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ARTICLE INFO	ABSTRACT
	Since large-scale environmental disruptions have become chronic, policymakers need to consider the long-term consequences of urgent crisis decisions. We develop design principles for a decision platform addressing strategic environmental crisis management, by which we mean coordinated decisions during an environmental urgency that are sensitive to long-term path dependencies and policy errors. To enhance critical questioning of formal doctrines, the decision platform includes policymakers and sectoral experts as equal participants. The agenda for decisionmaking is structured around future scenarios to encourage the participants to imagine alternative ways of framing the decision problem. The agenda also discourages defensive heuristics with which decision-makers attempt to preserve their short-term reputation. The design principles for strategic environmental crisis management are based on urban experimentation. The barrier of implementation for similar experiments in other contexts is low because they assume no major overhaul in existing administration

1. Introduction

The unprecedented scale of resources mobilized to manage global crises such as the coronavirus pandemic highlights the need to consider the long-term consequences of decisions made under extreme time constraints (Ansell and Boin, 2019; Heyd, 2021). According to global environmental reports, large-scale socio-ecological disruptions are likely to become chronic in the future and coping with them demands urgent policy decisions (e.g. IPBES, 2019; IPCC Intergovernmental Panel on Climate Change, 2018). For ecological economists, this means recognizing the need for radical change (Farley and Kish, 2021) and ensuring that shocks and breakdowns do not cascade into catastrophes (Stanley, 2020). Yet making urgent decisions while accommodating their long-term consequences is no simple task, because of the nature of the problems to be solved. They are characterized by complexities, uncertainties, path dependencies, and value conflicts in multiple dimensions, all of which tend to make any solution breed new problems (Funtowicz and Ravetz, 1994; Hukkinen, 2008; Rittel and Webber, 1973). These characteristics call for ample time and expertise which however are lacking when decisions are required immediately (Rochlin, 1997). The danger of making serious policy errors in the rush of things looms large.

In this article we develop empirically grounded principles for the design of decision platforms for strategic environmental crisis management that is sensitive to errors. By strategic environmental crisis management we mean coordinated decisions made in an environmental urgency that can cope with decadal-scale path dependencies and policy errors. With crisis and urgency we refer to a "creeping crisis", i.e., a threat to shared societal values or life-support systems that evolves over time and space under the influence of precursor events, attracts variable socio-political attention, and is insufficiently addressed by authorities (Boin et al., 2020). Climate warming is an example of a creeping crisis, as it requires immediate policy action to prevent it from maturing into cascades of full-blown emergencies.

Path dependencies, both in the sense of past decisions restricting current options and current decisions creating future constraints, emerge in several dimensions. Socio-ecological systems deploy large-scale technologies with technical and organizational components that grow over time toward specific goals (Hughes, 1987); economic calculations reinforce the technologies with unamortized assets and investment plans (Arthur, 2009); institutions support the systems with legislation and regulation (North, 2005); educators and experts ensure

the cognitive continuity of the systems (Hämäläinen and Lahtinen, 2016); and reputational norms persuade decision-makers to choose second-best options (Artinger et al., 2019). Path dependencies often lead to policy errors, which can be understood with the concepts of high reliability management: policy error is unacceptable deviance from pre-defined performance criteria. Sensitivity to errors is a cornerstone of highly reliable management of critical infrastructures (Roe and Schulman, 2008). As environmental deterioration makes ecosystem services ever more critical, it makes sense to draw an analogy between environmental management and the management of critical infrastructures (Korpilo et al., 2021).

On the face of it, making errors in environmental policy and management appears to be inevitable, particularly in light of numerous path dependencies. First, policy transfer from one time and place to another is an open-ended situational process. Knowing policy successes and failures beforehand is near impossible, as performance criteria are context dependent (Flyvbjerg, 2001; Stone, 2017) and long-term contingencies in socio-ecological systems are largely unknowable (Gould, 1989; Hughes, 1987; McNeill, 2000; Mitchell, 2009). Second, humans are not instinctively inclined to consider long-term path dependencies under conditions of uncertainty and urgency. On the contrary, they are either systematically biased (Kahneman, 2011) or resort to fast and frugal heuristics (Todd and Gigerenzer, 2012) when making decisions under uncertainty.

Yet we argue that something can be done to account for path dependencies in urgent environmental decisions. Institutional and cognitive path dependencies constrain the decision-making situation by narrowing down options for corrective measures. It therefore makes sense to reduce the institutional and cognitive lock-ins that may prevent corrective measures. We build on theorization of strategic crisis management (Ansell and Boin, 2019) but focus here on the design of a decision platform tasked to address environmental crises strategically, paying specific attention to the administrative and sense-making barriers to transformative policy. Since today's chronic socio-ecological disruptions render past socio-ecological templates largely outdated (Kaaronen et al., 2021), we hypothesize that an external force is required to facilitate the deliberate introspection of path dependencies and continuous updating of adaptive measures. External stimuli are needed to provoke the imagination in the decision-making situation.

In what follows, we outline principles for the design of environmental decision-making arrangements that can better cope with path-dependent policy errors. The design principles of strategic environmental crisis management are based on literature on crisis and high reliability management, scenario-based simulation exercises, and science-policy interaction; and empirical data from a series of simulation exercises conducted in 2019 on urgent long-term decision-making. We first present the methodological underpinnings of the simulation exercises and the experimental design. We then present our design principles for coping with path-dependent policy errors. We conclude with a discussion of the policy implications and applicability of the design principles.

2. Material and methods

The design principles for strategic environmental crisis management are the result of ongoing design experimentation that started in 2018 in collaboration with the City of Helsinki, Finland, and have since included other cities. Design experiments differ from controlled experiments in that they aim to create solutions through iteration and refinement of concepts, whereas controlled experiments aim to find out cause-and-effect relationships by controlling factors that may influence outcomes (Ansell and Bartenberger, 2016). The result of our design experiment, a platform for strategic environmental crisis decisions, is therefore bound to the specific situation in which it was conducted in Helsinki in 2019. However, since the design principles are conceptually and theoretically grounded in earlier research on related experimentation, we argue that

they are generalizable to other contexts where consideration of the long-term consequences of urgent environmental decisions is imperative.

