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PERSPECTIVE

# Sustainability: We need to focus on overall system outcomes rather than simplistic targets

Len Fisher[1] | Thilo Gross[2,3,4] | Helmut Hillebrand[2,3,4] | Anders Sandberg[5] | Hiroki Sayama[6,7]

[1]School of Physics, University of Bristol, Bristol, UK; [2]Helmholtz Institute for Functional Marine Biodiversity, Oldenburg, Germany; [3]Carl-von-Ossietzky University Oldenburg, ICBM, Oldenburg, Germany; [4]Alfred-Wegener Institute, Helmholtz Center for Marine and Polar Science, Bremerhaven, Germany; [5]Future of Humanity Institute, University of Oxford, Oxford, UK; [6]Binghamton Center of Complex Systems, Binghamton University, State University of New York, Binghamton, New York, USA and [7]Waseda Innovation Lab, Waseda University, Tokyo, Japan

**Correspondence**
Hiroki Sayama
Email: sayama@binghamton.edu

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## Abstract

1. Many of the global challenges that confront humanity are interlinked in a dynamic complex network, with multiple feedback loops, nonlinear interactions and interdependencies that make it difficult, if not impossible, to consider individual threats in isolation.
2. These challenges are mainly dealt with, however, by considering individual threats in isolation (at least in political terms). The mitigation of dual climate and biodiversity threats, for example, is linked to a univariate 1.5°C global warming boundary and a global area conservation target of 30% by 2030.
3. The situation has been somewhat improved by efforts to account for interactions through multidimensional target setting, adaptive and open management and market-based decision pathways.
4. But the fundamental problem still remains—that complex systems such as those formed by the network of global threats have emergent properties that are more than the sum of their parts. We must learn how to deal with or live with these properties if we are to find effective ways to cope with the threats, individually and collectively.
5. Here, we argue that recent progresses in complex systems research and related fields have enhanced our ability to analyse and model such entwined systems to the extent that it offers the promise of a new approach to sustainability. We discuss how this may be achieved, both in theory and in practice, and how human cultural factors play an important but neglected role that could prove vital to achieving success.

KEYWORDS
complex systems, complexity, market mechanisms and insurances, multidimensionality, open-ended adaptation, outcomes, policy decisions, sustainability

## 1 | INTRODUCTION

Policies for meeting the many environmental, economic and social challenges that humanity now faces (GCF, 2021; Rockström et al., 2009; WEF, 2022) are frequently formulated in terms of 'targets', such as the 1.5°C limit for increase in average global temperatures (Schleussner et al., 2016) or the 17 sustainable development goals (SDGs) recommended by the United Nations (UN, 2015). Such targets have the appealing features that they are readily grasped by the community and politicians alike; that they offer calls to action; and that the results (or non-results) of that action can be expressed in simple numerical terms.

Single-factor targets are particularly useful when the threat that they are addressing can be considered as an independent entity, and when the variable being measured aligns with some fundamental transition that exists deep within the system. Pandemics, for example, will quickly come to an end if the average number of secondary infections caused by an infected person, a variable called $R_0$, is less than one. So $R_0 < 1$ would be a simple policy target that aligns with a fundamental transition in the system.

In practice, however, most global threats are *inter*dependent, linked together in a complex network of cause and effect, action and reaction, multiple feedback loops and runaway chain reactions (Fisher & Sandberg, 2022). This interdependence means that the achievement of one target may actually be at the expense of other targets. Spillias et al. (2020), for example, point out that the achievement of renewable energy targets may actually undermine their sustainability—for example, by demanding large areas of land, with increased deforestation rates and biodiversity loss. In 2021, a joint workshop by the Intergovernmental panels IPCC and IPBES concluded that some measures to mitigate either of the two crises may have developed, but warned that '[m]easures narrowly focused on climate mitigation and adaptation can have direct and indirect negative impacts on nature and nature's contributions to people' (Pörtner et al., 2021). As one example, they mention afforestation with monocultures and non-indigenous species that can contribute to carbon capture but may have detrimental consequences for biodiversity conservation. Further conflicts arise with social SDGs when climate change policies are not evaluated properly, with consequential loss of livelihoods and lowering of living standards for many who are already poor, thus increasing the threats posed by income disparity and social differentiation, from starvation and mass migration to revolution and war.

These problems are now well recognized, as, for example, Pörtner et al. (2021) write 'Treating climate, biodiversity and human society as coupled systems is key to successful outcomes from policy interventions'. Fukuda-Parr and McNeill (2019) argue that 'Monitoring the implementation of SDGs should be based on a broad quantitative analysis focused on goals, not on the indicator framework alone'. Bodin et al. (2019) point out that 'achieving effective, sustainable environmental governance requires a better understanding of the causes and consequences of the complex patterns of interdependencies connecting people and ecosystems across scales'. Lade et al. (2020) make a similar point with regard to the interactions between planetary boundaries, and 'call for future research to better characterize interactions and as a framework to prompt policy discussions and planning towards a sustainable future'.

