Land Use Policy 164 (2026) 107926

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

A new scenario architecture to capture granularity of governance within and across Shared Socioeconomic Pathways

Simo Sarkki [a,b,c,*], Sirpa Rasmus [b,d], Joachim Otto Habeck [e], Heidrun Matthes [f], Mia Pihlajamäki [g,h], Jussi T. Eronen [i,j]

[a] Cultural Anthropology, University of Oulu, PO Box 1000, Oulu 90014, Finland.
[b] Arctic Centre, University of Lapland, P.O. Box 122 (Pohjoisranta 4), 96101 Rovaniemi, Finland
[c] Max Weber Centre for Advanced Cultural and Social Studies, Erfurt University, Germany
[d] Ecosystems and Environment Research Programme, Faculty of Biological and Environmental Sciences, University of Helsinki, PO Box 65 (Viikinkaari 1), 00014 Helsinki, Finland
[e] Institute for Social and Cultural Anthropology, Universität Hamburg, Edmund-Siemers-Allee 1, 20146 Hamburg, Germany
[f] Alfred Wegener Institute Helmholtz Center for Polar and Marine Research, Telegrafenberg A45, 14473 Potsdam, Germany
[g] Water and Development Research Group, Aalto University, P.O. Box 15200, FI-00076 Espoo, Finland
[h] Natural Resources Institute Finland, Helsinki, Finland
[i] Ecosystems and Environment Research Programme & Helsinki Institute of Sustainability Science (HELSUS), Faculty of Biological and Environmental Sciences, University of Helsinki, PO Box 65 (Viikinkaari 1), 00014 Helsinki, Finland
[j] BIOS Research Unit, Helsinki, Finland

ARTICLE INFO

Keywords:
Land use
Reindeer herding
Adaptive and anticipatory governance
Exploratory scenario archetypes
New scenario architecture

ABSTRACT

Scenario work is a prominent possibility to understand and address pressing socio-environmental sustainability challenges of today and tomorrow. Scenarios depict the possible futures for land-use, and land-use pressures. In this conceptual paper, we propose a novel governance-focused scenario architecture consisting of 1) Shared Socioeconomic Pathways (SSPs), or exploratory scenario archetypes, which explore future uncertainties affected by chosen drivers; 2) Shared Governance Assumptions: governance modes that define the logic of decision-making across the SSPs, and that change the future governance landscapes; and 3) Detailed Governance Assumptions: specific opportunities for agency offered by the varying future governance landscapes defined by SSP – Shared Governance Assumption combinations. We propose a six-step process to employ our scenario architecture, and use the case of land use and Arctic reindeer herding as a brief illustration. We find that our proposed scenario architecture i) offers a structured way to diversify SSP-based scenario sets and to connect SSPs strongly to policy and governance, ii) can be used to explore actor-based trade-offs, and iii) can be used to as a tool for anticipatory governance. Further work is needed to provide empirical applications of our scenario architecture and to innovatively compare and examine implications of different governance modes to targeted normative objectives (i.e. the granularity of governance) within and across SSPs.

1. Introduction

Current socio-environmental sustainability challenges call for urgent and transformative solutions (IPBES, 2024). Climate change (IPCC, 2022) and degrading biodiversity and ecosystem services (IPBES, 2019) are examples of these challenges. Scenarios are widely used to explore plausible futures and to envision sustainable worlds (O'Neill et al., 2020). A scenario is a plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces and relationships. Scenario analysis is a tool that can be used to explore and evaluate the extensive uncertainties associated with possible future development pathways (van Vuuren et al., 2014), and it can also inform strategic planning for building capacity to cope with ongoing and future challenges (Malekpour et al., 2016).

Socio-environmental scenarios have been developed for decades,

* Corresponding author at: Cultural Anthropology, University of Oulu, PO Box 1000, Oulu 90014, Finland.
E-mail addresses: simo.sarkki@oulu.fi (S. Sarkki), Sirpa.Rasmus@ulapland.fi (S. Rasmus), otto.habeck@uni-hamburg.de (J.O. Habeck), heidrun.matthes@awi.de (H. Matthes), mia.pihlajamaki@luke.fi (M. Pihlajamäki), jussi.t.eronen@helsinki.fi (J.T. Eronen).

https://doi.org/10.1016/j.landusepol.2026.107926
Received 4 May 2024; Received in revised form 2 February 2025; Accepted 8 January 2026
Available online 15 January 2026

and synthesis work has identified five exploratory scenario archetypes (Van Vuuren et al., 2012; Hunt et al., 2012; Harrison et al., 2019; Sitas et al., 2019). These archetypes correspond with the Shared Socioeconomic Pathway (SSP) narratives (Pedde et al., 2019). The SSP set includes five societal narratives, each of which can be linked to greenhouse gas emission trajectories: SSP 1: Sustainability; SSP 2: Business-As-Usual; SSP 3: Regional Rivalry; SSP 4: Inequality; and SSP 5: Fossil-Fuelled Development (O'Neill et al., 2013; 2017; Riahi et al., 2017). SSPs were designed as generic and policy free future pathways. The SSPs are part of the original three-dimensional scenario architecture established by the climate change research community in order to facilitate the integrated analysis of future climate impacts, vulnerabilities, adaptation, and mitigation (e.g. O'Neill et al., 2020). In addition to the SSPs, the original architecture includes Representative Concentration Pathways (RCP), and Shared Policy Assumptions (SPA) (Kriegler et al., 2014). The SPA concept was proposed to capture key policy attributes such as the goals, instruments and obstacles of climate change mitigation and adaptation measures, and to add a policy dimension to the matrix (Kriegler et al., 2014), while the different RCPs determine the magnitude of climate change. In this original framework, RCPs identify how much climate change we get, SSPs describe socioeconomic factors, and SPAs describe the policies. Because these aspects are interlinked, the three-dimensional matrix was created. When exploring the RCP-SSP combinations in this matrix, Integrated Assessment Models have been used to assess which combinations are possible.

SSPs include some assumptions on governance related issues under the heading of "policies and institutions": international cooperation (e.g. effective or weak), environmental policy (e.g. priorities and scale of attention to environmental problems), policy orientation (e.g. policy aims including sustainability, security, elite interests, or markets), and institutions (e.g. effective or weak) (O'Neill et al., 2017). Addressing the policy and governance aspects is important as finance, governance, institutional, and policy constraints have been found to constitute the globally most prevalent obstacles to adaptation to climate change (Thomas et al., 2021). Governance aspects have also been globally modelled (Andrijevic et al., 2020). While such global models are important, they tend to assume a rather unified governance approach within each SSP. This approach to governance may be necessary for global modelling, but also leaves open questions regarding more specific governance aspects, and does not enable local applications of the SSP-based scenario architecture or exploring diversity of governance aspects within an SSP.

It has been proposed that there *"is a need to identify SSP–SPA combinations that are tailored to the analysis of sustainable development policies"* (O'Neill et al., 2020: 1080), and that *"A continuous identification of new SPAs for policy scenarios would help the scenario framework stay up-to-date with the rapidly evolving policy landscape"* (O'Neill et al., 2020: 1076). Furthermore, enhancing details regarding legal and governance elements in scenario works combining SSPs and SPAs at multiple scales has been called for (Triyanti et al., 2023). In sum, as we consider that SSPs can benefit from novel ways to be increasingly geared towards governance aspects. Our work in the present paper is significantly inspired by the original three-dimensional scenario architecture and we seek to elaborate it by proposing a new governance-focused approach that integrates scenarios and normative approaches.

In the climate change scenario world, the integration of normative elements into scenario exercises has been hindered by the widespread tenet in climate science communities to be policy-relevant, but policy-neutral (see Havstad and Brown 2017; Livingston and Rummukainen, 2020; Wagner et al., 2024). Examples of combining exploratory scenarios with normative governance aspects include combining transition management and future studies in order to understand the dynamics of societal change and construct alternative pathways to societal transitions (Geels and Schot, 2007; Vähäkari et al., 2020). Such transitions also require power shifts that have been addressed, for example, through the concept of "disruptive seeds" (Rutting et al., 2023). Power shifts include changes in steering mechanisms in the present to shape uncertain futures (anticipatory climate governance; Quay, 2010; Vervoort and Gupta, 2018). Changes in existing policy systems can also be informed by scenarios identifying leverage points to change *"the fabric of legal, political, economic and other social systems"* (Chan et al., 2020: 694). Together, the above points stress the importance of combining normative considerations and exploratory scenario exercises. Conceptual tools and methods to do so are currently being developed, but novel solutions are needed.

The aim of our paper is to propose the concepts of Shared Governance Assumptions and Detailed Governance Assumptions, forming a new governance-focused scenario architecture through extending SSPs. The Shared Governance Assumptions consist of selected governance modes and seek to introduce a systematic way of including variation within SSPs, and combine SSPs with governance considerations. The Detailed Governance Assumptions seek to understand varying governance dynamics across SSP – Shared Governance Assumption combinations, and to identify scenario-specific opportunities for agency to advance normative objectives by specific actors.

Land use is one key domain where scenario work is applied, also in connection with SSPs (Popp et al., 2017). In the present paper, we use Arctic land use and reindeer herding as a brief illustration of our governance focused-scenario architecture. Reindeer herding in Finland is practiced both by indigenous Sámi people and ethnic Finn local communities. Arctic land use governance is important means to adapt to and mitigate climate change, to advance energy transition, to gain raw materials, such as timber and minerals, to protect ecosystems, and to enhance opportunities for cultural continuity of traditional nature-based livelihoods, such as reindeer herding. Governance landscape connected to Arctic land use encompasses European, national and sub-national levels, and is linked not only to policy makers, but also to businesses, civil society actors (e.g. ENGOs), local communities, and scientists. Given the multi-level, multi-sector and multi-actor characteristics of the Arctic land use governance, it offers an interesting case to diversify the SSP pathways. We present ten reindeer herding related scenario skeletons, in SSP – Shared Governance Assumption matrix to be fully published elsewhere (Authors, submitted).

Our argument proceeds as follows. In Section 2, we introduce the concepts of Shared and Detailed Governance Assumptions to be used in combination with SSPs or exploratory scenario archetypes. Section 3 identifies six-step approach to employ the proposed scenario architecture in a scenario exercise. Section 4 discusses the novelties of our paper regarding elaboration of the SSPs, applicability of the proposed scenario architecture, and considerations on the contribution of our approach for anticipatory and adaptive governance. Section 5 concludes that our scenario architecture can help to deal with governance aspects and examine plausible realization of normative sustainability objectives across SSPs or exploratory scenario archetypes.