The crafting of design principles began with a loosely formulated solution concept: to explore and improve the City of Helsinki's capability to prepare for and respond to foreseeable long-term social and environmental disruptions. In an analogy to the control rooms of critical infrastructures, we wanted to establish an experimental decision platform – a "Policy Operations Room" (POR) – that would enable not only strategic environmental crisis decisions but also simultaneous learning from such decisions. The design experiment proceeded as a continuous iteration between theoretical reflection over strategic environmental crisis management and empirical work on a series of decision simulation exercises, in which empirical results from the simulation exercises are used to revise the theory-grounded design concept of a POR (Ansell and Bartenberger, 2016). In this section, we describe only superficially the literature relied on during theoretical reflection and the series of POR exercises conducted in 2019. We save the details for Section 3 to give a flavor of the evolution of the design principles as a result of an iterative dialogue between the POR design concept and the empirical results.

Since the initial design objective was to develop an experimental decision platform for strategic environmental crisis decisions, the central fields of research for outlining the POR concept had to address several tensions of decision-making: the tension between short- versus long-term, between real versus simulated decision-making, between scientific and policymaking expertise, and between the interests of different stakeholders. The tension between short- and long-term time horizons in decision-making arises, because the two are often separated – not only in administrations but also in research communities studying decision-making. Yet the specific challenge of strategic crisis management is to tackle the long-term consequences of decisions made in an urgency such as the climate crisis (Ansell and Boin, 2019). To tackle the tension, we relied on research on policy, decision-making, crisis management, and high reliability management.

The tension between real versus simulated decision-making arises because empirical investigation of live decision-making in crisis situations is often impractical or impossible, which necessitates the study of simulated decision situations (Hukkinen et al., 2022). Since the PORs were simulation exercises, we conducted an extensive literature survey of research on scenarios, simulation exercises, and gaming (Järvensivu et al., 2021). The tension between scientific and policy expertise emerges as a result of calls for evidence-based policy, which is often seen as a threat to policymaking by democratically elected politicians (Jasanoff, 1990). Here we draw on science and technology studies (STS) and studies on science-policy interaction. Finally, tensions between the interests of different stakeholders arise, because expert and interest groups often define goals, successes, and errors in variable ways. We addressed the tensions by involving high-level policymakers and experts from various socio-technical domains, and by consulting diverse groups of experts and stakeholders during the POR design phase. Teams that include different kinds of thinkers often outperform homogenous groups on complex tasks, and heterogeneity in decision-making can provide "diversity bonuses" and adaptivity (Page, 2019).

In the empirical part of the POR design experiment, five simulation exercises were organized during 2019 (Table 1). The objective of the series of exercises was to develop a first version of POR, i.e., a decision platform for strategic environmental crisis decisions and simultaneous learning from such decisions. The first four exercises were preliminary exercises (Test-PORs) in which the POR concept was fine-tuned for eventual use in the fifth pilot exercise with the City of Helsinki personnel (Hel-POR). The first two Test-PORs were attended by researchers of our ongoing WISE project (https://wiseproject.fi), which studies adaptation to wicked socio-environmental disruptions. The next two Test-PORs were attended by university students, one by social science students, another by dramaturgy students. The Hel-POR was with the City of Helsinki's top politicians, administrators, and sectoral experts.

All PORs described in Table 1 followed approximately the same

Table 1

The Policy Operations Room (POR) exercises.

	Two *Test-PORs with researchers* (May & September 2019)	Two *Test-PORs with students* (November 2019)	*Hel-POR* with City of Helsinki (November 2019)
Objective	Detailing participant groups, scenario, script, and observation of POR	Preliminary testing of the POR concept	Piloting the POR concept with politicians and experts
Participants	9–16 researchers from WISE project	10–15 students of social sciences & dramaturgy	7 top politicians; 10 experts and administrators; 9 observers and facilitators from WISE project
Venue and duration	BIOS Research Unit office & University of Helsinki lecture hall in Helsinki; 3–4 h	University of Helsinki and University of the Arts lecture halls in Helsinki; 3–4 h	City of Helsinki Board meeting room; 2–3 h
Focus of observation	Framing and epistemic issues; Flow of the exercise, non-verbal and affective issues; Political coalitions and power issues	Flow of the exercise	All observations of Test-PORs; Strategic environmental crisis decisions; Deliberation and learning
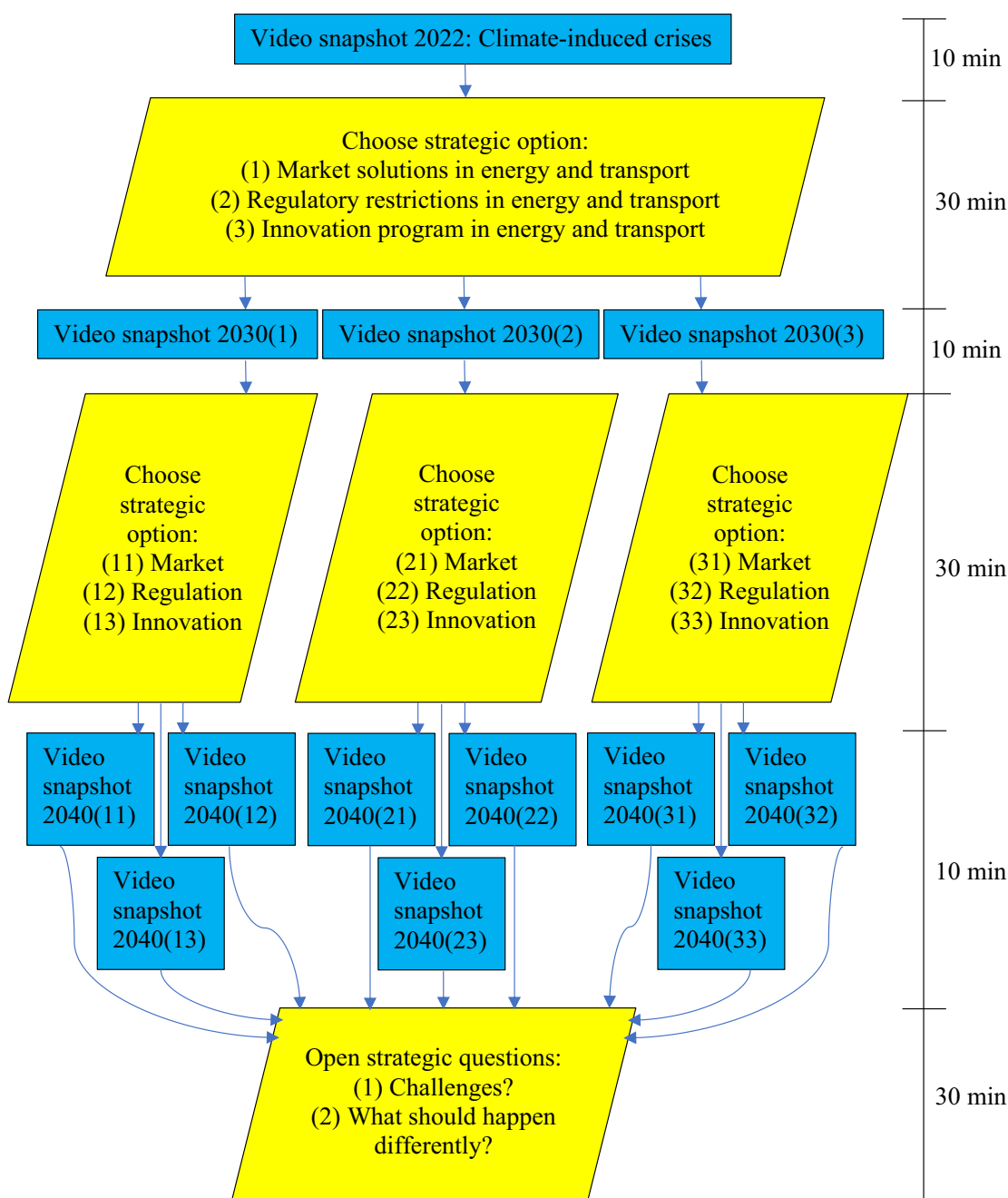
Fig. 1. Flow of the Policy Operations Room (POR) exercise.