Solutions have been proposed through multidimensional target setting (OPHI, 2022), adaptive and open management (UN, 2023) and market-based decision pathways (OECD, 2020). The network of global threats, and the global socio-economic-ecological world that they threaten, can only be dealt with effectively through understanding it as a *complex adaptive system* (*CAS*). Complex networks of many kinds, from human economic and social networks (Haynes & Alemna, 2022) to nature's ecological networks, global networks and beyond (Fan et al., 2021), have been the subject of CAS studies over the last several decades (Ladyman & Wiesner, 2020; Scheffer, 2008). Our core contribution here is to suggest that recent scientific advances in addressing complexity can serve as a basis for developing fresh approaches to sustainability policies. This relatively new field of complexity science highlights several unique features of complex systems that are relevant for managing interlinked problems, for example:

- Complex systems can exhibit dynamics at different scales, which require different level of description (Anderson, 1972; Ladyman & Wiesner, 2020).
- Small changes (either intrinsic or imposed from outside) in one part of a complex network may have cascading dramatic effects on distant parts of the system (Sornette, 2006). In the present case, efforts to stabilize or sustain some feature (such as global temperatures) can have unexpected and unforeseen consequences for other features (such as social stability or biodiversity)
- Complex networks can undergo sudden, dramatic transition to a very different state (including complete or near-complete collapse), with little or no warning *and with no obvious cause* (Dorogotsev et al., 2008; D'Souza et al., 2019).

This is not an exhaustive list and there are other non-trivial features often associated with complex systems and networks (De Domenico et al., 2019). Decisions about policies to deal with the complex network of global threats must take account of these properties, along with the complexity of society itself and relevant social, cultural and practical governance issues (see, e.g. Keith et al. (2023), and references therein). We argue here that complex systems research, and its sibling disciplines of network and data sciences, have made significant progresses in the last few decades to the stage where they offer a realistic basis for such decision-making, where we can begin to apply them to real-world complex problems and to avoid the simplifying assumptions inherent in the use of fixed targets and simple decision rules. With the powerful mathematical and analytical tools that have been developed, the complex interactions between many factors may be analysed and used as a foundation and a guiding principle for dynamic policies that are based on overall outcomes, rather than simple targets defined for each of the problem dimensions separately.

We develop our argument on the consequences of complexity for policy decisions in three stages:

1. Why multidimensional complexity means that we need to replace unitary sustainability targets by multidimensional system-based 'outcomes', and the changes in thinking that will be needed to achieve this objective.
2. Why complexity means that there is no fixed endgame. A complex systems approach indicates that we cannot have fixed goal posts when it comes to complex dynamic problems like sustainability. Our strategy for sustainability must be adaptive and open-ended. The price of sustainability is eternal vigilance.
3. What kind of practical tools we can use for decision-making in a complex environment. The market and insurance are suggested as practical tools for policy and decision-making about sustainability in an ongoing complex dynamic situation.

These three arguments constitute the outcome-centred management approach proposed in this article. Their connections are summarized in diagrammatic form in Figure 1.

## 2 | POLICY BEYOND ONE DIMENSION

There can be considerable conceptual advantages to modelling systems in terms of safe, sustainable operating spaces. The 'planetary boundaries' model of Rockström et al. (2009), which has helped to bring public and political attention to the dangers of passing such boundaries, is a case in point. It is important, however, not to interpret such boundaries as actual policy goals. They may be thought of as fences that are put up to circumscribe what we think of as a safe operating space for the respective system. In some cases, the fence aligns perfectly with a cliff that naturally exists in the landscape, while in other cases, the fence arbitrarily divides a softly undulating landscape (Figure 2). Many proposed policy goals are intermediate cases. For example, the 1.5°C climate goal is relatively well aligned with several important transitions for which the temperature itself is a direct driver, but it would be foolish to expect these transitions to occur exactly at 1.5°C warming; rather, the exact point where they occur will surely depend on a myriad of other variables. For the 30-by-30 conservation goal, the alignment with transitions in the system is even less clear, as the size of protected areas is only a fairly indirect driver of transitions in these systems. Moreover, extinctions occur locally and achieving the planetary goal of low number of extinctions has little importance for local ecosystem integrity, as the persistence of species × somewhere does not affect processes at the local to regional management scale. To stay within the image of Figure 2, setting up fences in this landscape already requires careful consideration of multiple options (secure the stairs, be aware of the slippery slope, reduce risk of cliff break-off), but these negotiations happen at full knowledge of the landscape. In many cases, thresholds