2. Scenario architecture and Governance Assumptions

2.1. The original three-dimensional scenario architecture

In our application of the relevant terminology, we follow van Vuuren et al. (2014) using the term "pathways" for unidimensional descriptions of potential futures, e.g. socio-economic pathways without assumptions of greenhouse gas emissions or climate policies, or greenhouse gas concentration pathways without any explicit assumptions about socioeconomics or policy. A "scenario" is a plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces and relationships. This requires assumptions on socioeconomic development, greenhouse gas emissions, climate policies as well as mitigation and adaptation measures. A much used framework to explore scenarios is the three-dimensional scenario architecture (Fig. 1) proposed by Kriegler et al. (2014) that decomposes driving forces of scenarios into three components: (1) Shared

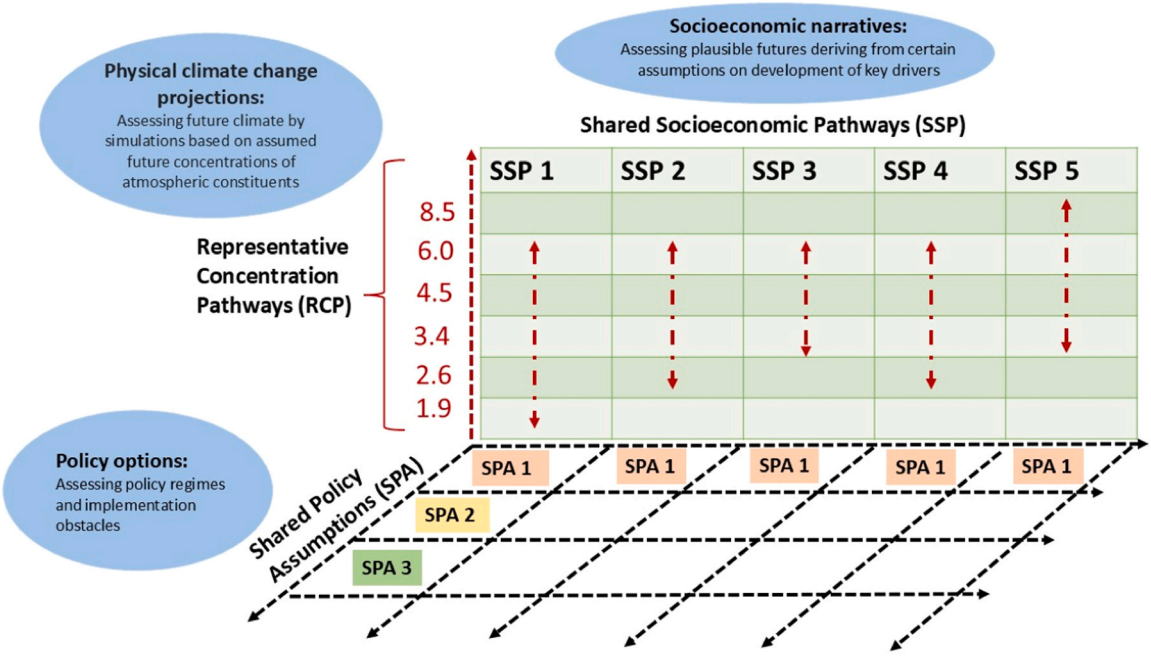

Fig. 1. The original three-dimensional scenario architecture. The concept of the three-dimensional scenario matrix derives from Kriegler et al. (2014), and the estimation of what RCP levels are possible in different SSPs derives from (Rogelj et al. 2018). Assumptions derived from SSPs, RCPs and SPAs then together form a scenario.

Socioeconomic Pathways as socioeconomic component, outlining plausible alternative states of societies at a macro scale and including narrative and quantitative elements of socio-ecological systems, such as demographic, political, social, cultural, institutional, lifestyle-related, economic and technological variables and trends (Frame et al., 2018). (2) the Representative Concentration Pathways (O'Neill et al., 2013) as the physical climate change driver, which were associated with the SSPs by using Integrated Assessment models, where the RCP projections have been connectable to SSPs so that only some RCP levels are possible across the SSP scenario set (Van Vuuren et al., 2014). And (3) Shared Policy Assumptions as the component describing climate change policies, mitigation and adaptation measures. The SPAs have the advantage of screening implications of key policies under different futures described by the SSPs (Kriegler et al., 2014) (Fig. 1).

2.2. Governance assumptions

We introduce a concept of Governance Assumptions to be used in connection with SSPs. Governance Assumptions are separate from SSPs by seeking to make assumptions on future decision making. The same Governance Assumptions work across the SSPs, but some Governance Assumptions may not be possible in all SSPs because of the contraction between the plausible future worlds described by the SSPs and the plausible ways to make decisions in those worlds described by the Governance Assumptions. This logic resembles the idea of the original three-dimensional scenario framework proposing that some RCPs or SPAs are not possible in all SSPs.

The novelty of our Governance Assumptions concepts derives from shifting focus from policy to governance. Governmental policies in a strict sense are no longer the most important ways of making decisions about environmental futures (Armitage et al., 2012). The concept of governance focuses on intersections of governments, market actors, civil society, and science (Lemos and Agrawal, 2006; Primmer et al., 2015; von Benda-Beckmann et al., 2016). Governance can be generally defined as *"the institutions, structures, and processes that determine who makes decisions, how and for whom decisions are made, whether, how and what actions are taken and by whom and to what effect"* (Bennett and Satterfield, 2018: 2). Governance is thus more fluid and wider than the concept of policy, which encompasses (inter-)governmental plans and actions that have been agreed upon. The concept of governance also enables a wider focus on overall rationales or modes for making decisions (Primmer et al., 2015; Pahl-Wostl, 2015), and a smaller-scale focus on decision-making structures and processes regarding specific topics (Newig and Fritsch, 2009) than the concept of policy.

The concept of Governance Assumptions includes the supporting concepts of governance mode and governance landscape. A governance mode consists of general decision-making processes between state, market, civil society, and science, that can take many forms. The governance modes differ from each other in terms of the actors involved and their roles, as well as regarding the logic of the interactions in which decision making is grounded (Pahl-Wostl, 2015). Examples of different governance modes are technocratic, hierarchical, adaptive, collaborative, bottom-up, top-down, strategic, evidence-based, affirmative, corporate-led reactive and proactive (Treib et al., 2007; Primmer et al., 2015). A governance mode is an underpinning logic by which the interactions, decision-making and actors work in a certain future scenario. We consider that the focus on governance modes as an underpinning logic of plausible future decision-making fits well to the scenario thinking. Scenario logic seeks to establish internal consistency between the various statements and assumptions that underpin an exploratory scenario storyline (Rounsevell and Metzger, 2010). Governance modes provide an overarching logic for decision-making and can be deconstructed to consist of set of actors, institutions, decision making structures and processes forming together certain kind of governance landscape.

Governance landscape is to be defined empirically, on a case-by-case basis, and it includes a complex set of actors, a space where new forms of agency and shifts in power and authority from the state may take place towards non-state, civil society, science, and private actors (Bäckstrand et al., 2017; Marquardt et al., 2022). Governance landscape can be viewed as a multilevel system where higher-level policy making may be connected to lower levels by vertical integration, and where societal actors may be horizontally connected (Gupta, 2007; Andonova and Mitchell, 2010). The structures of a multilevel governance landscape

vary, and link to power relations by facilitating some and hindering other interconnections (see Di Gregorio et al., 2019). Unlike the concept of policy regime (Kriegler et al., 2014), which often assumes homogenous functions and objectives, governance landscape is here viewed as a neutral term that does not presuppose certain relationships between governance arrangements (Betsill et al., 2015) and can capture collaboration as well as conflicts and contestations (Marquardt et al., 2022). We consider that governance landscape consists of 1) governance actors from the state, markets, civil society, and science; 2) institutions; 3) decision-making structures; and 4) decision-making processes (Pahl-Wostl, 2015; Bennett and Satterfield, 2018). The governance modes shape and structure the governance landscape leading to different types of outcomes (Table 1; Fig. 2).

2.3. Shared and detailed Governance Assumptions

We propose two types of Governance Assumptions: Shared and Detailed, which can be used in combination or separately in specific scenario exercises. Both add to SSP thinking by assessing policy and governance assumptions outside the SSP logics, thereby connecting SSPs (or exploratory scenario archetypes) better to real world normative objectives and diverse governance landscapes. (Table 2).

Governance Assumptions have two purposes. First, like the SPAs, the concept of Shared Governance Assumptions helps to link the SSPs with policy-relevant thematic narratives (Lenzner et al., 2019). This enriches SSPs for example through exploring regional variation (Pedde et al., 2021) from the governance perspective. Shared Governance Assumptions provide a systemic tool to create variation under a single SSP, for example under SSP 1 on Sustainability (see Lundquist et al., 2021; Sarkki et al., 2023). Fig. 3 outlines our proposal for a new governance-focused scenario architecture consisting of SSPs, Shared Governance Assumptions, and Detailed Governance Assumptions.

Second, Detailed Governance Assumptions address variation within governance landscape where the boundary conditions of each individual scenario are set by the given cell in the scenario matrix (i.e. SSP x Shared Governance Assumptions) (Fig. 3). Detailed Governance Assumptions are scenario-specific assumptions on opportunities of specific actors to advance their normative objectives. Detailed Governance Assumptions enable more fine-tuned possibilities to create scenarios that capture details of a governance landscape without assuming that a single governance mode would always deliver similar outcomes regardless of the governance landscape where the scenario is concretized.

1. Using the Governance Assumptions in scenario exercises

In order to utilize the Shared and Detailed Governance Assumptions scenario architecture, we propose a six-step scenario building process (inspired by Kosow, 2008; Alcamo and Henrichs, 2008; Rounsevell and Metzger, 2010; Falardeau et al., 2019).

Step 1: Choosing the normative objective, targeted actors and the geographic location

Normative objective frames the whole exercise and informs especially the Shared and Detailed Governance Assumptions decided and analyzed in the latter steps. The 17 United Nations Sustainable Development Goals (UN SDGs) offer the possibility to choose from a range of normative sustainability objectives that are widely accepted. Also, other questions related to, for example, climate change, biodiversity loss, ecosystem services, land use, and rural and urban development can be formulated as targeted normative objective. An actor-specific perspective needs also to be chosen; different actors may have divergent views on normative objectives. For example, mitigation of climate change by wind energy production may be a top priority for policy makers, but local groups may oppose wind power due to its land-use impacts. Thus, it is important for transparency that the actor-specific perspective is clearly voiced. Specifying the geographic location is needed to ensure that scenarios are concrete and can actually be constructed by using

Table 1
Governance modes: definitions and examples (a non-exhaustive list).