scenario and script, which however were fine-tuned iteratively on the basis of Test-POR experiences and reflection in light of research literature. The POR exercise simulates a decision-making session organized in response to a creeping crisis that has reached a critical threshold. It is chaired by the mayor and attended by the deputy mayors of Helsinki, leading politicians of the city council, and key experts from the administration. In Test-PORs, the researchers and students assumed the roles of specific politicians and experts. In Hel-POR, the invited politicians and experts were those that would be called upon in real life. Unlike in normal decision-making situations, the invited experts were present during the entire POR exercise. The participants were asked to imagine themselves in the year 2022, when climate-induced socio-environmental crises around the world impacted Helsinki to an extent that demanded exceptional and urgent policy measures at the city level. The decisions made in 2022 led to a new situation in 2030 and to a final situation in 2040 (Fig. 1). The participants were shown a 5-min video of the situation in 2022, 2030, and 2040, which in 2030 and 2040 was based on the earlier decisions. After the situational videos in 2022 and 2030, the participants were given three strategic options to choose from after a 30-min deliberation.

The videos were shot in advance and designed to present the state of the world at a future point in time and how Helsinki had developed following the strategic decisions. Global developments were based on paths anticipated in multidisciplinary environmental studies (e.g., extreme weather, disruptions in supply networks, climate migration) together with a surprising but plausible element (a long, extremely cold period during the winter due to the Warm Arctic, Cold Continents phenomenon theorized in some studies). The idea was that strategic decisions initiated and reinforced certain dynamics in Helsinki, leading to a particular kind of social, economic, material, and political situation in which the city would have to cope with global developments. The exercise participants found the videos highly credible, albeit differently. The developments that shocked the students were bland to the city leaders. The videos enabled the participants in all PORs to imagine themselves in future situations and engage in serious and lively discussions.

In the 2040 situation the participants encountered critical challenges with global origins and severe local consequences. Possibilities for coping with them depended on how Helsinki had evolved after the strategic choices made in earlier decades (Fig. 1). Climate-induced global food crises materialized in Finland as price fluctuations and uncertainties in food supply. The security of supply for domestic industries had also weakened. Persistent hot and dry weather in Southern Europe drove climate refugees to Finland. Helsinki's reputation as a city with reliable technical, economic, and social infrastructures was threatened. However, its relative social stability and clean environment still attracted tourists.

Since our aim was the design of a decision platform for making swift and transformative policy changes to prevent creeping environmental crises from evolving into emergencies (Boin et al., 2020), the POR scenarios were based on earlier analyses conducted by the BIOS Research Unit on the long-term options for energy transition in Helsinki (Vadén et al., 2019). Data for these analyses come from government documents and discussions with political decision-makers, technical experts, business insiders, researchers, and NGO representatives. Potential strategic vulnerabilities of different energy choices and paths were considered based on the reports and scenarios by the National Emergency Supply Agency (2018), the Security Committee (2017), and the Ministry of the Interior (2019). At the same time, we infused a sense of near-future realism into the POR decisions by telling the participants that the need to make long-term strategic choices right now was triggered by ongoing climate-induced emergencies such as floods, heat waves, cold spells, and uncontrolled migration.

To enhance learning, each POR ended with the participants' joint deliberation over the challenges of the 2040 situation, guided by the following questions: What were the key challenges in the 2040 situation? If the participants could return to the beginning of the exercise, what would need to happen in Helsinki during 2020–2040 to enable the city to better respond to the challenges in 2040? In addition, during the weeks following the Hel-POR exercise, researchers from the WISE project conducted debriefing interviews with almost all participants to allow them to evaluate the exercise.

3. Results: Design principles for coping with path-dependent policy errors

The five design principles for strategic environmental crisis management focus on the agenda for deliberations in the POR (Design principles 1–3) and the participants and their role in decision-making (Design principles 4–5). They originate in an iterative dialogue between theoretical concepts and empirical findings: each design principle begins with an overview of its theoretical background, followed by empirical illustration of the difficulties that were encountered in putting the principle in practice.

3.1. Provoke decision-makers' imagination with alternative futures

Design principle 1: Structure the agenda around alternative futures that provoke the imagination of decision-makers and facilitate critical introspection of human cognitive biases to past models of thought.

Theoretical background. Diverse strands of research show that humans have an innate capacity and inclination to imagine the future, in multiple different ways. From the perspective of coping with path-dependent policy errors, it makes sense to consider how this innate capacity can be nurtured in decision-making for the long-term future.

