uncertainties and that multiple plausible future trajectories are feasible. The role of anticipation then is to explore these futures through employing a deliberative approach, to build adaptive capacities and preparedness in the present that allows for diagnosing and navigating diverse, uncertain futures as their trajectories unfold.

Approach 3 conceives of the future as embedding multiple future worlds, shaped by interaction, and dependent on diverse interpretations of the world. Mobilizing diverse societal actors to collectively develop pluralistic, actionable pathways to generating change in the future is the action to be taken in the present, with the ultimate aim of co-creating new and transformed futures.

Approach 4 sees engagement with the future as “fabrications” or sociotechnical imaginaries that are speculative, but still performative in calling into being certain privileged visions of the future. By interrogating these imaginaries for their performative power, for instance, who or what is included or excluded in terms of actors, interests, and framings, the aim is to make clear their political implications and material consequences in and for the present.

We visualized these four approaches to anticipatory governance in Figure 1, with the x-axis depicting a continuum of diverse conceptions of the future; and the y-axis depicting the distinct implications for actions in the present. We mapped and summarized the content of each approach to anticipatory governance in the boxed text, including here the ultimate aim as well.

We also analyzed the tools and methods of anticipation that these four approaches rely on, finding that many of these are common to more than one approach. In Figure 2, we mapped the most widely used anticipation methods and tools onto our four anticipatory governance approaches (as shown in Figure 1), illustrating that similar methods are used in more than one approach to anticipatory governance, even as they serve distinct ends. Our review thus also builds on and complements the analysis in Low and Schäfer (2019), who investigate the conceptions of the future inherent in specific sets of methods and tools (in a climate engineering context).

In conclusion, we should emphasize again, as we did at the outset of our analysis, that our categorization of four approaches to anticipatory governance is not meant to imply hard boundaries between them, nor to suggest silos of scholarly inquiry that rigidly adhere to specific claims and assumptions. Instead, we recognize that the four approaches—and the diverse and overlapping scholarly perspectives underpinning them—cross-fertilize and engage with each other. In distinguishing these four approaches, our aim is to identify ideal-types that serve an analytical purpose: to map and shed light on how distinct ways of imagining and engaging with the future have implications for present-day research and practice in climate and sustainability governance.

Our aim also is to provide an analytical lens through which to further analyze the (likely to be) “messiness” of anticipatory approaches in practice, whereby different conceptions of the future, actions to be taken in the present, and ultimate aims might co-exist in a single anticipation process. This may be the case because different groups of researchers or practitioners collaborate and bring to the table different perspectives. While this could lead to novel outcomes, the result could also be conflict or an uncomfortable subservient role becoming assigned in practice to certain approaches—such as anticipatory activities aimed at creating novel, pluralistic futures (Approach 3) having to fit their outcomes into a process dominated by probabilistic assessments (Approach 1) or vice versa; or researchers focused on plausibility (Approach 2) struggling to engage with a process focused on imagining alternative desirable futures (Approach 3).

However, more deliberate and complementary combinations can also be imagined. For instance, an anticipation process may take as starting point a “multiple future worlds” Approach (3) to imagining the future development of human societies and technologies, but then use a “multiple plausible trajectories” or even “most probable future”

approach (Approaches 2 or 1) to population or climate change projections. In this way, those involved in a process may choose to assign plausibility or likelihood assessments to specific drivers, which then feed into the imagining of more radically pluralistic worlds (Vervoort et al., 2015). Finally, when considering complementarities, there is much potential for work that falls under the critical and interrogative Approach 4 to open up reflective spaces for the other approaches. Critical Approach 4 can identify and create new spaces for imagined futures, and for the inclusion of new groups of societal actors and their perspectives. For instance, Low and Buck (2020) investigate the extent to which responsible research and innovation (RRI) perspectives are an attempt to bring insights relating to performative futures (Approach 4) to enrich Approach 2's focus on enhancing societal preparedness and adaptive capacities.

Related to this, our mapping also serves to highlight that the scholarly perspectives that underpin the four approaches identified here vary in their degree of engagement with anticipatory governance on the ground. Thus, we see our categorization is useful not only because it helps to identify similarities and differences across scholarly engagement with concepts of anticipation and anticipatory governance, but also because it can serve as an analytical lens to assess ongoing *practices* of anticipatory governance that are now underway in various global contexts.

In doing so, a number of questions merit further scrutiny. For instance, an important first-order question is: what types of anticipatory practices are dominant in and around policy processes, and which conception of the future do they take as a starting point? What are the desired ends of engaging with anticipatory governance in policy environments? Our own experience working with anticipatory climate governance processes in the field indicates that Approach 1, focused on mitigating future risk, is far more common in policy environments than any of the other approaches—since it connects more with dominant, pre-existing conceptions of the future among policy makers, in terms of likelihood and risk, as well as with their interest in the development of long-term plans with predictable outcomes. In a similar finding for the specific domain of climate engineering, Low and Schäfer (2019) indicate that participatory foresight associated with what we characterize as Approaches 2 and 3 here still plays a minor role in research on futures, when compared to probabilistic modeling.

If this is the case, what opportunities are missed in the relative lack of prevalence of the Approaches 2, 3 and 4 in practice? What impact might a greater mainstreaming of these other approaches have on anticipatory governance practices, in terms of the inclusion of more plausible context scenarios, more fundamentally pluralistic desirable futures, and more critical investigation of the basic assumptions underpinning anticipatory governance practice? What preconditions would be needed for this, in terms of the future-related skills, backgrounds, and conventions of those involved in climate and sustainability governance? Questions raised about different approaches in practice are very relevant also in climate-vulnerable regions of the developing countries, where anticipation processes are proliferating in climate policy and planning but have not been much researched (but see Biermann & Möller, 2019; Macnaghten et al., 2014; Shi et al., 2016; Vervoort & Gupta, 2018).

Finally, it is important to consider that while we believe the four approaches to anticipation identified in this article cover the breadth of what can be found in diverse relevant literatures, this does not mean that other approaches to anticipation cannot be imagined. It will be worth investigating what other, entirely distinct approaches might be possible, and what such approaches might yield in addressing significant sustainability and climate challenges.

Our identification of four approaches to anticipatory governance allows for better scrutiny of such proliferating practices of anticipation in climate policy and planning contexts around the world. Our aim here has been to further understanding of their nature and implications for research and policy-making, and how they prioritize a range of present-day actions in the effort to realize diverse visions of transformative, climate-safe futures. Finally, we see our framework as offering the potential for reflexive interdisciplinary communication across a range of anticipation and anticipatory governance research communities, to clarify linkages and explore synergies between these approaches.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Karlijn Muiderman: Conceptualization; formal analysis; investigation; methodology; visualization; writing-original draft; writing-review and editing. **Aarti Gupta:** Conceptualization; formal analysis; funding acquisition; methodology; supervision; visualization; writing-original draft; writing-review and editing. **Joost Vervoort:** Conceptualization; formal analysis; funding acquisition; methodology; supervision; visualization; writing-original draft; writing-review and editing. **Frank Biermann:** Conceptualization; methodology; supervision; writing-original draft; writing-review and editing.

ORCID

Karlijn Muiderman  <https://orcid.org/0000-0001-8281-1242>

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