Governance modes	Definitions
Adaptive governance	Adaptive governance of interdependent social and ecological systems is key to address complex interactions and to manage uncertainty and periods of change. A central characteristic of such adaptive governance is collaborative, flexible and learning-based issue management across different scales (Stockholm Resilience Center, 2016).
Affirmative governance	Affirmative governance is characterized by decision-making which utilizes targeted approaches to alter power dynamics that have previously marginalized, excluded and even discriminated against certain actors. Affirmative governance enables previously excluded groups to participate in (land use) decision-making concerning their lives (see Ribot and Larson, 2012; UNSDG, 2023; UN Human Rights, 2023).
Anticipatory governance	Anticipatory governance is a flexible decision framework that uses a wide range of possible futures to prepare for change and to guide current decisions toward maximizing future alternatives or minimizing future threats (Quay, 2010), and generally implies governing uncertain futures in the present (Vervoort and Gupta, 2018).
Bottom-linked governance	'new forms of democratic governance collaboratively built between social innovation initiatives and activists, their scalarly dynamic networks and state institutions and agencies'. That is, bottom-linked governance involves time-space-specific forms of governance partnership between actors having different scales of influence. As such, it contains the potential to transform social relations and political practices across these different scales (Moulaert et al. 2019).
Bottom-up governance	bottom-up approaches are led by non-governmental actors such as grassroots initiatives, civil society, and local business or administrations. bottom-up governance includes micro- and meso-level non-governmental organisations which emerge in a specific local context. Bottom-up governance emphasizes community governance mechanisms, and are usually characterised by locally-driven and participatory decision-making processes, as well as local and collective distribution of outcomes (e.g. Međugorac and Schuitema, 2023).
Collaborative governance	Collaborative governance brings public and private stakeholders together in collective forums with public agencies to engage in consensus-oriented decision making (Ansell and Gash, 2008). These negotiations seek to include a wide array of diverse stakeholders. The problem in such collaborative arrangements is that they give more power to economic and big interest groups than to marginal actors (e.g. as is usually the case with IPLCs) (see Raitio, 2008).
Co-management	Co-management, or the joint management of the commons, is often formulated in terms of some arrangement of power sharing between the State and a community of resource users (Carlsson and Berkes, 2005).
Evidence-based policy	Evidence-based policy (EBP) refers to the idea that public policy should be based on or informed by scientific knowledge (Sager et al. 2023).
Hierarchical governance	"Hierarchical governance rests on the assumption that it is possible to realize coordination on the basis of power relations, on ordination and subordination. In essence, hierarchical governance is about top-down steering. The classical bureaucratic organization is the prototype of hierarchical governance." (Van Buuren and Eshuis, 2010: 286).
Network governance	Network governance refers to the interdependence of the (many) actors that are involved in planning and governing issues in modern societies. These actors represent a range of interests and perceptions

(continued on next page)

Table 1 (*continued*)

Governance modes	Definitions
	on the problems at stake, as well as on the preferred solutions. Network governance assumes that policy is developed and implemented in networks of organizations (Bouwma et al. 2015)
Non-State Market Driven (NSMD) governance	NSMD systems are defined here as deliberative and adaptive governance institutions designed to embed social and environmental norms in the global marketplace that derive authority directly from interested audiences, including those they seek to regulate, not from sovereign states. Operationally, they use global supply chains to recognize, track, and label products and services from environmentally and socially responsible businesses (Bernstein and Cashore, 2007).
Market governance	Market governance is based upon the economic principles of the interplay between the demands of consumers and the supply of producers. It coordinates through the invisible hand of the price-based system of exchange between self-interested actors (e.g. Williamson, 1985).
Self-governance	Self-governance is a form of governance in which 'the capacity of societal entities to govern themselves autonomously' (Kooiman, 2003: 79) is the central coordinative principle. In self-governance actors make voluntary agreements (see Bouwma et al. 2015)
Technocratic governance	Technocracy is a "system of governance in which technically trained experts rule by virtue of their specialized knowledge and position in dominant political and economic institutions" (Fischer, 1990, 17). In technocratic governance it is assumed "that human problems, like technical ones, have a solution that experts, given sufficient data and authority, can discover and execute. … Its antithesis is decision making through the weighing of forces and compromise" (Kuisel 1981, 76).

geographically specific knowledge (e.g. on climatic and other biophysical realities; socioeconomic conditions), and are linked to a realistic governance landscape.

Step 2: Mapping relevant governance landscape

When mapping the relevant governance landscape, the first option is to start from the chosen actors and think which elements of governance

Table 2
Links of Shared and Detailed Governance Assumptions to normative policy screening and exploratory scenarios.

	Shared Governance Assumptions	Detailed Governance Assumptions
Definition	Assumptions on the overall logic (i.e. governance mode) by which decision-making works; this shapes the governance landscape.	Assumptions on the opportunities for specific actors to pursue targeted normative objectives in varying future governance landscapes.
Link to scenario set	Work across SSPs	Specific for each SSP – Shared Governance Assumption combination
Link to timing in scenario exercise	Identified before building the scenarios	Identified after the scenarios have been built
Question for the normative policy screening	How do different combinations of SSPs and Shared Governance Assumptions vary in terms of their implications to the chosen normative objective across scenario set?	What kind of opportunities do the SSP – Shared Governance Assumption scenarios provide for mobilization of specific actors to advance their normative objectives?
Added value to SSPs	To systematically diversify SSPs or scenario archetypes (e.g. Sustainability scenarios)	To understand potential for agency of particular actors within SSP – Shared Governance Assumption scenarios

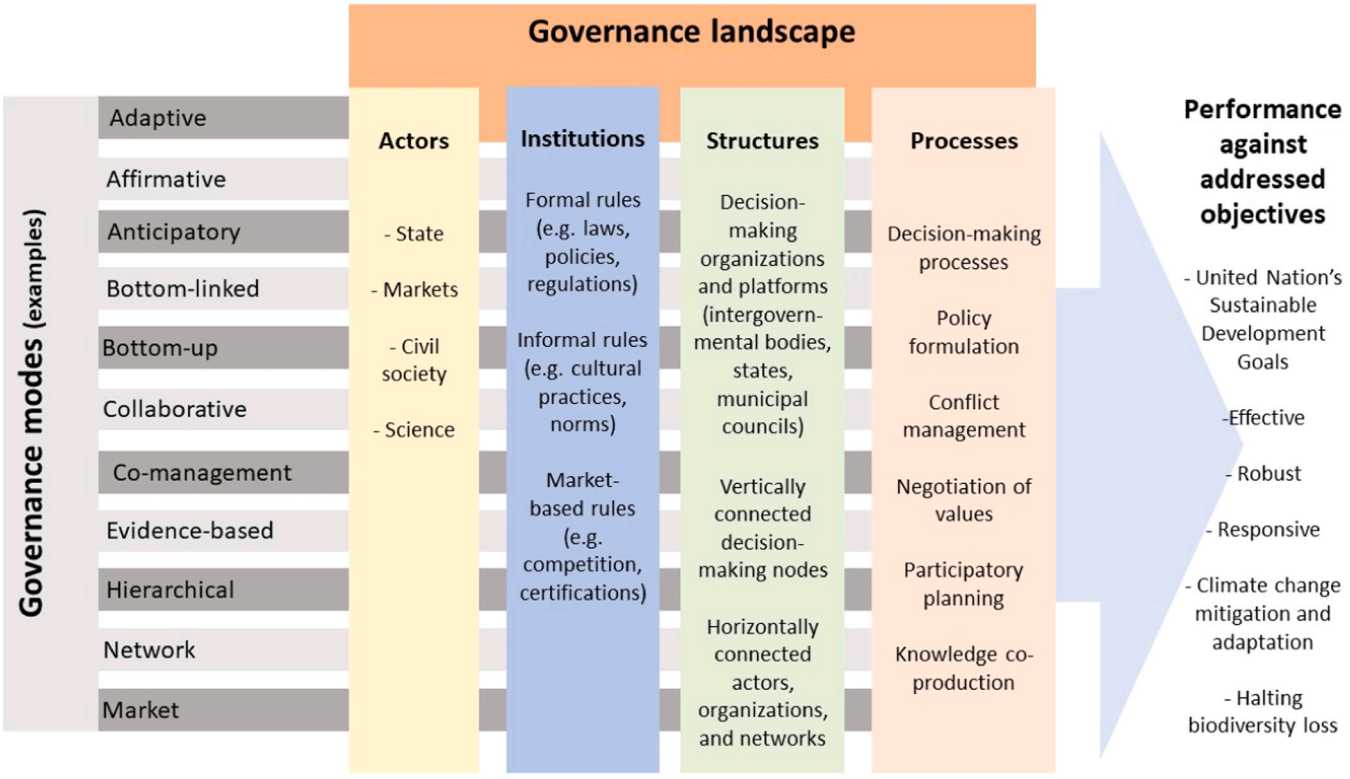

Fig. 2. Linkages between governance modes (Table 1), governance landscape and normative objectives. A governance landscape consists of four elements: actors, institutions, structures, and processes, and the way these are arranged depends on the governance mode. This then leads to implications for normative future objectives.

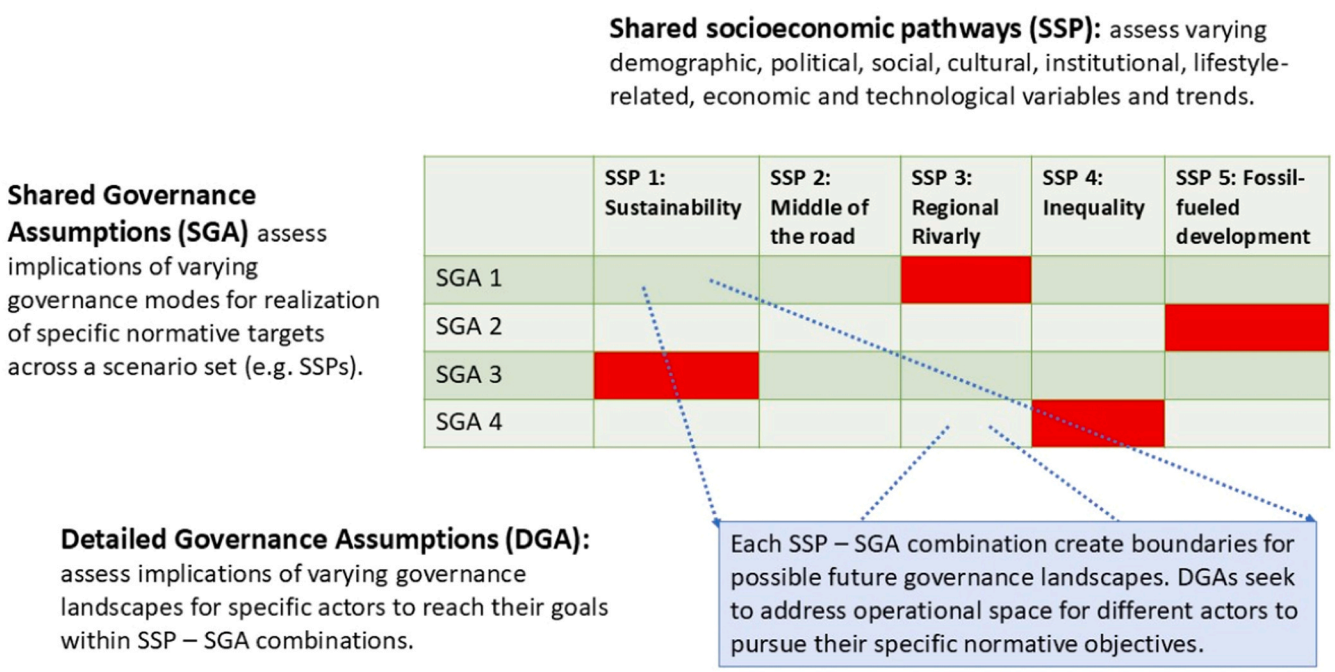

Fig. 3. The proposed governance-focused scenario architecture.

landscapes are connected to these actors and to the specific normative objectives assessed. For example, the governance landscape relevant for the same geographical location can vary regarding what normative objective is assessed, and also regarding the opportunities it offers or the hindrances it presents for specific actor groups. Same governance landscape can provide different opportunities for different social groups, like different land users and livelihoods, local communities, ENGO or businesses. The second option is to start the analysis from a certain governance topic (e.g. climate change; biodiversity; land use) and identify the assessed governance landscape around that. For example, the European governance landscapes for climate change and biodiversity are very different, even though their integration has been proposed as they are closely connected and interdependent (see Pettorelli et al., 2021). The third option is to start from a policy (e.g. EU Nature Restoration law), or a policy instrument (e.g. regulations, incentives, market-based instruments) and the required structures and processes used in its implementation (e.g. national bodies and negotiations between diverse actors). Whatever option is chosen, it is important that the framing is clear in order to make the mapping of the relevant governance landscape concrete and describing the chosen level(s) of governance from local to global. When linking governance landscapes and scenario logic, the indicator approach can be useful. It employs the deconstruction of the governance landscape into indicators that are relevant for the chosen normative target. These indicators then behave differently across the scenario matrix (SSP – Shared Governance Assumption combinations). Thereby, the indicators provide a proxy to assess to what extent the scenarios deliver for the chosen normative target in the future.