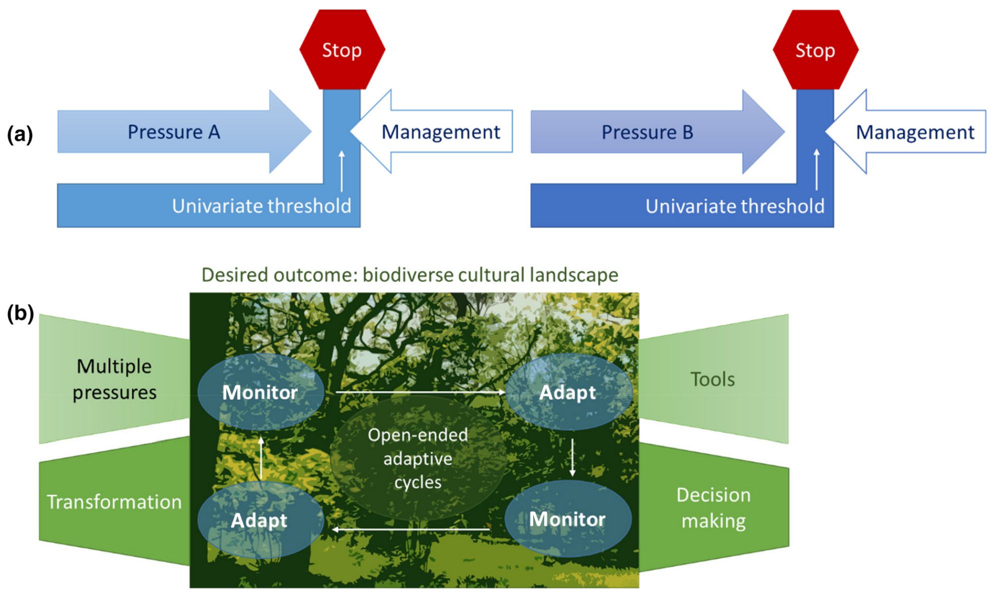


FIGURE 1 Conceptualization of an outcome centred management approach. (a) Classical management for sustainability derives from a linear connection between a pressure A, for which a maximum allowable change (target) is defined that often derives from a threshold. Management is devised to counteract the pressure and avoid threshold transgressions. The same approach is then used for a different pressure B, but independently from or only indirectly linked to the problem arising from pressure A. (b) An outcome-oriented management approach connects an outcome goal (here as an example a biodiverse cultural landscape such as in Gotland's 'lövängʼ in the background) with a consistently updated agile management cycle. This cycle requires monitoring of pressures and status of the system with respect to the goal, adaptive management and monitoring of its impact to allow agile adjustment. This is not possible without developing tools for management and decision-making, which often is multilevel and outside of the domain of the system to manage. In the example of cultural landscapes, the local implementation of management often hinges upon regional to supranational strategies (e.g. the common agricultural policy of the EU). Therefore, the adaptive cycle needs also to lead to societal transformation and thus updated goal formulation to reduce multiple pressures over the long run.

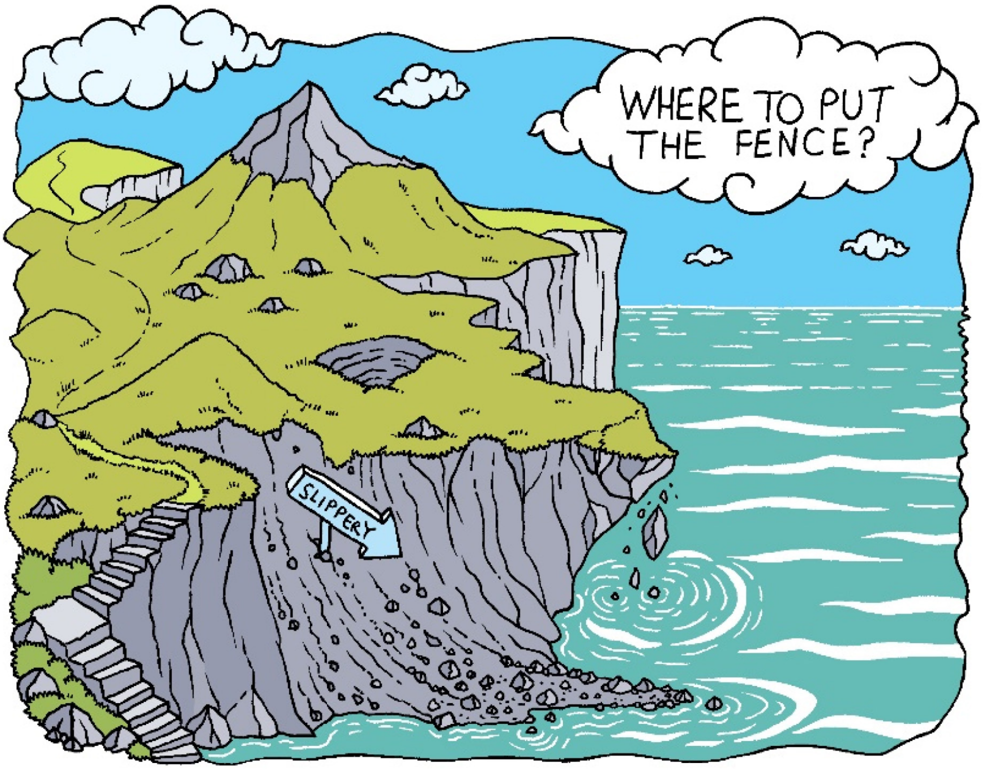


**FIGURE 2** Where to put the fence? A schematic illustration of a complex landscape. Setting sustainability goals may be analogized to putting up fences around safe operating space, but the true problem landscape is often much more complex.

between risky and safe operating spaces tend to be blurred or hard to foresee (Hillebrand et al., 2020, 2023), which makes negotiations happen under very imperfect knowledge.

