Review

Decision-making under the deep uncertainty of climate change: The psychological and political agency of narratives

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Abstract

Fossil fuel-based development has resulted in climate change and biodiversity loss, threatening the ability of the biosphere to sustain civilization. However, despite the transformative change needed to address climate change, the complexity inherent in dynamic, coupled social-ecological systems can create challenges that stifle mitigation and adaptation efforts. For example, increasing urbanization can mask information about the local and distal ecological impacts of unsustainable consumption patterns. Diverse actors, powerful vested interests in the status quo, and differential impacts of climate change create inevitable tradeoffs and conflicts among stakeholders. The multitude of plausible future scenarios and their dependence on actions taken today create challenges for planning, governance, and collective action. While there is a long history in psychology and economics of studying decision-making under uncertainty, we argue that the *deep* uncertainty inherent in climate change cannot be easily understood using these same paradigms. In this context, narratives—stories about how the world works, what the future will look like, and our own role in this process—can extend cognition, creating shared knowledge across space and time, and shape our beliefs, values and actions in the face of tremendous uncertainty. Narratives thus have political and psychological agency and can reinforce or challenge existing power relations and trajectories. Here, we review some of this literature in the context of climate change.

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Introduction

Since the industrial revolution, humanity has become a major force shaping the Earth system. Fossil fuel-based development has driven climate change, biodiversity loss, and growing inequalities [26]. This trajectory threatens the ability of the biosphere to sustain civilizations, and risks triggering irreversible tipping points [89]. Transformative change is needed across our social and economic systems, and in how we conceive of and manage humanity's relationship with the biosphere [64,87,90]. A social-ecological systems perspective highlights the inextricable connections between humans, other species, and the milieus they inhabit, and the complex and adaptive nature of these relationships [14,15,73]. These complex dynamics can obscure the functioning of the system, one's role in its evolution, and make it difficult to anticipate future outcomes [13]. There are diverging future trajectories for the planet depending on the actions taken today. In particular, the *absence* of mitigating actions may lead to the development of infrastructure that locks-in catastrophic temperature change [31]. The multitude of future scenarios, and their dependence on actions taken today, creates challenges for planning, governance, and collective action [44].

A long and rich history of studying decision-making under uncertainty has focused on how individuals decide when faced with situations where outcomes and their probabilities are known (aleatory uncertainty) or where probabilities are completely or partially unknown but outcomes are known (ambiguity) [49,82]. In contrast, addressing sustainability issues requires understanding how individuals and communities navigate

deep uncertainty. Not only are key variables and probability distributions unknown (parametric uncertainty), but the underlying generative model is changing and complex (structural uncertainty), which objective function (and in turn whose interests) should be prioritized is unclear (ethical uncertainty), and future trajectories are numerous [32,35,50]; see Figure 1. Under this type of uncertainty, people rely on heuristics and social cues to guide their decisions, but also cultural artifacts and narratives to make sense of the world. Narratives—stories about how the world works and our role in this process—play a vital role in shaping environmental publics, policy and politics. They can be strategically crafted and disseminated, or they can emerge, be reinforced or revised through social relations. To the extent that those with vested interests in the existing system also have power over information flows, uncertainty may create the conditions for the intentional manufacturing of narratives that reproduce existing power relations and serve those interests, including discourses of denial, uncertainty and delay [45]. However, those narratives are increasingly at odds with rapidly changing realities, and social movements. This fissure could create an opening for narratives that instead foreground systemic transformation and the interdependence of social and environmental outcomes.

We consider cognition as an active agent in (and product of) a dynamic, complex social-ecological context and discuss associated challenges. We then turn to a brief review of the role of narratives in making sense of our intertwined system and motivating or impeding collective action. These dimensions of cognition are crucial in the context of climate change but have been absent in studies of decision-making under uncertainty.

Epistemological and ethical challenges
Climate change and biodiversity loss are difficult to perceive. Natural variability in temperature, weather, and ecosystems make it difficult for individuals to recognize subtle shifts in patterns and relate them to

global change processes unfolding over multiple human lifetimes [28,40]. The raw signals we have access to are also noisy and mediated by institutional contexts, creating a formidable signal detection problem. The long and complex causal chain leading to events such as wildfires and flash flooding makes it difficult to know when to attribute these signals to climate change or to mismanagement by mediating actors [6,63]. To make things worse, carbon emissions and their effects have been increasing exponentially. This means that the world as we know and experience it today cannot be easily extrapolated to estimate the future [43].

Furthermore, nature and society co-evolve in a globally interconnected complex adaptive system, creating trajectories that cannot be fully anticipated [13,42]. Globalization has exacerbated these perceptual challenges by increasing the interdependence between distant places, for example through global supply chains and financial markets [2,11,75]. Extensive urbanization has further increased the distance between communities and the resources that sustain them [19,55,56]. Societies extract resources and make them available to consumers through expansive infrastructures that mask dynamic system responses from ordinary citizens. For example, water or food can be imported from distal sources so that local scarcity is not passed onto urban consumers. Prices, which should in theory reflect scarcity or extraction costs, can be slow to respond, are often subsidized by governments and do not reflect externalities or social costs of goods and services [16,77]. This eases the lives of urban populations but sacrifices the ability of these signals to reflect the environmental impacts of human action (see Figure 2).