Step 3: Choosing the socioeconomic pathway

Exploratory scenarios examine selected future uncertainties in a structured way (e.g. MA 2005). While they are often associated to the five general scenario archetypes that have been identified (Van Vuuren et al., 2012) and correspond to the SSP narratives (Pedde et al., 2019), Governance Assumptions can also be used with other exploratory scenarios, including regionals scenarios, for example in the Arctic (Nilsson et al., 2017; Haavisto et al., 2016; Erokhin and Rovenskaya, 2020; Lazariva et al., 2021). Exploratory scenarios based on the SSPs, or scenario archetypes, offer a safe choice, because they are widely accepted and applicable to diverse contexts. Nevertheless, of key importance is that the chosen exploratory scenarios are relevant to the addressed normative objective, and targeted actors. Furthermore, a scenario exercise can use only one exploratory scenario, when the objective is to diversify the specific narrative by several Shared Governance Assumptions.

Step 4: Choosing the Shared Governance Assumptions

Choice of the Shared Governance Assumptions (i.e. governance modes) should reflect the overall objective of the scenario exercise. The idea is that the chosen Shared Governance Assumptions are likely to perform differently regarding the assessed normative objective. For example, Sarkki et al. (2023) examined socially equitable land use from the point of view of Indigenous Peoples and Local Communities (IPLCs). They diversified Sustainability scenarios by considering how three different governance modes could link to these. The Half Earth scenario (based on the hierarchical governance mode), the Sharing the Planet scenario (collaborative governance mode), and the Rights for Life scenario (affirmative governance mode) were screened regarding their implications for the social equity of land use for reindeer herders (Sarkki et al., 2023). The second example considers the future of green economy (e.g. EU's Green Industrial Plan as part of the Green Deal, EC, 2024). Here, governance modes linked to market governance, hierarchical governance, network governance, and self-organized governance modes (Table 1) can offer comparison to explore the implications of these governance modes for economic growth and competitive European market. The normative target of environmental sustainability offers a third example. The governance modes of evidence-based policy, bottom-linked governance supporting social innovation, and the Non-State Market-Driven governance mode can be compared regarding how they play out against the normative objective of environmental sustainability. Of key importance is to choose the assessed Shared Governance Assumptions so that they offer a meaningful comparison regarding the targeted normative objective, and the key actors.

Step 5: Developing the Governance Integration Matrix

In Step 5, the chosen exploratory scenario(s) and chosen Shared Governance Assumptions (governance modes) are integrated in a two-dimensional matrix. It is likely that the matrix will also include empty cells, because not all governance modes are compatible with the logics of all exploratory scenarios (Van Vliet and Kok 2013). In Table 3, we display an overview of a plausible generic scenario matrix corresponding to five scenario archetypes or SSPs and (non-exhaustive) list of

Table 3
Generic scenario matrix combining exploratory scenario archetypes and varying governance modes (Shared Governance Assumptions). The color green implies that the exploratory scenario archetype is compatible with the governance mode, the color red implies that the given governance mode is not compatible with the logic described by the exploratory scenario archetype. The color yellow means that it depends on the specific interpretation of the exploratory scenario archetype logic whether the given governance mode is compatible with the archetype or not (Interpretation by the authors).

Governance modes/ SGAs	Global sustainability (SSP1)	Local sustainability (SSP1)	Regional Rivalry (SSP3)	Inequality (SSP4)	Fossil-fueled development (SSP5)
Adaptive governance					
Affirmative governance					
Anticipatory governance					
Bottom-linked governance					
Bottom-up governance					
Collaborative governance					
Co-management at local level					
Evidence-based environmental policy					
Hierarchical governance					
Network governance					
Non-State Market Driven governance					
Market governance					
Polycentric governance					
Self-governance					
Technocratic governance					

governance modes (Table 1). Our understanding of the general scenario logics is based on relevant publications on SSPs (e.g., O'Neill et al., 2013, 2017; Kriegler et al., 2014; Riahi et al., 2017; Pedde et al., 2019; Lacroix et al., 2019), and on general exploratory scenario archetypes (Van Vuuren et al., 2012; Hunt et al., 2012; Harrison et al., 2019; Sitas et al., 2019) that correspond to SSPs, which is why we choose a SSPs as a demonstrative example. In particular, we have divided SSP 1 into two narratives: global sustainability and local sustainability (Sitas et al., 2019). We perform overall screening on the compatibility of exploratory scenario archetypes and various governance modes / Shared Governance Assumptions in Table 3, which can act as an inspiration for subsequent studies, seeking to use the concept of Shared Governance Assumptions in connection with SSPs or exploratory scenario archetypes.

When the scenario matrix is ready, the logic deriving from the particular combinations of the exploratory scenario archetypes and governance modes is applied to the examined case. The scenario archetypes provide key assumptions on how the future world may work, and governance modes provide a logic on how the decisions within those worlds are made. These together form a scenario logic that shapes the governance landscape mapped in Step 2, also having normative implications. We provided above an example (Sarkki et al., 2023) where sustainability scenarios and their implications on IPLCs were linked. In the Half Earth scenario (global sustainability – hierarchical governance) seeks to protection of 50 % of Earth's surface is considered. It is likely that a hierarchical governance mode is required to enable its

implementation. This would have profound impacts on IPLCs by evicting people from their home areas or at least by stopping the practice of culturally important nature-based livelihoods. On the other hand, the Sharing the Planet scenario (global sustainability – collaborative governance) considers developing multifunctional landscapes where both people and nature can flourish. Still, competition between livelihoods may compromise IPLCs' opportunities to practice their livelihoods.

There are several methodological options to assess the normative implications of the scenarios: participatory methods, document analyses, informed expert assessments, and modelling. Whatever method is used, the key issue is to understand the logics of governance landscapes in each cell of the scenario matrix (Table 3) and then assess how this will impact the analyzed normative objective for a particular group of actors.

Step 6: Analyzing dynamics of governance landscape to identify scenario-specific Detailed Governance Assumptions

The sixth step focuses on identifying Detailed Governance Assumptions as opportunities for agency of specific actors to pursue their normative objectives within a governance landscape varying across the scenario matrix. The actors' part of the governance landscape can be analysed through the concept of advocacy coalition, which is *"composed of people from various organizations who share a set of normative and causal beliefs and who often act in concert"* Sabatier (1988): 133). Furthermore, if the actors do not know each other, but share an agenda or an opponent, then perhaps a more fitting concept is the discourse coalition defined as groups of actors sharing a common interpretation of the world, which structures their individual and collective actions (Hajer, 1995). A key issue here is that the scenarios with varying governance landscapes offer diverging opportunities to build advocacy or discourse coalitions to influence decision-making. We propose an assessment grid to understand the space for agency that the different scenarios offer for specific actor groups. This suggestion builds on the concepts of "seeds" (i.e. emerging initiatives or organizations for transformation that are making positive changes for the benefit of people and the environment, Falardeau et al. (2019)), and weak signals as information on potential change of a system toward an unknown direction (Mendonça et al., 2004). Weak signals derive here from systemic thinking of the plausible future dynamics of governance landscapes behaving differently across the scenario matrix. Table 4 presents our assessment grid, with four detailed questions towards understanding what kind of opportunities for agency varying governance landscapes offer for specific actors.

Varying governance landscape offers diverse possibilities for targeted actors to pursue their normative objectives, also through actor coalitions. For example, in a sustainability scenario relying on evidence-based policy, scientists are likely to act in concert with governmental policy-makers supported also by ENGOs. In contrast, in a sustainability scenario relying on co-management, local resource users are likely to collaborate closely with policy makers and scientists. Another example can be given regarding the contrast between the hierarchical governance where bureaucratic barriers would hinder and block civil society initiatives, and bottom-up governance, where social innovations of civil society actors would be supported and incentivized by policies. Regarding institutions and decision-making structures, it can be considered that in SSP 3 based on affirmative governance, support and subsidies for actors in remote areas would be plenty, while in SSP 3 based on self-governance, every actor would have to survive on their own. To make the application of the six-step scenario exercise more concrete, Box 1 provides an illustrative example of the process, the case being land use and reindeer herding in Finland (Sarkki et al. 2025).

3. Conceptual novelties of our scenario approach

3.1. Governance assumptions elaborate the SSP-based scenario architecture

The concept of Shared Governance Assumptions is close relative to the SPAs (Kriegler et al., 2014), with the major difference that whereas SPAs focus on governmental and intergovernmental policies, the Shared Governance Assumptions target the wider field of decision-making including societal actors, businesses, and science, which all can have diverse roles in future decision-making. Our scenario architecture can be applied at any level from local to global, and also in multi-level context through the idea of governance landscape. Capturing the fine granularity of governance landscapes also allows leeway to make targeted considerations on diverse possibilities or obstacles that the scenario-specific governance landscape unique for each cell in the scenario matrix (Table 3) offers for specific actors. The concept of Detailed Governance Assumptions does not have a corresponding concept in the existing scenario frameworks. Its purpose is to outline opportunities for agency that the scenario-specific governance landscapes offer for particular actors to advance targeted normative objectives. This helps to address issues of agency and power as part of a scenario exercise (Falardeau et al., 2019; Rutting et al., 2023).

Our SSP-Governance Assumption scenario architecture is designed to explore future worlds in connection or in separation from climate change. Our SSP-Governance Assumption scenario architecture seeks to integrate capacity of SSP thinking to understand large scale developments with detailed assumptions on future governance. In general, this brings policy and governance more strongly to the focus of scenario work. Our Governance Assumption approach can be applied in futures exercises targeting various contested and value-laden issues including land use, biodiversity, climate change, social equity and justice (see IPBES, 2024).

Going forward in the analysis of climate change impacts, various studies argue for the need to replace the RCPs with emission pathways (e.g. Sanderson et al., 2024; Meinshausen et al., 2024), for example through Representative Emission Pathways (REP) that fulfill various policy research objectives, including pathways aligned with the Paris Agreement and current policies (Meinshausen et al., 2024). These pathways would be intricately linked to policy and mitigation assumptions. Meinshausen et al. (2024) also argue for the need to clearly separate climate-focused descriptions ("framing pathways") like the REPs from socioeconomic futures. Following these propositions would lead to removing one of the potentially independent element from the three-dimensional scenario architecture proposed by Kriegler et al. (2014), reducing it to a two-dimensional framework. Even if in the future development of climate change research, socioeconomic pathways were in general tied to specific emission pathways and/or policy and mitigation assumptions, Governance Assumptions would still work on the socioeconomic narratives in that future framework. While

Table 4
Assessment grid to identify scenario-specific Detailed Governance Assumptions. Developed from and inspired by Sabatier (1988), Hajer (1995), and Falardeau et al. (2019).