A problem with adoption of such simple unidimensional policy goals is that it entails some significant risks:

- While all simple policy goals are easily communicable, not all of them make compelling arguments: When standing at the edge of a cliff, it is easy to respect, but if it stands in the middle of a plain, it cannot be too bad to step beyond the fence, or even move the fence, can it?
- Fences may become targets rather than safety margins, supporting exploitation to the max (Schlesinger, 2009) and pushed forward in political negotiations beyond scientific advice (Carpenter et al., 2016).
- If the precise policy goal is the result of a decade-long process of negotiations, it will be very hard to update later when the new data become available. We end up with a fence set in concrete, the equivalent of straight-line national borders, negotiated between colonial powers before the topography of the land—let alone ethnical divides—was even known.
- Looking at each dimension of a multidimensional boundary separately gives an illusion that there are multiple boundaries, even if there is only one such boundary (Figure 3a). Unawareness of this multidimensionality and interactions of dimensions may lead to implementing an oversimplified regulation focusing on only one dimension that causes an unwanted effect on another dimension (Figure 3c). In this respect, an awareness of Goodhart's Law (naïve application of metrics to a system can distort the system in ways that undermine the original goal) is particularly important (Manheim, 2018).
- Due to its unidimensional nature, our policy goal will be dividing the landscape with a straight line. However, the systems we are dealing with are high-dimensional nonlinear systems, and by their very nature, the safe operating spaces within them rarely have straight boundaries. If we now try to fence in an organically shaped operating space by straight fences, we may end up fencing off areas that are entirely safe, depriving us of options, or worse still, we might designate some regions as safe that are in fact disastrous (Figure 3b).

Given the shortcomings of unidimensional goals, what is the alternative? In principle, the policy goal could also be formulated in a high-dimensional way. If necessary, an agreement could put up a complex convoluted fence, but such an agreement would be hard to communicate and impossible to negotiate.

A simplifying approach for the use of policymakers is to redraw the map in terms of straight lines, in a manner similar to the famous stylized map of the London Underground rail network (Hadlaw, 2003). In mathematical terms, when faced with a safe operating space that has a complicated shape, we can move to a new set of variables in which the same is simpler and has straighter borders. This is typically achieved by projecting the current variable space onto a different space using appropriate nonlinear mapping rules (Figure 4). For example, the edge

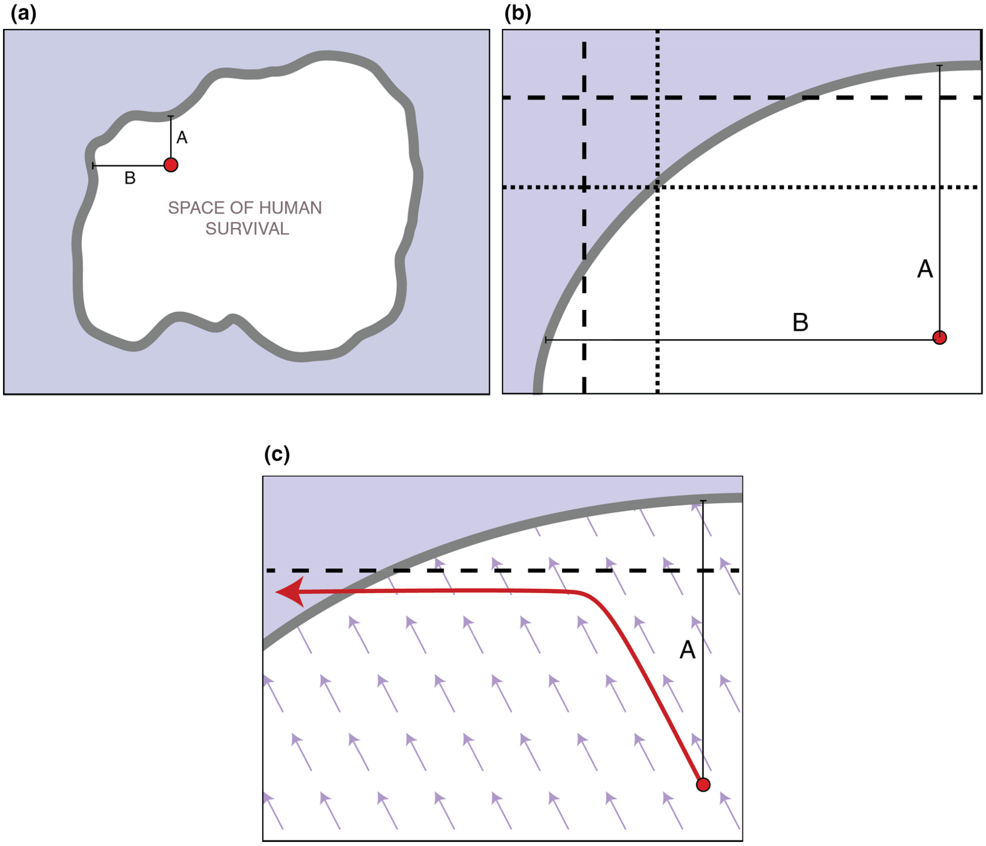


FIGURE 3 Problems with adoption of simple unidimensional policy goals. (a) There is only one planetary boundary. From the current state of the planet (red dot), we can judge how far we can push different parameters before a fundamental boundary is crossed and we enter a regime that is incompatible with human survival (light blue area). Because science is fractured into different disciplines, the distance from the boundary is measured in different dimensions (A, B) such as global warming, ocean acidification and biodiversity loss. This gives the illusion of different planetary boundaries (end points of thin black lines). However, as all of these factors are interconnected, these points are all facets of a single planetary boundary (grey line). (b) Difficulty in regulation using straight fences. Suppose from the current state (red dot), we measure the distance to the planetary boundary (grey line) in two dimensions. Even if we establish legislation to put up regulatory fences ahead of the boundary in two dimensions (dashed lines), then there is still a large set of undesirable outcomes that can be reached although all regulatory targets are met. To ensure the boundary is not crossed, much tighter regulations would be necessary (dotted lines). However, these would exclude us from large regions of the acceptable (white) parameter space. This dilemma becomes even more pronounced in higher dimensional spaces. (c) Unwanted effect of regulation. Consider a planetary state (red dot) where the influence of societal and economic pressure (blue arrows) pushes us towards a boundary (grey line) that we do not wish to cross. We may be able to estimate the distance to a planetary boundary in a certain dimension, say warming (measurement A) and introduce legislation that establishes a limit (dashed line) well ahead of the boundary. However, due to the multidimensional nature of the system, we have now created a situation where the future trajectory (red arrow) crosses a different segment of the same boundary.