The emergence of linguistic symbols in human cultural evolution set free the human cognition from the immediate perceptual situation by enabling multiple simultaneous representations of all possible perceptual situations (Bender, 2020; Heyes, 2012; Tomasello, 1999). Recent advances in cognitive science suggest that our capacity for imagination exists for adaptive purposes. Imagination exists for considering alternative opportunities for action, allowing "us to make better choices and select better actions" (Clark, 2016: 85). It is equally obvious that in uncertain situations, we typically do not imagine much. Tversky and Kahneman propose that the fast heuristics we use in uncertain environments are inherently biased, often resulting in flawed or suboptimal decisions (Kahneman, 2011). Contrarily, the proponents of "fast and frugal" heuristics emphasize that biased heuristics may work well when used in the right environments (Todd and Gigerenzer, 2012). But even in the latter case, the success of heuristics is typically restricted to stable environments, and heuristics offer little in the way of "imagination" in unforeseen scenarios. Heuristics, typically decision-tree-like algorithmic rules, are not particularly suitable for considering previously unencountered path dependencies or alternative scenarios. A more promising way to consider path-dependent effects is to impose on decision-makers structured patterns of thought that can rapidly spark the imagination, such as scenarios, imagined futures, and alternative narratives of the future (Ansell and Boin, 2019).

Imagination is the topic of at least two lines of inquiry pertinent to our focus. Beckert (2016) discusses the "imagined futures" underpinning capitalism. In capitalist economic systems, humans orient themselves toward a future they perceive to contain both risks and opportunities. The future orientation is anchored in institutions and in human ability to imagine future states of the world that are different from the present. According to Beckert, human ability to fill the future with counterfactual imaginaries is key to understanding the dynamics of capitalism. Switching the perspective slightly, the same capitalist systems are also socio-technical systems, the focus of analysis in science and technology studies. "Sociotechnical imaginaries" are "collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and

technology" (Jasanoff, 2015: 4).

The purchase of imagined futures for coping with path-dependent policy errors is in their capacity to bridge the material world with the normative push of human agencies to shape that world. Stirling (2008) lists the following benefits of pursuing a diversity of future technological commitments and pathways: it nurtures context sensitivity, helps accommodate irreconcilable values and interests, hedges against ignorance, mitigates premature lock-in, and promotes robust innovation and social learning. Empirical evidence from the PORs adds nuances to these literature-based observations.

Empirical illustration. The aim of the Hel-POR and the Test-PORs was to counter existing decision-making deficiencies with simulation exercises that facilitate bold and imaginative decision-making with long-term path dependencies in mind. Both sets of PORs attempted to provoke alternative futures in accordance with the principles of scenario effectiveness, i.e., engendering productive discomfort and creative ambiguity in the scenario audience (Selin et al., 2015). The POR exercises did this by presenting the participants with three distinct imagined socio-technical futures: 1) the Market path, 2) the Regulatory frugal path, and 3) the Innovation and investment path (Fig. 1). Differences in how the students in Test-PORs and the city decision-makers in Hel-POR handled the socio-technical complexities of the scenarios reveal key obstacles to tackling the long term.

The students in Test-PORs explored the scenario paths comprehensively to figure out together what would result from each of the given strategic options. The possibilities and futures imagined by the students were characterized by an openness to question the implications of both the scenarios presented and the ways in which they had been built. They also recognized and admitted the socio-technical complexities built into the scenarios, including issues of social justice. They relied on the assumption that there is no easy way out of the situation the city is facing. They were cautious, for example, about so-called green paradoxes where a certain emission-cutting measure could lead to unintended consequences and increase total emissions (Sinn, 2008).

The recognition of these complexities was also strongly on the agenda of the Hel-POR participants. Our aim was to build a situation in which the city participants would come to terms with the real boundaries, uncertainties, and wickedness of getting emissions down while meeting other political goals. We attempted this by focusing on actual socio-technical issues (heating and transport) instead of party-ideological divides or programs, and by inviting only substance experts to the exercise, in addition to politicians. At first, the Hel-POR exercise proceeded as the Test-PORs. However, a vocal energy expert – with a professional background in corporate responsibility – reduced the complexities and uncertainties of all three paths into an easily solvable technical issue: that of digitalization and substituting one fuel for another. One decision-maker did recognize the wickedness built into some of the scenarios but did not explicitly challenge the energy expert's framing of the issue. The reframing of the issue into a matter of efficiency and existing expertise significantly impoverished deliberations over the wickedness of the socio-technical imaginaries and closed down available options for the imagination of possible futures for Helsinki. The process was amplified as the other experts remained silent.

In sum, the scenarios in the two sets of PORs partially fulfilled the task of imposing alternative futures that provoke imagination and critical introspection of past models of thought. Although the rugged vision of the world in the last scenario snapshot (Fig. 1) appeared to the Hel-POR participants as "bland," the exercise still led to the insight that outcomes might be ambivalent; that there are deep tensions between different aspects of how to govern a city that should be explicitly debated despite running budgetary concerns; and that it might be wise for Helsinki to prepare for this future world in view of inescapable global connections. The Test-PORs however managed to open up alternative imaginaries for collective inspection in a more nuanced way, probably in part because these groups were not limited by the everyday technicalities (especially budgetary) and procedures (especially the role of

experts, who normally express their views only when asked by politicians).

3.2. Highlight alternative problem frames

Design principle 2: Highlight on the agenda the implications of alternative problem frames and alternative causal hypotheses for each problem frame.

Theoretical background. Systematic exploitation of alternative problem frames provides decision-makers with effective cognitive tools to consider path-dependent policy errors. Erving Goffman defines a frame situationally. When individuals attend to a situation, they ask themselves a sense-making question: "What is it that's going on here?" The answer to the question is the frame and it enables the individuals to get on with the affairs at hand (Goffman, 1986: 8). Goffman's aim in frame analysis speaks directly to coping with policy errors: to isolate basic frameworks available in a society for making sense of events and to analyze the vulnerabilities of these frames of reference (Goffman, 1986; see also "bracketing" in Bateson, 1972).

To get a fuller picture of the vulnerabilities of different frames, a range of alternative frames of reference is needed. Building on Alfred Schutz's (1967) work, Harold Garfinkel highlights the contrasts between frames relating to scientific rationality on one hand and daily life on the other. Actions governed by scientific rationalities adhere to stable scientific ideals, whereas actions governed by the pragmatics of daily life are marked by an absence of scientific ideals or stabilities (Garfinkel, 1984). Stirling (2008) draws the policy implications of the differences between scientific rationality and daily life with a call for an "opening-up approach," i.e., "systematically revealing how alternative reasonable courses of action appear preferable under different framing conditions and showing how these dependencies relate to the real world of divergent contexts, public values, disciplinary perspectives, and stakeholder interests" (Stirling, 2008: 280).