	Institutions, decision-making structures and processes	Actors: Advocacy and discourse coalitions
Seeds	What institutions, decision-making structures and processes exist in the current governance landscape that help targeted actors to achieve their normative objective, and in what scenarios can these prevail?	What kind of actor coalitions exist in the current governance landscape that help targeted actors to advance their normative objectives, and how are these coalitions shaped across the scenarios?
Weak signals	What kind of institutions, decision-making structures and processes can be imagined to be effective in varying scenarios and to help the targeted actors to reach their normative objectives?	What kind of advocacy or discourse coalitions can be envisaged in future governance landscapes that can help the targeted actors to achieve their normative objectives?

Box 1
Illustrative example of the use of the six-step scenario exercise when studying Arctic land use and reindeer herding (participatory workshop method: Wang et al. 2024; Rasmus et al. 2025; detailed results, including matrix: Sarkki et al. 2025). The analysis is based on participatory workshops with reindeer herders, and on expert assessment by authors with long-term experience on topic.

Title: Socially equitable land use for reindeer herders in northern Finland

Background: Reindeer herding in Finland is a traditional and culturally important nature-based livelihood that is practiced both by indigenous Sámi people and ethnic Finn local communities. Reindeer herding provides a case of a livelihood practiced by Indigenous Peoples and Local Communities (IPLC). Recent literature has concluded that the inclusion of social equality and sustainability objectives related to IPLCs into the scenario work is strongly needed (Hill et al., 2020; McElwee et al., 2020; Lundquist et al., 2021). We combined insights from two participatory futures workshops and our expert assessment.

Step 1: Choosing the normative objective, targeted actors and the geographic location Socially equitable land use for reindeer herders in Northern Finland was identified as a key objective for herders in the workshop including the aim that the livelihood would continue for future generations.

Step 2: Mapping relevant governance landscape. 18 key indicators central to the operational environment of reindeer herding, and reflecting the governance landscapes, were selected based on discussions in participatory workshops and our expert assessment. Assessing how these indicators behave across the scenario set allowed us to compare how hierarchical, collaborative and affirmative governance modes effect on socially equitable land use for reindeer herders across SSPs in the future.

Step 3: Choosing the exploratory scenario or scenario set. Chosen exploratory scenarios need to be relevant for the chosen normative objective, targeted actors and location. In the reindeer herding case, we considered between some regional Arctic scenarios and SSPs. We chose SSPs because of recent developments in geopolitics (SSP 3), relevance of climate change (e.g. SSP 5), increasing ambitions for the green transition in the Arctic (SSP 1), and persisting inequality in land use experienced by herders (SSP 4).

Step 4: Choosing the Shared Governance Assumptions. We considered that hierarchical, collaborative, and affirmative governance modes can provide diverse insight into how the socially equitable land use is realized across SSPs for reindeer herders. They form a continuum from top-down hierarchical governance via a middle option of collaborative governance to affirmative governance with special arrangements to enhance participation of herders and social equity of land use for the herders.

Step 5: Developing the Governance Integration Matrix. Developing a two-dimensional scenario matrix including combinations of four SSP scenario narratives (excluding SSP 2: Business-as-usual) and the three Shared Governance Assumptions resulting in ten cells describing individual scenarios. Each scenario has distinct implications for the social equity objectives in connection to land use and reindeer herding. The status of 18 indicators under each scenario was then assessed, based on the logic provided by the scenario matrix.

Step 6: Analyzing the dynamics of governance landscape to identify scenario-specific Detailed Governance Assumptions. Developing a set of scenario-specific recommendations for herders about how they can pursue the objective of socially equitable land use under each scenario. The recommendations relate to different opportunities for building actor coalitions and to identification of current and plausible future decision-making structures and processes that could enhance socially equitable land use in relation to reindeer herding.

assessing the normative objectives would become more complex under these circumstances, there would still be a benefit of applying Shared Governance Assumptions to connect the socioeconomic narratives to policy and governance.

3.2. Applicability of our governance-focused scenario architecture

Shared Governance Assumptions concept offers a structured way to diversify SSP-based scenario sets and connect SSPs strongly to policy and governance. There is a need to connect SSPs more strongly to policy, for example using SSP – SPA combinations (see O'Neill et al., 2020). We consider Shared Governance Assumptions as promising way forward. We recognize the large number of regional applications of the SSPs, with various attempts to combine SSPs and management/policy actions, across sectors and themes (Pedde et al., 2023). Our Shared Governance Assumption concept offers a novel and structured way to integrate SSPs to governance aspects. Governance Assumptions can provide structure for subsequent SSP-based scenario studies, and thereby means for comparing and standardizing the rich set of regional SSP applications. To illustrate the application of the generic scenario matrix (Table 3), Table 5 shows combinations of three different Shared Governance Assumptions and SSPs, in the case of land use and Arctic reindeer herding (case described in Box 1; details of scenarios: Sarkki et al. 2025).

The SSP – Shared Governance Assumptions matrix approach can be used to screen implications of the assessed governance modes on various future objectives to identify trade-offs between actors. This is important because common good and benefits for all is often an illusion, as increasingly recognized in the transformative change assessments (IPBES, 2024). As an example, Eronen et al. (2024) have identified tensions within SSP 1 regarding normative objectives from the EU perspective, and local level aims of reindeer herders. Looking at the range of governance modes (Table 3), we consider that preferred governance mode from EU perspective would include evidence-based, collaborative and market governance, while reindeer herders would prefer affirmative governance, co-management, or even self-governance (especially within Indigenous Sámi people home region). This implies that SSP 1 appears very different regarding the governance mode in use, and regarding whose perspective is emphasized. The Detailed Governance Assumptions can capture spaces for action, not only specific to certain SSP, but to certain SSP – Shared Governance Assumption combinations, and for specific actors.

3.3. Governance assumptions approach as a tool for anticipatory governance

Our scenario architecture can work as a tool for anticipatory and adaptive governance. Anticipatory governance, associated with strategic foresight activities, has been also considered as an element of an adaptive governance mode (Umbach, 2024). Adaptive governance concept has emerged in the social-ecological resilience literature. It emphasizes means to advance resilience, navigate future uncertainties and complexity, and linked to interactions between various types of actors to reach desired future goals, and enhance renewal and reorganization in the face of change (Folke et al., 2005; Chaffin et al., 2014).

Table 5
Application of SSP - Shared Governance Assumption matrix in the case of land use and reindeer herding in Finland (see Box 1 and Table 3)".

Shared Socio-economic Pathway (SSP)	Shared Governance Assumption 1: Hierarchical governance enforcing environmental goals	Shared Governance Assumption 2: Collaborative governance to achieve intertwined environmental and equality goals	Shared Governance Assumption 3: Affirmative governance to ensure IPLCs' rights
SSP 1: Sustainability: Taking the Green Road	**"Half Earth":** Remote Arctic areas are fully protected by hierarchical policy approach. Reindeer herders and other land use are excluded from protected remote areas.	**"Sharing the Planet":** Sustainability is advanced through multifunctional landscapes. Reindeer herders compete with other land users for access to land.	**"Rights for Life":** Rights of nature and IPLCs (e.g. reindeer herders) fully recognized and land use governance focuses on securing these rights. Reindeer herding flourishes relying fully on natural pastures.
SSP 3: Regional Rivalry: A Rocky Road	**"Iron Hand for the Nation":** Geopolitical tensions are strong, and land use governance is state-based and hierarchical seeking to enhance national self-sufficiency in energy, raw materials, and food. Reindeer herders are not considered in land use governance.	**"Fortress Europe":** Europe is unified in terms of politics and economy, and land use governance is based on rationalization and effectiveness of agriculture. For reindeer herding this mens that only owners of big herds remain in business.	**"Security by Social Equity":** Social equity is a key policy goal and used as a tool to ensure cohesion, and as means to keep remote areas inhabited for geopolitical security. Reindeer herders are are recognized as an important part of national food security.
SSP 4: Inequality: A Road Divided	**"Policies for Elites":** Urban – rural divide deepens, and most rural areas are used mainly as resource storages, and also as sites for nature conservation and tourism. Reindeer herding becomes a mere cultural curiosity for tourists, and livelihood degenerates.	**"Markets and Authenticity":** International "elites" dominate also policy development, and many regions and actor groups are left further behind. Only traditional practices and Indigenous herders are recognized in land use governance and connect their livelihood with tourism by authentic products and services.	Not considered (in this scenario IPLCs are in a marginal position)
SSP 5: Fossil-Fuelled Development: Taking the Highway	Not considered (this scenario suggests that economy is only weakly regulated)	**"Engineering for Sustainability"** Economic growth is highly fuelled by technological innovations, global markets, fossil fuels, and participatory society. Whether and how reindeer herding is recognized in engineering for sustainability is a contested issue.	**"Compensations for Moral Relief"** Policy makers decide to reserve significant funds for those suffering from climate change. Herders receive plenty of resources to adapt to the impacts of climate change and compensations from land users in the reindeer herding area.

The rationale for anticipatory and adaptive governance is to increase the capacity to cope with pressures created by rapid technological advances, environmental shifts, changing demographics, geopolitical tensions, and evolving societal needs, by anticipating and shaping future opportunities in proactive way (OECD, 2024). In sum, anticipatory and adaptive governance seeks to make decisions today that can help to navigate future uncertainties towards desirable futures.

Anticipatory governance uses foresight methods and plausible future scenarios to test a broad range of policy options against future targets (see Ruhl and Craig, 2022). Such normative implications are justified by accelerating sustainability challenges and their potentially disruptive societal consequences (Muiderman et al., 2020). Therefore, a key task for anticipatory governance is to identify policy recommendations at present that can help to avoid undesirable futures, or reach desirable futures (Quay, 2010; Vervoort and Gupta, 2018). Climate targets as drivers for policy change is another example (Dekker et al., 2023). We see promise in scenarios that illustrate outcomes of specific policy and governance options for particular normative objectives (see Miller et al., 2013; Biermann et al., 2022). We consider that our concept of Shared and Detailed Governance Assumptions contributes to discussions on how to produce scenarios that can help to respond to the needs of policy makers (Wright et al., 2020), and to enable transformations to sustainability by solution-oriented scenario approaches (Kowarsch and Jabbour, 2017). Our approach can offer a conceptual scenario tool that can be used as part of anticipatory governance, enabling development of anticipatory policy recommendations for the present based on governance-focused scenario analysis. Furthermore, our approach can inform anticipatory governance by identifying how different governance interventions are likely to endure across the scenario set. This resembles idea that certain actions are more in line with some exploratory scenarios than others (Kok et al., 2011).

4. Conclusion

We introduced the concepts of Shared and Detailed Governance Assumptions, to be used in connection with exploratory scenario archetypes of SSP narratives to screen implications of diverse future pathways on specific normative objectives, and to enhance SSPs' connection to policy and governance. Together with SSPs, our Shared and Detailed Governance Assumptions form a new governance-focused scenario architecture. We consider that our proposed scenario architecture 1) can integrate exploratory scenarios with normative sustainability objectives, 2) provide a conceptual tool to systematically diversify established SSPs and other scenario archetypes, 3) can capture and assess governance aspects in a finer granularity than most existing scenario approaches, and 4) can be used to identify the future implications of present-day policy recommendations, and function as a possible conceptual tool to be used as part of anticipatory governance to address pressing sustainability challenges of our times.