of a disk is a curved line when we describe it in *x* and *y* coordinates, but when each point on the edge is mapped in a space made of the distance from the centre and the angle, then the result becomes a straight line. Similar techniques of projection to another (possibly higher dimensional) space have been frequently used in data science and machine learning, such as classification tasks and pattern detection.

For many real-world problems, we already know the right variables in which the safe operating space becomes a simple shape. Such variables typically live in the *outcome space*, that is, they are phrased in terms of the vocabulary that we use to describe outcomes, not drivers, of the system. Examples of such policy goals could be 'the west Antarctic ice sheet cannot be allowed to collapse' or 'the major functions of marine ecosystems (carbon sequestration, food supply, …) must be sustained'. Also, our pandemic example $R_0 < 1$, 'the number of cases should decline, not grow', follows this rule of phrasing policy in outcome space.

Clearly, these top-level outcome-space goals must then be translated into actionable policy measures (a process which we discuss in more detail below). Outcome-space goals are by no means meant to be unquantifiable goals. Quantifiability is needed to guide the translation of outcome-space goals into actual implementable measures (Pimm et al., 2019). A negative example is provided by biodiversity targets. The 1992 Aichi targets on biodiversity (Stock, 2002) were well quantifiable outcome-space goals but lacked a functioning implementation layer. A much more graspable narrative is of 'bending the curve' of biodiversity loss, which as an operational target lends itself to integrative efforts (Leclère et al., 2020). Quantifiable outcome-space targets, combined with the will to meet those targets, can thus create a

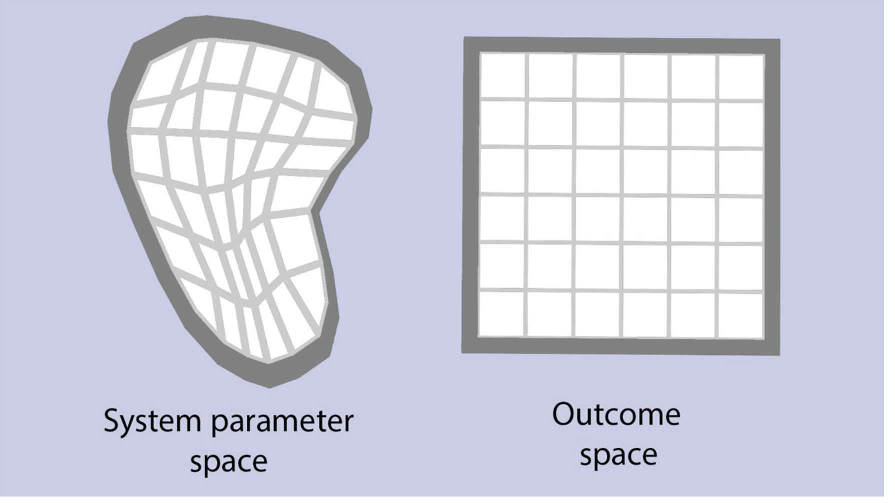


**FIGURE 4** Mapping of a system parameter space onto an outcome space. The safe operating space with a complicated shape in the system parameter space (left) may look much simpler in the outcome space (right) after nonlinear space projection.

framework of core values, based on which decisions can be made using simpler, faster and potentially localized processes.

The basic idea to start with phrasing goals in outcome space is well known in other areas of politics and management. For example, the German constitution starts with 'Human dignity shall be inviolable', a central tenet from which all subsequent articles follow. A technical example is provided by the Sievert (Sv)—the SI unit for equivalent radiation dose. In contrast to the physical unit of radiation, the Gray (Gy), the Sv is specifically designed to measure the effect on the human body. This means that, for example, workplace regulations can be formulated in a unidimensional way, avoiding the need to distinguish between multiple types of radiation and modes of exposure that affect the body differently. All this complexity is hidden in the conversion between the Gy space and the Sv space, a projection that is multidimensional and could in principle be updated if fundamentally new insights into the effect of radiation become available.

Summarizing this point, we argue that phrasing policy goals in terms of quantifiable outcomes makes sure that there is a clear and widely understood alignment between the metric of success and the actual long-term goals. After such top-level agreements have established a suitable value system, established institutions and local stakeholders can then enter into a dialogue with policy by proposing concrete steps and scenarios to reach the policy goals. It is a challenge that scientists and policymakers alike must face if we are to make progress towards a truly sustainable future.

## 3 | ADAPTIVE, OPEN-ENDED EXPLORATION OF SOLUTION SPACE

Another major aspect of our proposed approach is that policies (and policymakers) will need to be more agile, flexible, adaptable and open to various (sometimes unconventional) solution possibilities than is the case when fixed goals are issued. Changes in scientific and social factors will inevitably mean changes in recommendations and policies as our understanding develops. Sometimes new discoveries in science or technological innovations may open up a space of previously unknown options and provide an opportunity for a much more feasible solution than was known before. Policies and policymakers will need to remain flexible and adaptive to be able to navigate a complex dynamic landscape and seize such opportunities as they arise. The challenge is thus to establish mechanisms that allow us to quickly react to new opportunities when they present themselves. At the same time, we must avoid misusing the possibility of future innovation as an excuse to delay actions that must be taken now.