A related tension exists between scientific doctrines and professional practices concerned with errors (Ansell and Boin, 2019). Among high reliability professionals, "having the bubble" refers to infrastructure operators who can successfully construct and maintain a cognitive map that enables them to integrate various inputs into a single situational picture and operational status. "Losing the bubble" represents a state of incomprehension or misunderstanding even in an ambiance of good information (Rochlin, 1997). Schulman (1988) extends these observations to the broader society. Policies grounded in formal doctrines risk policy errors when the issues at hand are complex and uncertain. Such doctrinal errors can be avoided with institutional pluralism. Just as in control rooms an operator losing the bubble is not critical as long as there is another operator who can take over, so in the societal realm a failing policy approach is not critical as long as alternative policy approaches remain intact. In sum, "ideational policy could threaten the error containment which institutional pluralism provides" (Schulman, 1988: 286).

The conflict between scientific and professional frames of reference is asymmetrical. Problem frames rooted in professional practices have a formidable opponent in scientific rationality, firmly rooted in the "calculative agencies" (Callon, 1998) of various disciplines. For example, benefit-cost and cost effectiveness are calculative agencies "formatted, framed and equipped with prostheses which help [the policy analyst] in his calculations and which are, for the most part, produced by economics" (Callon, 1998: 51; see also Kay and King, 2020). Paul Schulman makes a similar point with respect to formal risk assessment: "How rational are formal analytic and risk-assessment models, when these frameworks themselves can become risky actors in close conjunction with actual public policy making?" (Schulman, 1988: 288–289).

Empirical illustration. In Hel-POR, the dominant framing from the very start became that of "business as usual." The decision-makers asked "how credible" selected aspects of the Market path would be and what "the factual meaning" of the Regulatory frugal path would be. They asked "how realistic it would be that you would get something that is not

already invented in the Silicon Valley or China or Germany" for the proposed investment sum of the Innovation and investment path (Fig. 1). They also asked about the "effectiveness" of the Regulatory frugal path from the point of view of emissions and alternative fuels. Only the energy expert answered the questions while the environmental experts remained silent. A decision-maker who tried to broaden the discussion to the EU goal of carbon neutrality was swiftly dismissed by others as unrealistic, after which the discussion narrowed down to the topic of fuel. Economic realism was the dominant frame also in strategic choices of Hel-POR. In the final discussion, the decision-makers congratulated themselves: "We might have economic problems, yes, but apparently in relation to the rest of the world we are doing incredibly well." One decision-maker however did recognize that the discussion sidetracked the "tension between the need to increase economic growth and the simultaneous need to reduce material consumption."

What is remarkable about this sequence of framings is the complete absence of the environmental "scientific rationality" and the overall dominance of "daily life" as interpreted by the city's top politicians. We hypothesize that the decision-makers prudently avoid long-term decisions that might endanger their chances of being re-elected (Section 3.3). Cognitive-institutional structures reinforce the choice to downplay environmental rationalities, as shown in the silence of the environmental experts. In the city's daily *Realpolitik*, the strategy for avoiding the intricacies between economic and other considerations is to make an a priori cognitive assessment of plausibility and probability: considerations beyond economics are framed as implausible and improbable to succeed (Janasik, 2021).

The students in Test-PORs spent much time and effort to identify and evaluate the problem frames. The dramaturgs identified major themes of special concern: food security, migration and refugees, and the complexity of the local system. They also saw a problem with the "endless running down the technological alley" implied by the path-dependent developments built into the scenario structure. The social scientists recognized that there might be total surprises, concluding with the observation that in addition to infrastructural changes, "changes of mentality can occur really fast," for example in younger generations. In contrast to the Hel-POR participants who congratulated themselves for managing the immediate crisis "incredibly well," the Test-POR students anguished at length over the nature of the problem they should manage. When confronted with the reactions of the Test-PORs in the debriefing of Hel-POR, politicians and experts alike shrugged off the students' framings as being evidence of "youthful anxiety and angst" and, by contrast, saw themselves as being the realistic and rational grown-ups.

In sum, what sets the Hel-POR and Test-PORs apart is the question of what "the bubble" is in the first place. The Hel-POR participants accepted the premises of current cognitive-institutional pathways and defined the problem-space as well-defined and fully under control. In doing so, they excluded long-term thinking from the deliberative process. In contrast, the Test-POR participants started out from the premises of a collective and existential sustainability crisis, defining "the bubble" as ill-defined and requiring critical thinking and systemic change. In the interviews conducted after the Hel-POR, we confronted some of the decision-makers with the contrast between professional decision-making procedures and existential sustainability concerns. One decision-maker highlighted their professional growth and survival skills in the political game on one hand, and the private sorrow over the discernible processes of destruction on the other (moving to tears at this point in the interview). Thus, one way to deal with the tension between short-term economic and long-term environmental concerns is to split oneself in two, one professional and one private, and to call upon them as the context requires. Yet the cost of such doctrinal adherence to economic efficiency in professional decision-making is an increasing threat to long-term error containment (Roe and Schulman, 2008; Schulman, 1988). Characterizing the problem as well-defined curtails the process of imagining possible futures.

3.3. Discourage defensive heuristics

Design principle 3: Design the agenda to encourage learning and discourage defensive heuristics that aim to secure a decision-maker's personal reputation.

Theoretical background. Defensive decision-making can pose a significant hindrance to the consideration of path-dependent policy errors. Defensive decision-making occurs when a decision-maker has a best option in mind for a task or organization, but nonetheless deliberately chooses a sub-optimal decision to protect themselves against negative consequences (Artinger et al., 2019; Gigerenzer, 2015). Defensive decision-making has been associated with a negative error culture, where errors are not accepted or openly discussed, and therefore learning from errors is difficult. It has been documented in various domains, from medical professionals to public administration. A study on German public administration found that 80% of managers had made least one defensive decision and that 17% of managers stated that at least half of their decisions were defensive (Artinger et al., 2019). This suggests that it is important for decision-makers to acknowledge the potential presence of defensive decision-making, as well as foster a positive error culture to help develop groups that are self-aware of defensive decisions and their possible negative consequences.