Future research to employ our scenario architecture in diverse cases is needed to establish the concepts of Shared and Detailed Governance Assumptions as part of existing scenario thinking. First, more empirical applications of the framework are needed to prove its usability across different contexts. This could take place for example within existing database on SSP-based scenario studies (Pedde et al., 2023). Second, our example (Box 1; Table 5) addressed the normative objective of socially equitable land use; future work addressing different types of normative objectives, for example ones linked to UN SDGs, is needed. Third, a key challenge in using the concept of Shared Governance Assumptions is to design the comparison of governance modes in a meaningful and insightful way. Thus, further examples of comparisons between diverse governance modes are needed. Finally, testing the Shared and Detailed Governance Assumptions concepts with different methods and in different cases is important to prove the value of our approach more generally.

CRediT authorship contribution statement

Eronen Jussi T: Funding acquisition, Writing – review & editing, Conceptualization. **Mia Pihlajamäki:** Conceptualization, Writing – review & editing. **Heidrun Matthes:** Conceptualization, Writing – review & editing. **Habeck Joachim:** Conceptualization, Writing – review &

editing. **Sirpa Rasmus:** Investigation, Writing – original draft, Conceptualization, Writing – review & editing. **Simo Sarkki:** Investigation, Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

Acknowledgement

This work has received funding under the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no. 869471 (CHARTER) and through the MAKERA funds of the Ministry of Agriculture and Forestry in Finland (POVAUS). This work was also supported by the Research Council of Finland (grant number 338558) and by the Kone Foundation. The authors would like to thank Sonja Kivinen for valuable discussions in the early stage of this work.

Data availability

Data will be made available on request.

References

Alcamo, J., Henrichs, T., 2008. Chapter two towards guidelines for environmental scenario analysis. In: Joseph Alcamo (Ed.), Developments in Integrated Environmental Assessment, 2. Elsevier, pp. 13–35. https://doi.org/10.1016/S1574-101X(08)00402-X.

Andonova, Liliana, Mitchell, Ronald, 2010. The rescaling of global environmental politics. Annu. Rev. Environ. Resour. 35. https://doi.org/10.1146/annurev-environ-100809-125346.

Andrijevic, M., Crespo Cuaresma, J., Muttarak, R., et al., 2020. Governance in socioeconomic pathways and its role for future adaptive capacity. Nat. Sustain 3, 35–41. https://doi.org/10.1038/s41893-019-0405-0.

Ansell, Chris, Gash, Alison, 2008. Collaborative governance in theory and practice. J. Public Adm. Res. Theory 18, 543–571.

Armitage, D., de Loë, R., Plummer, R., 2012. Environmental governance and its implications for conservation practice. Conserv. Lett. 5, 245–255. https://doi.org/10.1111/j.1755-263X.2012.00238.x.

Bäckstrand, K., Kuyper, J.W., Linnér, B.-O., Lövbrand, E., 2017. Non-state actors in global climate governance: from copenhagen to paris and beyond. Environ. Polit. 26 (4), 561–579. https://doi.org/10.1080/09644016.2017.1327485.

Bennett, N.J., Satterfield, T., 2018. Environmental governance: a practical framework to guide design, evaluation and analysis. Conserv. Lett. 11, e12600. https://doi.org/10.1111/conl.12600.

Bernstein, S., Cashore, B., 2007. Can non-state global governance be legitimate? An analytical framework. Regul. Gov. 1, 347–371. https://doi.org/10.1111/j.1748-5991.2007.00021.x.

Betsill, M., Dubash, Navroz K., Paterson, Matthew, van Asselt, Harro, Vihma, Antto, Winkler, Harald, 2015. Building productive links between the UNFCCC and the broader global climate governance landscape. Glob. Environ. Polit. 15 (2), 1–10. https://doi.org/10.1162/GLEP_a_00294.

Biermann, F., Hickmann, T., Sénit, C.A., et al., 2022. 2022. Scientific evidence on the political impact of the sustainable development goals. Nat. Sustain 5, 795–800. https://doi.org/10.1038/s41893-022-00909-5.

Bouwma, I.M., A.L. Gerritsen, D.A. Kamphorst & F.H. Kistenkas (2015). Policy instruments and modes of governance in environmental policies of the European Union; Past, present and future. Statutory Research Tasks Unit for Nature & the Environment (WOT Natuur & Milieu), WOt-technical report 60. 42 p.; 1 Fig; 2 Tabs; 80 Refs; 2 Annexes.

Carlsson, Lars, Berkes, Fikret, 2005. Co-Management: concepts and methodological implications. J. Environ. Manag. 75, 65–76. https://doi.org/10.1016/j.jenvman.2004.11.008.

Chaffin, B.C., Gosnell, H., Cosens, B.A., 2014. A decade of adaptive governance scholarship: synthesis and future directions. Ecol. Soc. 19 (3), 56. https://doi.org/10.5751/ES-06824-190356.

Chan, K.M.A., Boyd, D.R., Gould, R.K., et al., 2020. Levers and leverage points for pathways to sustainability. People Nat. 2, 693–717. https://doi.org/10.1002/pan3.10124.

Dekker, M.M., Hof, A.F., van den Berg, M., et al., 2023. Spread in climate policy scenarios unravelled. Nature 624, 309–316. https://doi.org/10.1038/s41586-023-06738-6.

Di Gregorio, M., Fatorelli, Leandra, Paavola, Jouni, Locatelli, Bruno, Pramova, Emilia, Nurrochmat, Dodik Ridho, May, Peter H., Brockhaus, Maria, Sari, Intan Maya, Kusumadewi, Sonya Dyah, 2019. Multi-level governance and power in climate change policy networks. Glob. Environ. Change 54, 64–77. https://doi.org/10.1016/j.gloenvcha.2018.10.003.

EC 2024. The Green Deal Industrial Plan. Putting Europe's net-zero industry in the lead. At: ⟨https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/green-deal-industrial-plan_en⟩.

Erokhin, D. & Rovenskaya, E. (2020). Regional Scenarios of the Arctic Futures: A Review (Working paper No. WP-20-013). Laxenburg, Austria: IIASA. ⟨http://pure.iiasa.ac.at/id/eprint/16648/1/WP-20-013%20a.pdf⟩.

Eronen, J., Rasmus, S., Sarkki, S., 2024. Tens. dreams Policy Option a Sustain. Arct. Backgr. Policy Brief. Chart. Work. Pap. 4. ⟨https://www.charter-arctic.org/wp-content/uploads/2024/11/CHARTER_working_paper_4_tensional_dreams.pdf⟩.

Falardeau, M., Raudsepp-Hearne, C., Bennett, E.M., 2019. A novel approach for co-producing positive scenarios that explore agency: case study from the Canadian Arctic. Sustain Sci. 14, 205–220. https://doi.org/10.1007/s11625-018-0620-z.

Fischer, Frank, 1990. Technocracy and The Politics of Expertise. Sage, Newbury Park/London/New Delhi.

Folke, C., Hahn, T., Olsson, P., Norberg, J., 2005. Adaptive governance of social-ecological systems. Annu. Rev. Environ. Resour. 30, 441–473. https://doi.org/10.1146/annurev.energy.30.050504.144511.

Frame, B., Lawrence, Judy, Ausseil, Anne-Gaelle, Reisinger, Andy, Daigneault, Adam, 2018. Adapting global shared socio-economic pathways for national and local scenarios. Clim. Risk Manag. 21, 39–51. https://doi.org/10.1016/j.crm.2018.05.001.

Geels, F., Schot, J., 2007. Typology of sociotechnical transition pathways. Res. Policy 36 (3), 399–417. https://doi.org/10.1016/j.respol.2007.01.003.

Gupta, J., 2007. The multi-level governance challenge of climate change. Environ. Sci. 4 (3), 131–137. https://doi.org/10.1080/15693430701742669.

Haavisto, R., Pilli-Sihvola, K., Harjanne, A., Perrels, A., 2016. Socio-economic Scenarios for the Eurasian Arctic by 2040. Ilmatieteen laitos, Helsinki, Finland. ⟨https://helda.helsinki.fi/handle/10138/160254⟩.

Hajer, M.A., 1995. The Politics of Environmental Discourse: Ecological Modernization and the Policy Process. Oxford University Press, New York, NY.

Harrison, P.A., Harmáčková, Z.V., Aloe Karabulut, A., Brotons, L., Cantele, M., Claudet, J., Dunford, R.W., Guisan, A., Holman, I.P., Jacobs, S., Kok, K., Lobanova, A., Morán-Ordóñez, A., Pedde, S., Rixen, C., Santos-Martín, F., Schlaepfer, M.A., Solidoro, C., Sonrel, A., Hauck, J., 2019. Synthesizing plausible futures for biodiversity and ecosystem services in Europe and Central Asia using scenario archetypes. Ecol. Soc. 24 (2), 27. https://doi.org/10.5751/ES-10818-240227.

Havstad, J.C., Brown, M.J., 2017. NEUTRALITY, RELEVANCE, PRESCRIPTION, AND THE IPCC. Public Aff. Q. 31 (4), 303–324. https://doi.org/10.2307/44732800.

Hill, R., Adem, Çi.ğdem, Alangui, Wilfred V., Molnár, Zsolt, Aumeeruddy-Thomas, Yildiz, Bridgewater, Peter, Tengö, Maria, Thaman, Randy, Adou Yao, Constant Y., Berkes, Fikret, Carino, Joji, Carneiro da Cunha, Manuela, Diaw, Mariteuw C., Díaz, Sandra, Figueroa, Viviana E., Fisher, Judy, Hardison, Preston, Ichikawa, Kaoru, Kariuki, Peris, Karki, Madhav, Lyver, Phil O.B., Malmer, Pernilla, Masardule, Onel, Oteng Yeboah, Alfred A., Pacheco, Diego, Pataridze, Tamar, Perez, Edgar, Roué, Michèle-Marie, Roba, Hassan, Rubis, Jennifer, Saito, Osamu, Xue, Dayuan, 2020. Working with Indigenous, local and scientific knowledge in assessments of nature and nature's linkages with people. Curr. Opin. Environ. Sustain. 43, 8–20. https://doi.org/10.1016/j.cosust.2019.12.006.

Hunt, Dexter V.L., Lombardi, D.Rachel, Atkinson, Stuart, Barber, Austin R.G., Barnes, Matthew, Boyko, Christopher T., Brown, Julie, Bryson, John, Butler, David, Caputo, Silvio, Caserio, Maria, Coles, Richard, Cooper, Rachel F.D., Farmani, Raziyeh, Gaterell, Mark, Hale, James, Hales, Chantal, Hewitt, C.Nicholas, Jankovic, Lubo, Jefferson, I., Leach, J., MacKenzie, A.Rob, Memon, Fayyaz Ali, Sadler, Jon P., Weingaertner, Carina, Whyatt, J.Duncan, Rogers, Christopher D.F., 2012. Scenario archetypes: converging rather than diverging themes. Sustainability 4 (4), 740–772. https://doi.org/10.3390/su4040740.

IPBES (2019): Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (editors). IPBES secretariat, Bonn, Germany. 1148 pages. https://doi.org/10.5281/zenodo.3831673.