When implementing the outcome-space-based, adaptive policy, it is essential to combine the formulation goals and boundaries with strong, quantitative measures of success that are objectively verifiable. Two insights from complexity research are that proximal states of a system are easier to compare than distal states (Coifman & Lafon, 2006) and short-term prediction is easier than long-term prediction (Lorenz, 1996). Yet policy seems to be very eager to formulate long-term, distal state-based goals. The Kunming-Montreal Global Biodiversity Framework under the Convention on Biological Diversity (https://www.cbd.int/gbf/) formulates as 2050 vision as 'a world of living in harmony with nature where … biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people'. While the goal has unanimous support and even mid-term 2030 missions are formulated, such long-term goal posts must be accompanied by a metric that quantifies the proximity to the goal over shorter timescales of weeks, months or years and even quantifies the impact of specific policy decisions.

If we are confident that we can make the distal, long-term predictions that are involved in establishing a goal that is decades away, then it is implausible that we are not confident in making the shorter scale comparisons that are necessary to establish a metric that quantifies in what way a specific decision or the developments in a certain month affected the distance from the goal. Clearly these metrics can and should change as a result of ongoing advances. Nevertheless, they are an essential tool that enables us to judge the impact of decisions that need to be made now and track our progress along the way. By contrast, the distance of a goal will likely reduce its impact on present-day decisions if the connections are not made explicit. To make agile governance possible, we need to progress to a state where we can link immediate actions such as establishing an offshore windfarm or a fisheries closure to the 2050 vision of the CBD.

The introduction of short-term success metrics could also enable policy to make pledges in a different way. Instead of committing to a goal which may be in the far future or committing to specific measures, which may be obsolete or even detrimental by the time they can be implemented, legislators could commit to a certain amount of progress towards the goal on a shorter timeframe, or even to keeping metrics moving toward the goal at a certain speed.

One salient example that demonstrates the importance of adaptive, open-ended exploration for sustainability is biological life and its evolution on Earth. Such a long-term sustainability of evolutionary biological systems is not coming merely from its robustness or resilience, but is largely due to its continual adaptive changes, or 'suppleness' (Bedau, 1998; Sayama, 2019a). Recent developments in complex systems research have begun to capture this amazingly adaptive and innovative nature of evolutionary biological systems in more formal frameworks. One is the concept of the 'adjacent possible' originally proposed by theoretical biologist Stuart Kauffman (Kauffman, 1993, 2000), which depicts the set of possibilities that are immediately reachable/discoverable from the set of currently known possibilities by making a small modification, and thus, they serve as the gateway to potentially groundbreaking discoveries and innovations in a vast (yet mostly unknown) domain of complex problems. It has been accepted as a fundamental concept in business and innovation domains (Johnson, 2011) and has been utilized for scientific modelling of discovery processes (Loreto et al., 2016; Tria et al., 2014) and evolution of social interactions (Ubaldi et al., 2021). A key implication of this concept is that, unlike most of the traditional understanding of dynamical systems, the exploration of the adjacent possible *continuously expands the system's possibility space itself*, and this change is *intrinsic to the exploration and not necessarily coming from external factors*. This further invalidates the idea of setting a fixed goal or target for the sustainability effort, because the problem landscape can and will change drastically during (and because of) our effort to accomplish sustainable society.

Another relevant concept that has emerged from Artificial Intelligence/Artificial Life research communities (Lehman & Stanley, 2008; Packard et al., 2019; Stanley, 2019; Taylor et al., 2016) is that of 'open-endedness'. Researchers inspired by the astoundingly creative, open-ended nature of biological evolution (Ruiz-Mirazo et al., 2004) have eagerly sought after key ingredients that can make a system exhibit continuous exploratory dynamics without converging at any stationary point. This research has produced several promising approaches, such as prioritizing novelty over performance (Lehman & Stanley, 2011), co-evolving codes/languages that describe entities (Pattee & Sayama, 2019; Taylor, 2019) and facilitating dynamic formation of higher order entities (Moreno & Ofria, 2019; Sayama, 2019b). This is in stark contrast to the majority of mainstream Artificial Intelligence/Machine Learning research efforts where objectives are typically set to optimization of performance metrics or convergence to human abilities (e.g. text generation, image recognition). This contrast resonates well with the fixed goal versus ultimate outcome argument discussed above in the context of sustainability. If biological life were a closed-ended simple optimizer towards a predefined target, it would have ended its existence billions of years ago.

'Adaptive governance' is the key (Walker et al., 2010). In terms of governance for sustainability, it rests on five supporting pillars (Fisher & Sandberg, 2022):

- Recognition that global catastrophic risks, individually and collectively, are linked in complex network where perfect certainty and control are not achievable and sudden, system-wide change is an ongoing possibility;
- Integrated monitoring and action for global threats;
- Flexible, rapid decision-making on timescales that reflect the behaviour of the system;
- Cooperation and coordination to make and implement those decisions;
- Investment in resilience and preparedness for situations when change becomes inevitable.