A positive error culture can be fostered through "error management," which deals with errors openly after they have occurred, aiming to minimize negative error consequences and maximize positive error consequences such as learning and innovation (Frese and Keith, 2015). The prevalence of defensive decision-making in most institutions responsible for path-dependent decision-making is unknown, but there is good reason to assume that, when faced with wicked problems, decision-makers often rather conform to defensive C.Y.A. ("cover your ass") decision-making instead of doing what they believe to be strategic in the long-term. Many reasons for this might exist, such as 1) the lack of incentives to drive (costly) long-term policies when success is measured in short-term election cycles, 2) having to stay within tight short-term budgets despite long-term benefits of immediate investment, 3) avoiding public critique/shame by conforming to *status quo* expectations, 4) avoiding blame/litigation for radical responses. It is plausible that in many if not most organizations, defensive decision-making is a pernicious, pervasive, and to some degree inevitable outcome. It may be difficult to identify due to the variable definitions of "optimal" outcomes by different stakeholders – not to mention that the definition of optimality is also contingent on the temporal scale chosen for assessing decision outcomes (notably, short-term optimization may lead to long-term errors). This suggests that a positive error culture should maintain that errors are likely, and that their negative consequences should therefore be bounded.

Should errors occur, they should be restricted to environments where 1) the negative second-order effects of errors are confounded, i.e., policy professionals should approach complex decision-making with high degrees of precaution (Flyvbjerg, 2020) and preferably be restricted to 2) errors that can be learned from. For example, critical infrastructure operators must recognize quickly and with intuition the precursors to system failure, and therefore place a high premium on preparedness and precaution (Roe and Schulman, 2008). Infrastructure operators typically emphasize the role of real-time learning, practically acquired expertise, and adaptation in decision-making (Rochlin, 1997). This is contrary to the prevalent decision-making culture where political decision-makers have been documented to systematically avoid personal responsibility or having "skin in the game," thus restricting learning opportunities and personal investment in failure (Artinger et al., 2019).

Empirical illustration. PORs with their deliberative approach and debriefings were designed to provide an avenue for error management and promote a "positive error culture" that discourages defensive decision-making. We emphasized to the participants that the exercise was not a test of their abilities as decision-makers or the correctness of their decisions, but rather an opportunity to deliberate on important

factors influencing strategic decisions. The design objective was achieved in the Test-PORs, whose participants threw themselves into frame-questioning interpretive activities. However, the Hel-POR exercise was not able to break the patterns of the city's organizational culture, especially as regards issues of long-term energy safety. On the contrary, the exercise was a disappointment when compared to for instance the Helsinki Energy Challenge, an international competition the city announced in 2020 for "radically new solutions" to achieve carbon neutrality by 2035 (https://energychallenge.hel.fi/). Consideration of long-term complexities was not absent in the deliberations, as illustrated for example in efforts to frame the problem (Section 3.2) – it was just overwhelmed by consideration of short-term efficiencies.

In sum, stronger measures than those applied in Hel-POR are needed to overcome the cognitive-institutional underpinnings of defensive decision-making. The measures we as organizers applied in Hel-POR, such as encouraging the participants to see the exercise as an opportunity for creative thinking rather than a test of decision-making, failed to create a safe space for breaking conventions and taking risks. Earlier research suggests at least two broad institutional measures to elicit honest opinions, namely, 1) decoupling conflicting interests by organizing PORs separately for decision-makers and experts, possibly even for different political groups among decision-makers (Hukkinen et al., 1990) and 2) reducing the burden of institutional representation by explicitly asking the POR participants to participate in the exercise in their personal instead of professional capacity (Haas, 1989). Both measures would facilitate a sense of safe space by diminishing the need to defend professional positions and enhancing experimentation with unconventional ideas.

3.4. Enhance pragmatic interaction between science and policy

Design principle 4: Enhance pragmatic interaction between science and policy by bringing together experts and policymakers in structured deliberation over policy choices.

Theoretical background. Well-established approaches to science-policy interaction can serve to incorporate long-term considerations in policymaking. Charles Lindblom and Edward Woodhouse summarize their instructions to "extend the intelligence of democracy" as follows: 1) adapt analysis to politics with "thoughtful partisanship;" 2) engage in intelligent trial and error based on precaution and flexibility; 3) reduce professional impairment by preventing politics from turning into a process through which elites can obstruct citizens from learning (Lindblom and Woodhouse, 1993).

The idea of thoughtful partisanship emerges in different variations in the literature. Some analysts adhere to Lindblom and Woodhouse's (1993) original position that policy analysts ought to turn their attention to issues and stakeholders they believe deserve higher priority than they are receiving in the predominant policy discourses (e.g., Roe and Schulman, 2008). In contrast, Pielke (2007) warns experts against becoming "issue advocates" and promotes instead the role of an "honest broker," who facilitates science-policy interaction with scientifically sound alternatives that speak to a range of values. In light of our POR experiences, Pielke's ideal of treating all scientifically supportable alternatives equally in policy deliberations appears rather naive. As was pointed out in Section 3.2, some lines of scientific enquiry (such as economic calculations) have over time gained such an influential position in policy discourses that they in fact silence potentially relevant but institutionally weaker approaches to the long-term future.

Regardless of the role the expert takes in science-policy interaction, eliciting honest expert views on long-term policies requires governance arrangements that secure a balance between negotiation and boundary work: scientists engaged in policymaking must be seen to have a separate role from that of policymakers to maintain their scientific credibility (Jasanoff, 1990). Jasanoff qualifies Wildavsky's (1987) idea of experts "speaking truth to power" by pointing out that the link between experts and policymakers is not one-directional but rather interactive

negotiation across institutionally safeguarded positions. To prevent the defensive heuristics described in Section 3.3 from kicking in, the institutional safeguards should protect decision-makers and experts against threats that far-sighted decisions may pose for budgeting, career, reputation, or legal action.

Lindblom and Woodhouse's (1993) second advice for intelligent policymaking – precautionary trial and error – is particularly important for identifying potential path-dependent policy errors. Scientists should be embedded in a durable social context of dialogue and action with policymakers, such as PORs, to reveal potential errors and to facilitate critical reflection that catalyzes learning from errors (Hoppe, 1999). The POR is designed as a simulation exercise, which has been found to offer an analyzable proxy for the kind of dialogue between experts and decision-makers that is required for long-term planning. Simulation exercises are test beds for both practicing and analyzing decision-making in a realistic setting (Boin et al., 2004; Järvensivu et al., 2021; Kinzig et al., 2013; Mayer, 2009).