IPBES. (2024). Thematic Assessment Report on the Underlying Causes of Biodiversity Loss and the Determinants of Transformative Change and Options for Achieving the 2050 Vision for Biodiversity of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. O'Brien, K., Garibaldi, L., Agrawal, A., Bennett, E., Biggs, O., Calderón Contreras, R., Carr, E., Frantzeskaki, N., Gosnell, H., Gurung, J., Lambertucci, S., Leventon, J., Liao, C., Reyes García, V., Shannon, L., Villasante, S., Wickson, F., Zinngrebe, Y., and Perianin, L. (eds.). IPBES Secretariat. https://doi.org/10.5281/zenodo.11382215.

IPCC, 2022: Summary for Policymakers [H.-O. Pörtner, D.C. Roberts, E.S. Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem (eds.)]. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press.

Kok, K., van Vliet, Mathijs, Bärlund, Ilona, Dubel, Anna, Sendzimir, Jan, 2011. Combining participative backcasting and exploratory scenario development: experiences from the SCENES project. Technol. Forecast. Soc. Change 78, 835–851. https://doi.org/10.1016/j.techfore.2011.01.004.

Kooiman, J., 2003. Governing as Governance. Sage, London.

Kosow, H. 2008. Methods of future and scenario analysis: overview, assessment, and selection criteria / Hannah Kosow; Robert Gaßner. DIE Re-search Project "Development Policy: Questions for the Future". – Bonn:Dt. Inst. für

Entwicklungspolitik, 2007 – (Studies / Deutsches Institut für Entwicklungspolitik; 39).
Kowarsch, M., Jabbour, J., 2017. Solution-oriented global environmental assessments: Opportunities and challenges. Environ. Sci. Policy 77, 187–192. https://doi.org/10.1016/j.envsci.2017.08.013.
Kriegler, E., Edmonds, J., Hallegatte, S., et al., 2014. A new scenario framework for climate change research: the concept of shared climate policy assumptions. Clim. Change 122 (2014), 401–414. https://doi.org/10.1007/s10584-013-0971-5.
Kuisel, Richard, F., 1981. Capitalism and the state in modern France. Renovation and Economic Management in the Twentieth Century. Cambridge University Press, Cambridge, UK.
Lacroix, D., Laurent, Louis, de Menthière, Nicolas, Schmitt, Bertrand, Béthinger, Audrey, David, Bernard, Didier, Christophe, Parent du Châtelet, Jacques, 2019. Multiple visions of the future and major environmental scenarios. Technol. Forecast. Soc. Change 144, 93–102. https://doi.org/10.1016/j.techfore.2019.03.017.
Lazariva, Anastasia, Kalinin, Alexey, Middleton, Alexandra, Nilssen, Frode, Belostotskaya, Anastasia, 2021. SKOLKOVO Institute for Emerging Market Studies, Available at SSRN. Arct. 2050 Mapp. Future Arct. ⟨https://ssrn.com/abstract=3784762⟩.
Lemos, M.C., Agrawal, A., 2006. Environmental governance. Annu Rev. Environ. Resour. 31, 297–325.
Lenzner, B., Leclère, D., Franklin, O., Seebens, H., Roura-Pascual, N., Obersteiner, M., Dullinger, S., Essl, F., 2019. A framework for global twenty-first century scenarios and models of biological invasions. Bioscience 69 (9), 697–710. https://doi.org/10.1093/biosci/biz070. Epub 2019 Jul 31. PMID: 31527924; PMCID: PMC6739238.
Livingston, J.E., Rummukainen, M., 2020. Taking science by surprise: the knowledge politics of the IPCC Special Report on 1.5 °. Environ. Sci. Policy 112, 10–16. https://doi.org/10.1016/j.envsci.2020.05.020.
Lundquist, C., Hashimoto, S., Denboba, M.A., Peterson, G., Pereira, L., Armenteras, D., 2021. Operationalizing the Nature Futures Framework to catalyze the development of nature-future scenarios. Sustain. Sci. 16 (6), 1773–1775. https://doi.org/10.1007/s11625-021-01014-w.
MA (Millennium Ecosystem Assessment) 2005. Ecosystems and Human Well-Being: Synthesis. Island Press, Washington.
Malekpour, S., de Haan, Fjalar J., Brown, Rebekah R., 2016. A methodology to enable exploratory thinking in strategic planning. Technol. Forecast. Soc. Change 105, 192–202. https://doi.org/10.1016/j.techfore.2016.01.012.
Marquardt, J., Fast, C., Grimm, J., 2022. Non- and sub-state climate action after Paris: From a facilitative regime to a contested governance landscape. WIREs Clim. Change 13 (5), e791. https://doi.org/10.1002/wcc.791.
McElwee, P., Fernández-Llamazares, Á., Aumeeruddy-Thomas, Y., et al., 2020. Working with Indigenous and local knowledge (ILK) in large-scale ecological assessments: reviewing the experience of the IPBES Global Assessment. J. Appl. Ecol. 2020 57, 1666–1676. https://doi.org/10.1111/1365-2664.13705.
Međugorac, V., Schuitema, Geertje, 2023. Why is bottom-up more acceptable than top-down? A study on collective psychological ownership and place-technology fit in the Irish Midlands. Energy Res. Soc. Sci. 96, 102924. https://doi.org/10.1016/j.erss.2022.102924.
Meinshausen, M., Schleussner, C.-F., Beyer, K., Bodeker, G., Boucher, O., Canadell, J.G., Daniel, J.S., Diongue-Niang, A., Driouech, F., Fischer, E., Forster, P., Grose, M., Hansen, G., Hausfather, Z., Ilyina, T., Kikstra, J.S., Kimutai, J., King, A.D., Lee, J.-Y., Lennard, C., Lissner, T., Nauels, A., Peters, G.P., Pirani, A., Plattner, G.-K., Pörtner, H., Rogelj, J., Rojas, M., Roy, J., Samset, B.H., Sanderson, B.M., Séférian, R., Seneviratne, S., Smith, C.J., Szopa, S., Thomas, A., Urge-Vorsatz, D., Velders, G.J.M., Yokohata, T., Ziehn, T., Nicholls, Z., 2024. A perspective on the next generation of Earth system model scenarios: towards representative emission pathways (REPs). Geosci. Model Dev. 17, 4533–4559. https://doi.org/10.5194/gmd-17-4533-2024.
Mendonça, S., Pina e Cunha, Miguel, Kaivo-oja, Jari, Ruff, Frank, 2004. Wild cards, weak signals and organisational improvisation. Futures 36, 201–218. https://doi.org/10.1016/S0016-3287(03)00148-4.
Miller, T.R., Wiek, A., Sarewitz, D., Robinson, J., Olsson, L., Kriebel, D., Loorbach, D., 2013. The future of sustainability science: a solutions-oriented research agenda. Sustain. Sci. 9 (2), 239–246. https://doi.org/10.1007/S11625-013-0224-6.
Moulaert, Frank & Maccallum, Diana & Van den Broeck, Pieter & Cabeza, Marisol (2019). Bottom-linked governance and socially innovative political transformation.
Muiderman, K., Gupta, A., Vervoort, J., Biermann, F., 2020. Four approaches to anticipatory climate governance: different conceptions of the future and implications for the present. WIREs Clim. Change 11, e673. https://doi.org/10.1002/wcc.673.
Newig, J., Fritsch, O., 2009. Environmental governance: participatory, multi-level – and effective? Env. Pol. Gov. 19, 197–214. https://doi.org/10.1002/eet.509.
Nilsson, A.E., Bay-Larsen, Ingrid, Carlsen, Henrik, van Oort, Bob, Bjørkan, Maiken, Jylhä, Kirsti, Klyuchnikova, Elena, Masloboev, Vladimir, van der Watt, Lize-Marié, 2017. Towards extended shared socioeconomic pathways: a combined participatory bottom-up and top-down methodology with results from the Barents region. Glob. Environ. Change 45, 124–132. https://doi.org/10.1016/j.gloenvcha.2017.06.001.
O'Neill, B., Kriegler, E., Riahi, K., Ebi, K., Hallegatte, S., Carter, T., Mathur, R., van Vuuren, D., 2013. 2013. A new scenario framework for climate change research: the concept of shared socioeconomic pathways. Clim. Change 122, 387–400.
O'Neill, B.C., Kriegler, E., Ebi, K.L., Kemp-Benedict, E., Riahi, K., Rothman, D.S., van Ruijven, B.J., van Vuuren, D.P., Birkmann, J., Kok, K., et al., 2017. The roads ahead: narratives for shared socioeconomic pathways describing world futures in the 21st century. Glob. Environ. Change 42 (2017), 169–180.
O'Neill, B.C., Carter, T.R., Ebi, K., et al., 2020. 2020. Achievements and needs for the climate change scenario framework. Nat. Clim. Chang 10, 1074–1084. https://doi.org/10.1038/s41558-020-00952-0.
OECD. 2024. Anticipatory governance. At: ⟨https://www.oecd.org/en/topics/anticipatory-governance.html⟩.
Pahl-Wostl, C., 2015. Governance Modes. Water Governance in the Face of Global Change. Water Governance - Concepts, Methods, and Practice. Springer, Cham. https://doi.org/10.1007/978-3-319-21855-7_5.
Pedde, S., K. Kok, K. Hölscher, C. Oberlack, P.A. Harrison, and R. Leemans. 2019. Archetyping shared socioeconomic pathways across scales: an application to central Asia and European case studies. Ecology and Society 24(4):30. https://doi.org/10.5751/ES-11241-240430.
Pedde, S., Harrison, Paula A., Holman, Ian P., Powney, Gary D., Lofts, Stephen, Schmucki, Reto, Gramberger, Marc, Bullock, James M., 2021. Enriching the Shared Socioeconomic Pathways to co-create consistent multi-sector scenarios for the UK. Sci. Total Environ. 756, 143172. https://doi.org/10.1016/j.scitotenv.2020.143172.
Pedde, S., Johnson, O., Carlsen, H., Kemp-Benedict, E., Kok, K., Talebian, S., Xing, X., 2023. Sub-global Scenarios that Extend the Global SSP Narratives: Literature DatabaseVersion 1, 2014-2021NASA Socioeconomic Data and Applications Center (SEDAC)Palisades, NY10.7927/w6w3-3896.
Pettorelli, N., Graham, N.A.J., Seddon, N., Maria da Cunha Bustamante, M., Lowton, M. J., Sutherland, W.J., Koldewey, H.J., Prentice, H.C., Barlow, J., 2021. Time to integrate global climate change and biodiversity science-policy agendas. J. Appl. Ecol. 58, 2384–2393. https://doi.org/10.1111/1365-2664.13985.
Popp, A., Calvin, Katherine, Fujimori, Shinichiro, Havlik, Petr, Humpenöder, Florian, Stehfest, Elke, Bodirsky, Benjamin Leon, Dietrich, Jan Philipp, Doelmann, Jonathan C., Gusti, Mykola, Hasegawa, Tomoko, Kyle, Page, Obersteiner, Michael, Tabeau, Andrzej, Takahashi, Kiyoshi, Valin, Hugo, Waldhoff, Stephanie, Weindl, Isabelle, Wise, Marshall, Kriegler, Elmar, Lotze-Campen, Hermann, Fricko, Oliver, Riahi, Keywan, Vuuren, Detlef P. van, 2017. Land-use futures in the shared socio-economic pathways. Glob. Environ. Change 42, 331–345. https://doi.org/10.1016/j.gloenvcha.2016.10.002.
Primmer, E., Jokinen, Pekka, Blicharska, Malgorzata, Barton, David N., Bugter, Rob, Potschin, Marion, 2015. Governance oF Ecosystem Services: a framework for empirical analysis. Ecosyst. Serv. 16, 158–166. https://doi.org/10.1016/j.ecoser.2015.05.002.
Quay, R., 2010. Anticipatory governance: a tool for climate change adaptation. J. Am. Plan. Assoc. 76 (4), 496–511. https://doi.org/10.1080/01944363.2010.508428.
Raitio, K., 2008. You can't please everyone – Conflict management practices, frames and institutions in Finnish state forests. PhD Thesis Univ. Joensuu Soc. Sci. 86.
Rasmus, Sirpa, Sarkki, Simo, Wang, Irina, Burgess, Philip, Otto Habeck, Joachim, Horstkotte, Tim, Jokinen, Mikko, Matthes, Heidrun, Mettiäinen, Ilona, Parviainen, Tuuli, Pekkarinen, Antti-Juhani, Post, Laura, Rikkonen, Taru, Sorvali, Jaana, Turunen, Minna, Väärälä, Tuulia, Jussi, T. Eronen, 2025. Surprises and Dreams: workshop method to co-create community-based transformative knowledge. The Polar Journal. https://doi.org/10.1080/2154896X.2025.2565959.
Riahi, K., van Vuuren, Detlef P., Kriegler, Elmar, Edmonds, Jae, O'Neill, Brian C., Fujimori, Shinichiro, Bauer, Nico, Calvin, Katherine, Dellink, Rob, Fricko, Oliver, Lutz, Wolfgang, Popp, Alexander, Cuaresma, Jesus Crespo, KC, Samir, Leimbach, Marian, Jiang, Leiwen, Kram, Tom, Rao, Shilpa, Emmerling, Johannes, Ebi, Kristie, Hasegawa, Tomoko, Havlik, Petr, Humpenöder, Florian, Da Silva, Lara Aleluia, Smith, Steve, Stehfest, Elke, Bosetti, Valentina, Eom, Jiyong, Gernaat, David, Masui, Toshihiko, Rogelj, Joeri, Strefler, Jessica, Drouet, Laurent, Krey, Volker, Luderer, Gunnar, Harmsen, Mathijs, Takahashi, Kiyoshi, Baumstark, Lavinia, Doelman, Jonathan C., Kainuma, Mikiko, Klimont, Zbigniew, Marangoni, Giacomo, Lotze-Campen, Hermann, Obersteiner, Michael, Tabeau, Andrzej, Tavoni, Massimo, 2017. The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: an overview. Glob. Environ. Change 42, 153–168. https://doi.org/10.1016/j.gloenvcha.2016.05.009.
Ribot, J., Larson, A.M., 2012. Reducing REDD risks: affirmative policy on an uneven playing field. Int. J. Commons 6 (2), 233–254. https://doi.org/10.18352/ijc.322.
Rogelj, J., Popp, A., Calvin, K.V., et al., 2018. Scenarios towards limiting global mean temperature increase below 1.5 °C. Nat. Clim. Change 8, 325–332. https://doi.org/10.1038/s41558-018-0091-3.
Rounsevell, M.D.A., Metzger, M.J., 2010. Developing qualitative scenario storylines for environmental change assessment. WIREs Clim. Change 1, 606–619. https://doi.org/10.1002/wcc.63.
Ruhl, J.B., Craig, R.K., 2022 Dec 6. Designing extreme climate change scenarios for anticipatory governance. Proc. Natl. Acad. Sci. USA 119 (49), e2216155119. https://doi.org/10.1073/pnas.2216155119.
Rutting, L., Vervoort, J., Mees, H., et al., 2023. Disruptive seeds: a scenario approach to explore power shifts in sustainability transformations. Sustain Sci. 18, 1117–1133. https://doi.org/10.1007/s11625-022-01251-7.
Sabatier, P.A., 1988. An advocacy coalition framework of policy change and the role of policy-oriented learning therein. Policy Sci. 21, 129–168. https://doi.org/10.1007/BF00136406.
Sager, F., Hadorn, S., Schlaufer, C., 2023. Evidence-Based Policy. In: van Gerven, M., Rothmayr Allison, C., Schubert, K. (Eds.), Encyclopedia of Public Policy. Springer, Cham. https://doi.org/10.1007/978-3-030-90434-0_75-1.
Sanderson, B.M., Booth, B.B.B., Dunne, J., Eyring, V., Fisher, R.A., Friedlingstein, P., Gidden, M.J., Hajima, T., Jones, C.D., Jones, C.G., King, A., Koven, C.D., Lawrence, D.M., Lowe, J., Mengis, N., Peters, G.P., Rogelj, J., Smith, C., Snyder, A.C., Simpson, I.R., Swann, A.L.S., Tebaldi, C., Ilyina, T., Schleussner, C.-F., Séférian, R., Samset, B.H., van Vuuren, D., Zaehle, S., 2024. The need for carbon-emissions-driven climate projections in CMIP7. Geosci. Model Dev. 17, 8141–8172. https://doi.org/10.5194/gmd-17-8141-2024.
Sarkki, S., Pihlajamäki, M., Rasmus, S., Eronen, J.T., 2023. Rights for Life" scenario to reach biodiversity targets and social equity for indigenous peoples and local