That these supporting pillars can be developed in practice is illustrated by the creation of the Kristianstads Vattenrike in Sweden (Olsson et al., 2004) and the restoration of the Everglades ecosystem in the United States (Gunderson et al., 2002). The former is a wetlands biosphere reserve that is a model for sustainable development close to towns and agriculture. The latter brings a novel perspective to ecosystem resilience, where trust and engagement of different groups have played a key part.

The key factors in the success of these projects have been analysed by Olsson and his collaborators (Olsson et al., 2006) in terms of building knowledge, networking and leadership. An important factor in the first example was identifying knowledge gaps and initiating studies to fill them. In the second case, this aim was achieved through modelling workshops where information was synthesized and used to develop composite policies.

In both cases, a key factor was to develop networks linking actors with different interests and at different organizational levels. Leadership for collective action was an emergent response to these factors. It appears that strong networking and the development of a knowledge base are necessary conditions for the emergence of leadership. Another important factor is the existence of community norms. In a study of the use of indigenous knowledge for climate-change resilient water management (Ghorbani et al., 2021), it was found that long-term successful management strategies in Eritrea, Australia, Ecuador and Iran all used 'an adapted, spontaneous common-pool resource management framework' where there was a 'congruence between the water appropriation and provision rules' and where there was an 'accountability between water appropriators and those that monitor water usage' based on a hierarchical leadership structure.

This is not to say that effective leadership necessarily emerges from networking and collective interests. All too often (especially in the West) competition between vested interests trumps cooperation. Olsson et al. (2006) examine the cases of The Northern Highlands Lake District in Wisconsin, United States, where a growing population and increasing demand for building land is putting increasing pressure on habitat resources for wildlife; the Mae Nam Ping Basin in Thailand, where political and developmental agendas are putting high pressure on water resources; and the Goulburn-Broken Catchment in Australia, where overuse of the water catchment for irrigation had produced a crisis in the availability of water for community use. In the first two cases, competing strands of leadership for the pursuit of specific interests meant that effective agreement could not be reached, while in the latter case leadership for collective action did emerge but was hamstrung by interests at a higher level.

Many other examples, both positive and negative, may be adduced (e.g. Berkes et al., 2000; Marshall et al., 2022; WEF, 2022). As Van Bavel et al. (2020) have pointed out, realignment of scenarios/recommendations as scientific understanding of the system evolves needs more than science. To make further progress, especially in overcoming the negative cases, requires an understanding of social and cultural influences on behaviour, science communication, moral decision-making, leadership and stress and coping—together with a sympathetic and understanding leadership. It also requires close monitoring to allow agile management. Sustainability requires eternal vigilance as boundary conditions, decision-making processes, goals and available information constantly change.

## 4 | PRACTICAL TOOLS FOR DECISION-MAKING: MARKET MECHANISMS AND THE MONETIZATION OF RISK

Leadership must be provided with the right set of tools. These tools must help resolve the question of how rigid structures, defined by laws and treaties, can be redesigned to provide continuous monitoring and flexible, adaptive responses to emerging situations, while keeping the system moving towards the desired goals.

Many such tool sets may be visualized, depending on the economic, cultural and political values of the participating parties. Rather than attempting a list, we briefly outline one possibility that may be appropriate across a range of societies—a modification of the classical market insurance principle.

The modification that we propose would be to complement the profit motive with one of mutual investment for advice, protection and recovery. The participating parties would be individual nations. The scheme would be administered by an institution specifically designed for the purpose (although possibly under an umbrella such as that of the United Nations), with the responsibility for assigning both costs and benefits to individual members in the light of needs for action that would benefit the group as a whole (such as flood defences to protect vital export food crops; de Haen & Hemrich, 2007). There are already working models for such institutions, including the Pacific Catastrophe Risk Assessment and Financing Initiative (https://www.gfdrr.org/en/pacific-catastrophe-risk-assessment-and-financing-initiative-phase-3) and the Caribbean Catastrophe Risk Insurance Facility (https://ccrif.org), whose mission is to 'optimize disaster risk management and climate change adaptation practices supporting long-term sustainable development'. These organizations usually operate on a parametric basis, paying out for damage recovery in proportion to the damage experienced, but they also attempt to ameliorate risk by investing in sustainable practices ahead of the game.

The conceptual details for such a model were spelled out by one of us as a finalist in the $US5m Global Challenges 'New Shape' competition of 2017 (Fisher, 2018). One potential obstacle is that market-inspired mechanisms offer flexibility, but monetized thinking often encourages individual risk-taking behaviour, leading to environmental defaults and damages that are socially costly (as in the traditional game theory 'free rider' problem (Fisher, 2008)).

Market mechanisms exist, however, that can prevent those defaults and mitigate damages. Particularly, consider the case of mandatory insurance (Gross et al., 2018). In high-value manufacturing, it is a common practice that original equipment manufacturers mandate that their suppliers are insured against business disruptions. Because of the nature of the risk, the respective insurances are typically not standardized products. Instead, the insurance provider works with its customers to understand and minimize the risk to make the customer's business insurable.