The third instruction for extending the intelligence of policymaking is a warning against professional impairment, through which expert and policymaking elites obstruct citizens from learning. The farther into the future the implications of today's decisions extend, the greater the uncertainties – and the danger that political and economic elites reduce democracy by simply preserving their own advantages (Lindblom and Woodhouse, 1993). To avoid this, interaction between science and policy should be crafted into a self-reflexive dialogue over the rationalities and procedures of decision-making (Hukkinen, 2020; Wickert and Schaefer, 2015). Externally imposed imperatives to arrive at single evidence-based solutions should be avoided. Although ambiguity about what constitutes the single best way forward may be uncomfortable, an open process renders the positively evaluated range of options collectively robust (Page, 2019; Stirling, 2008).

Empirical illustration. To ensure the pragmatic relevance of the POR scenarios and decision options to the City of Helsinki (Fig. 1), our research group organized five interactive planning meetings with the city personnel during the year preceding the Hel-POR. In the meetings, the scenarios and decision options were refined with technical detail provided by the Safety and Preparedness Unit, the Urban Environment Division, the city's energy company Helen, and the Mayor's Office. The refinement was iterative, with each meeting's agenda probing at increasing level of detail the most critical aspects of the city's energy and transportation management.

Experiences from the PORs offer both positive and negative illustrations of the design principle. PORs aimed to facilitate thoughtful partisanship by highlighting that today's time-pressured decision-making pays inadequate attention to the long-term consequences of policies. The participants were exposed to scenarios of the future, including decision options and outcomes, all of which were based on multidisciplinary scientific findings (Section 2). They had to imagine themselves as the shapers of the city's future while experiencing the creeping catastrophes over decadal timescales. Both the Test-PORs and Hel-POR succeeded in raising the participants' sympathetic awareness of the short-term bias of today's policies.

The Hel-POR was less successful, however, in facilitating precautionary trials and errors and avoiding the decision-making elites' professional impairment. Hel-POR aimed to create a platform for trials and errors by offering research-based decision options for deliberation and encouraging the city's substance experts to present their perspectives. Yet the experts failed to divorce themselves from their usual role of producing background data and analyzing the city's policies with ample time. They were unable to provide an answer to a decision-maker's urgent question such as: "What should the city actually do if it were to radically and rapidly lower its climate emissions and at the same time adapt to climate change?" Furthermore, the absence of political pressure in Hel-POR exacerbated the politicians' professional impairment. As the decision-makers pointed out in the debriefing after the exercise, they could play the game "too easily," without having to worry about the

concerns of the citizens of Helsinki, the politics of party alliances, bad press, or re-election.

In sum, although the overall aims of the PORs supported structured deliberation between experts and policymakers over policy choices, the assumption – based on an extensive review of simulation and gaming literature (Järvensivu et al., 2021) – that a realistic decision setting would best promote the aims, proved to be incorrect. In particular, the experts' role in the deliberations needs to be strengthened. Furthermore, injecting realistic political pressures in POR deliberations could push the deliberations beyond the limits of normal decision-making.

3.5. Promote equality of authority and plurality of evaluative criteria

Design principle 5: Question formal doctrines by promoting equality of authority and plurality of evaluative criteria among participating experts and decision-makers.

Theoretical background. When the challenge is to project far into the future what path-dependent errors might result from today's decisions, enhancing the intelligence of policymaking with expertise seems uncontroversial. Yet doing so is a sensitive proposal from the point of view of political democracy (Barry, 2008). Heidenreich (2018) identifies three challenges: 1) How to secure a requisite level of expertise without defaulting into meritocracy? 2) How to secure citizens' participation and deliberation without losing the effectiveness of organized decision-making? 3) How to reconcile the need for long-term decisions with the slow pace and short time span of decisions that characterize today's democracies? A concise summary of the sensitive lock-in of expert knowledge and power is offered by Turnhout et al. (2016: 69): "…how one knows constrains how one governs and how one governs shapes what one needs to know."

Earlier research offers the broad outlines of a resolution to the tension between expert and political authority. The key is to find a satisfactory balance between the extent to which experts and policymakers engage in institutional boundary work to maintain their professional identities, and the extent to which they engage in negotiation across the boundaries (Section 3.4). Engagement in the two activities can ideally generate "serviceable truths" that satisfy scientific requirements and serve policy purposes as well (Jasanoff, 1990). Yet even in the best of circumstances, it is advisable to expect interruptions, breakdowns, and ambiguities in coordination across groups (Ansell and Boin, 2019).

Based on extensive empirical research on critical infrastructures, Paul Schulman draws an interesting analogy between preventing the abuse of power in a political system and managing a utility plant reliably: "The differentiated yet overlapping authority of the plant is equivalent to the separation of powers. Maintaining credibility and trust are equivalent to 'constitutionalism' (the voluntary restraint on the exercise of power) within a polity" (Schulman, 1993: 353). Since formal powers in democratic settings rest with policymakers, the power of experts is often implicit, i.e., based on knowledge of whether, when, where, how, and with what intensity to influence the policy cycle (Hukkinen, 2016, 2020).

Empirical illustration. Although the Test-PORs and the Hel-POR were all prefaced with an instruction to decision-makers and experts to participate equally in the deliberation over decisions, only the Test-POR participants followed the instruction and were able to introduce non-doctrinal viewpoints to the discussion. In Hel-POR, politicians and experts were largely unable to divorce themselves from their daily roles. In practice this resulted in politicians wielding the stronger deliberative power. We suspect that the decision to organize the exercise in a realistic setting, the Helsinki City Board's meeting room, contributed to biased deliberations. This highlights the fact that promoting diversity in decision-making processes (sensu Page, 2019) is not sufficient by itself, and that the inevitable power structures in decision-making processes should also be acknowledged and proactively anticipated.

Another factor contributing to the narrow range of perspectives in the Hel-POR deliberations was that the elected politicians profiled

themselves as "professional decision-makers." They emphasized that urban decisions are typically "less about ideology and more about getting things done," which in their interpretation reduces ideological conflicts across political groups. Interestingly, this self-image only boosted their authority in the deliberations because they could claim to possess a cross-sectoral view that the sectoral experts lacked. Exacerbating this was the observation that not all knowledge is equal. Although the Hel-POR scenario and decision options explicitly foregrounded social, technical, and environmental dimensions over economic ones, the politicians tended to frame the decision issues predominantly in terms of financial management (Section 3.2).