communities. Biol. Conserv. 280, 109958. https://doi.org/10.1016/j.biocon.2023.109958.
Sarkki, S., Rasmus, S., Habeck, O., Matthes, H., Pihlajamäki, M., 2025. Exploring the land-use futures related to reindeer herding in Finland through "wild logic scenarios. J. Land Use Sci.,. https://doi.org/10.1080/1747423X.2025.2504420.
Sitas, N., Harmáčková, Z.V., Anticamara, J.A., Arneth, A., Badola, R., Biggs, R., Blanchard, R., Brotons, L., Cantele, M., Coetzer, K., DasGupta, R., Den Belder, E., Ghosh, S., Guisan, A., Gundimeda, H., Hamann, M., Harrison, P.A., Hashimoto, S., Hauck, J., Klatt, B., Kok, K., Krug, R.M., Niamir, A., O'Farrell, P.J., Okayasu, S., Palomo, I., Pereira, L.M., Riordan, P., Santos-Martín, F., Selomane, O., Shin, Y., Valle Tobar, M., 2019. Exploring the usefulness of scenario archetypes in science-policy processes: experience across IPBES assessments. Ecol. Soc. 24 (3), 35. https://doi.org/10.5751/ES-11039-240335.
Stockholm Resilience Center 2016. Insight #3 Adaptive governance. Governance of social-ecological systems in an increasingly uncertain world needs to be collaborative, flexible and learning-based. Available at: ⟨https://www.stockholmresilience.org/download/18.3e9bddec1373daf16fa439/1459560363382/Insights_adaptive_governance_120111-2.pdf⟩.
Thomas, A., Theokritoff, E., Lesnikowski, A., et al., 2021. Global evidence of constraints and limits to human adaptation. Reg. Environ. Change 21, 85. https://doi.org/10.1007/s10113-021-01808-9.
Treib, Oliver, Bähr, Holger, Falkner, Gerda, 2007. Modes of Governance: a Note Towards Conceptual Clarification. J. Eur. Public Policy 14, 1–20. https://doi.org/10.1080/13501760606107140 6.
Triyanti, A., Haomiao, Du, Dries, L.T., Hegger, Peter, P.J., Driessen, Helena, F.M.W., van, Rijswick, Murray, Scown, Herman, Kasper Gilissen, 2023. Clarifying and strengthening the role of law and governance in climate scenario frameworks. Earth Syst. Gov. 18, 100199. https://doi.org/10.1016/j.esg.2023.100199.
Umbach, G., 2024. Futures in EU governance: anticipatory governance, strategic foresight and EU Better Regulation. Eur. Law J. 2024 30 (3), 409–421. https://doi.org/10.1111/eulj.12519.
UN Human Rights. 2023. Special Rapporteur on the rights of Indigenous Peoples. At: ⟨https://www.ohchr.org/en/special-procedures/sr-indigenous-peoples⟩.
UNSDG. 2023. Universal Values. Principle Two: Leave No One Behind. At: ⟨https://unsdg.un.org/2030-agenda/universal-values/leave-no-one-behind⟩.
Vähäkari, N., Lauttamäki, Ville, Tapio, Petri, Ahvenainen, Marko, Assmuth, Timo, Lyytimäki, Jari, Vehmas, Jarmo, 2020. The future in sustainability transitions - Interlinkages between the multi-level perspective and futures studies. Futures 123, 102597. https://doi.org/10.1016/j.futures.2020.102597.
Van Buuren, M.W. van, & Eshuis, J. (2010) 'Knowledge governance: complementing hierarchies, networks and markets?', In 'T Veld, R. J. (ed.) Knowledge democracy - consequences for science, politics and media, Springer: Heidelberg: 283-297.
Vervoort, J., Gupta, A., 2018. Anticipating climate futures in a 1.5°C era: the link between foresight and governance. Curr. Opin. Environ. Sustain. 31, 104–111.
van Vliet, M., Kok, K., 2013. Combining backcasting and exploratory scenarios to develop robust water strategies in face of uncertain futures. Mitig. Adapt. Strateg. Glob. Change 20 (1), 43–74. https://doi.org/10.1007/S11027-013-9479-6.
2016. von Benda-BeckmannF.von Benda-BeckmannK.EckertJ.von Benda-BeckmannF. von Benda-BeckmannK.EckertJ.Rules of Law and Laws of Ruling: Law and Governance between Past and FutureIn: Rules of Law and Laws of RulingRoutledge130.
van Vuuren, D.P., Riahi, K., Moss, R., Edmonds, J.A., Nakicenovic, N., Kram, T., Berkhout, F.G.H., Swart, R., Janetos, A., Rose, S., Arnell, N., 2012. A proposal for a new scenario framework to support research and assessment in different climate research communities. Glob. Environ. Change 22 (1), 21–35. https://doi.org/10.1016/j.gloenvcha.2011.08.002.
van Vuuren, Detlef P, Kok, Marcel T.J, Girod, Bastien, Lucas, Paul L, de Vries, Bert, 2012. Scenarios in Global Environmental Assessments: Key characteristics and lessons for future use. Glob. Environ. Change 22 (4), 884–895. https://doi.org/10.1016/j.gloenvcha.2012.06.001.
van Vuuren, D.P., Kriegler, E., O'Neill, B.C., et al., 2014. A new scenario framework for climate change research: scenario matrix architecture. Clim. Change 122, 373–386. https://doi.org/10.1007/s10584-013-0906-1.
Wagner, N., Sarkki, Simo, Dietz, Thomas, 2024. More than policy neutral: justifying the power of science-policy interfaces through legitimacy. Earth Syst. Gov. 21, 100219. https://doi.org/10.1016/j.esg.2024.100219.
Williamson, O., 1985. The Economic Institutions of Capitalism. Free Press, New York.
Wright, D., Stahl, Bernd, Hatzakis, Tally, 2020. Policy scenarios as an instrument for policymakers. Technol. Forecast. Soc. Change 154, 119972. https://doi.org/10.1016/j.techfore.2020.119972.