A similar model could be implemented for the management of natural resources. This is a substantial advance on simpler ideas such as 'risk trade-offs' (Baum & Barrett, 2017). A fuller analysis is beyond the scope of this review and will be the subject of a separate communication. Here, we offer a summary of some major points in support of the view that an insurance model is not only practical but may be essential for the long-term promotion and governance of systemic sustainability. As Shea and Hutchin (2013) have pointed out 'The insurance industry is a driver of social and economic activity and, as such, has the mechanisms and incentives in place to facilitate sustainable business activity on a macro level'.

### 4.1 | General principle

An actor seeking to carry out a risky activity in a system can be mandated to take out suitable coverage against the risk of triggering transitions in the system. Such mandates make the human impacts themselves adaptive by allowing expected activities deemed low risk, while making those that are deemed too risky financially infeasible, without the need for overly detailed regulation. Perhaps more importantly, such mechanisms create an incentive for better quantification of the true risk can translate into reduced insurance premiums, ultimately making the system more governable. A suitably structured insurance approach may also be built into or grafted onto many current governance systems without drastic, or even revolutionary change to the system as a whole.

### 4.2 | Sustainability risk management is already an active field

Insurance-based mechanisms are already a staple in the private sector, where they are used widely not only to manage residual risk but also to drive research to make the risk manageable. A common example is supply chain management (Anderson & Anderson, 2009), where a large manufacturer will typically mandate that its suppliers need to be insured against major risk that could endanger supply, including supply disruptions from further up the chain. A company seeking insurance against supply chain disruption will typically have to work with the insurance company to document and improve its supply chain to make it insurable.

### 4.3 | Under social and investor pressures, business sustainability is increasingly combining market logic with social welfare logic

There would seem to be a time/rate problem here, in that market logic is often associated with the pursuit of short-term profit, while social welfare logic, based on altruism and the fulfilment of social needs, can involve much longer time horizons. However, as Risi (2020) points out, this dichotomy 'may not be as tight as is commonly assumed', and there are mechanisms available for aligning the timescales and coordinating objectives.

### 4.4 | Practical guidelines are already available for incorporating environmental sustainability into their core business strategies

The basic principles for sustainable insurance in a profit-driven environment were laid down in the United Nations' Environmental Programme and Finance Initiative's seminal 'Principles of Sustainable Insurance' (UN, 2012). These principles are:

- [To] embed in our decision-making environmental, social and governance issues relevant to our insurance business.
- [To] work together with clients and business partners to raise awareness of environmental, social and governance issues, manage risk and develop solutions.
- [To] work together with governments, regulators and other key stakeholders to promote widespread action across society on environmental, social and governance issues.
- [To] demonstrate accountability and transparency in regularly disclosing publicly our progress in implementing the principles.

Our proposed model is one way to provide a framework for implementing these principles in an environment governed by social responsibility rather than profit per se.

In particular, it *makes* environmental, social and governance issues a core part of the insurance business, by ensuring that the business is set up on those principles. Also, rather than a profit-oriented insurance business working 'together with governments, regulators and other key stakeholders', the socially oriented insurance business adopts a key role in the governance process itself. This is a step beyond such suggestions as the '5C' framework (commitment/configuration/core business/communication/continuous improvement) suggested by Johannsdottir and McInerney (2018) and similar suggestions for introducing sustainability practices into current insurance business models. It is revolution, rather than evolution. But revolution, in some practical form that involves rapid, flexible responses to continuously monitored emerging situations, is what is needed if we are to cope with the many global catastrophic threats that the world now faces.

## 5 | CONCLUSIONS

Effective governance for sustainability requires that political decision makers focus on outcomes rather than targets and prioritize long-term goals over short-term benefits. Such goals need to be phrased in the outcome space and might include statements such as 'Fish stocks in the North Sea cannot be allowed to collapse' or 'The average living standard must be maintained'.

To achieve such goals requires continuous monitoring and flexibility of response across geographic and political boundaries. A new class of administrative bodies, tasked with continually monitoring the progress towards the goals, developing actionable strategies, interfacing with science and feeding back conflicts between goals to political decision makers, would almost certainly be required. Current bodies such as IPBES and IPCC already fill part of this role (IPBES, 2019; IPBES-IPCC, 2021; IPCC, 2021), but would need to be more fully integrated into global political decision-making.

On an even finer level, market mechanism could be used to allow flexibility while aligning progress with the overarching goals and minimizing risks. Again, such market mechanisms exist already, for example, in the form of fishery quota. However, current implementations are relatively heavy-handed, overly constrained flexibility and lack effective mechanism for emergency intervention and damage mitigation. Instead, we envision a more flexible system utilizing insurance-like institutions that prevent externalities from individual risk-taking from being socialized.

In this ideal but necessary global scenario, private actors exploiting natural systems would have an interest in advancing and even funding research as the advancement of knowledge reduces the risk and thus may make new uses of systems insurable. Due to continuous monitoring, the public would be able to understand the impact of decisions that are made towards goals. As these goals are formulated in outcome space rather than detailed regulations, the priorities set by policymakers would be transparent.

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Len Fisher, Thilo Gross, Helmut Hillebrand, Anders Sandberg and Hiroki Sayama conceived the ideas for this perspective and co-wrote

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## ORCID

*Len Fisher* https://orcid.org/0000-0003-2880-1152
*Thilo Gross* https://orcid.org/0000-0002-1356-6690
*Helmut Hillebrand* https://orcid.org/0000-0001-7449-1613
*Anders Sandberg* https://orcid.org/0000-0001-5636-5402
*Hiroki Sayama* https://orcid.org/0000-0002-2670-5864


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