In sum, the POR experiments provide empirical support for the workability of differentiated yet overlapping authority between experts and policymakers when tackling the long-term policy implications of current decisions. In practice, however, POR design needs to find ways to strengthen both the different kinds of expertise pertinent to the crisis at hand and the authority granted to the experts to deliberate critically across sectors.

4. Discussion

The design principles for facilitating strategic environmental crisis management are formulated in broad terms to provide generalizability in a variety of decision settings. To illustrate how the general principles can be adjusted to specific settings, we summarize in Table 2 how the principles could be crafted into specific designs to meet the strategic

Table 2
Critical assessment of the design principles for strategic environmental crisis management.

Design principle	Observed weaknesses	Potential remedies
1. Structure the agenda around alternative futures that provoke the imagination of decision-makers and facilitate critical introspection of human cognitive biases to past models of thought	Dominant voices among participants narrow down consideration of alternative scenarios	Support silenced scenarios with stronger facilitation of POR procedures; Include voices from diverse experts and stakeholders
2. Highlight on the agenda the implications of alternative problem frames and alternative causal hypotheses for each problem frame	Agenda is framed doctrinally as a matter of credibility, realism, and efficiency	Support alternative problem frames with stronger facilitation of POR procedures; Include voices from diverse experts and stakeholders
3. Design the agenda to encourage learning and discourage defensive heuristics that aim to secure a decision-maker's personal reputation	Cautious short-termism dominates over unconventional long-term considerations	Make POR less about decision-making and more about agenda-formation by de-emphasizing the institutional roles of participants; Invest time in iteration and dialogue between different perspectives
4. Enhance pragmatic interaction between science and policy by bringing together experts and policymakers in structured deliberation over policy choices	Most experts remain silent during deliberations; Politicians are not adequately challenged by political pressure	Strengthen the role of experts in POR or organize separate PORs for experts and decision-makers; Introduce realistic pressure from voters in POR
5. Question formal doctrines by promoting equality of authority and plurality of evaluative criteria among participating experts and decision-makers	Politicians take on professional roles as multi-sector experts	Conduct POR in an unfamiliar setting to participants; Differentiate decision-maker versus expert authority in POR while ensuring overlapping authority

environmental crisis management needs of the City of Helsinki. Other contexts of application would likely generate other variations of the design.

First, dominating participants and doctrines can hinder consideration of a broad range of scenarios and problem framings, which are essential for maintaining strategic options in situations where earlier decisions have proven to be erroneous (Table 2). POR procedures need adjustment, for example by having a neutral facilitator chair the proceedings and incorporating alternative problem framings explicitly in the agenda.

Second, defensive heuristics can lead to persistent short-termism that questions the very idea of a POR, namely, far-sighted environmental crisis management (Table 2). One way to reduce defensive heuristics is to turn the POR into a platform for crafting decision options for consideration by formal decision-making bodies at a later stage. The participants would then act in their expert rather than institutional capacity, which would enable bolder consideration of future alternatives. Yet the problem of defensive heuristics emerging at a later stage would remain. Addressing the issue may require embedding the POR in deeper institutional reforms. We are reminded of Arild Vatn's (2020) proposal to create a separate second chamber in democratic decision-making bodies with the responsibility to ensure that policies safeguard sustainable futures.

Finally, politicians overruling sectoral experts in POR deliberations is a systemic weakness in the city's decision-making culture (Table 2). To remedy the situation, sectoral experts can be empowered by organizing PORs with experts alone, without politicians. The weak position of environmental expertise in decision-making can also be supported by introducing environmentalist voter or NGO pressure in the deliberations (Bächtiger et al., 2018). De-familiarizing the POR setting may also be significant in creating a sense of equal authority between politicians and experts. While there is an urgent need to make strategic environmental crisis management part and parcel of the normal procedures of urban affairs, it is at the same time important to signal the unique differences between running the everyday affairs of the city (where advisory expertise is adequate) and coping with inevitable policy errors resulting from chronic environmental crises (where vociferous expertise is crucial).

We are drawing on these lessons in our ongoing collaboration on PORs with Helsinki and two other Finnish cities. To tone down dominant voices and doctrines in future PORs, we are positioning ourselves as external consultants to the city and will have a member of our research group chair the POR deliberations. To tackle the issues of defensive heuristics and dominating politicians in the deliberations, we aim to boost the expert voices by sequencing the POR sessions such that the first POR will be with sectoral experts alone and the second with experts and politicians. Another method of strengthening the expert voices is simply having the experts meet together before the POR with the politicians, so as to help the experts identify common ground among themselves and increase their confidence in sharing their views with the politicians. We are also strengthening science-based argumentation about the critical consequences of climate change with a visual dashboard displaying simulation model results of a realistic cascade of climate-induced multi-hazard events (heat wave over Southern Finland resulting in a major storm that leads to flooding in the city and forest fires in the surrounding regions).

5. Conclusion

As large-scale environmental disruptions become chronic, it is imperative for ecological economics to consider the long-term consequences of urgent crisis decisions. We have developed broad principles for the design of a decision platform, the Policy Operations Room, to tackle the challenges of strategic environmental crisis management, by which we mean coordinated decisions during an environmental urgency that are sensitive to long-term path dependencies and policy errors.

Since policy errors are inevitable in urgent decisions with decadal-scale consequences, the central standard of performance in strategic environmental crisis management is the capacity to recognize and cope with errors.

The design principles for strategic environmental crisis management address the critical issues of who should participate in what role in the decisions, and what should be the agenda for the deliberations. The POR participants should include both policymakers and sectoral experts to enhance pragmatic interaction between policy and science. At the same time, policymakers and experts should be given equal authority to enable the questioning of formal doctrines in the deliberations. The agenda should be structured around scenarios of alternative futures to stimulate the imagination of the participants. Critical questioning of alternative ways to frame the decision problem should be encouraged. Finally, the agenda should discourage defensive heuristics with which decision-makers have been found to preserve their short-term reputation and political tenure.

The design principles for strategic environmental crisis management were developed in metropolitan experimentation. Their applicability in other decision contexts at different levels of governance should be explored in future research because chronic environmental crises are here to stay. The barrier of implementation for POR experimentation is low because it assumes no major overhaul in existing administrations. All that is needed is willingness to experiment across sectors.

Declaration of Competing Interest

Acknowledgements

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