Long time horizons and distributed impacts of climate change create additional challenges. For example, the impact of emissions are not realized solely at the source of pollution and will mostly fall on future generations [39,80]. Spatial and temporal interdependencies create intra- and intergenerational conflicts and distributional

Figure 1
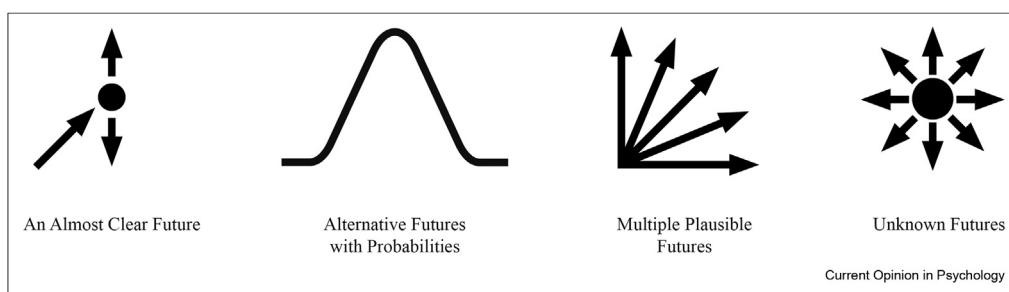
Types of Uncertainty. Representation of increasing uncertainty about the underlying system and plausible future outcomes depicted from left to right. Adapted from Ref. [85].

Figure 2
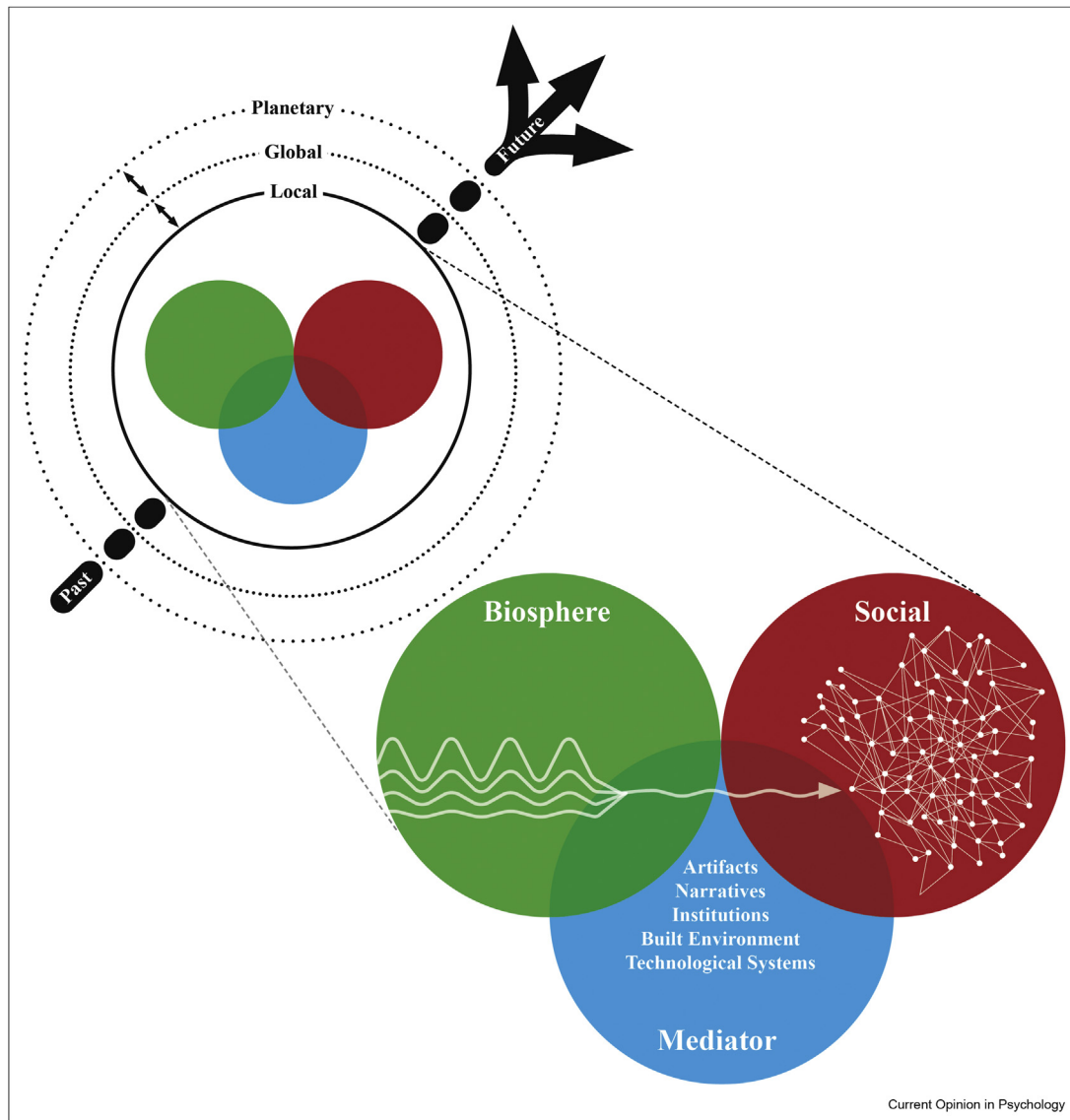
Mediated Social-Ecological System. Inner circles depict a mediated relationship between the biosphere (green) and the social sphere (red). The mediating sphere (blue) might be technical systems, e.g. infrastructure and the built environment, economic markets, which generally smooth (though they can also exaggerate) signals of scarcity or precarity, or the narratives and artifacts used for sense-making about the social-ecological system. Grey circles indicate the broader global and planetary system, while grey arrows indicate the feedback and path dependence of the system over time, as well as the diverging futures.

tradeoffs. These complex contingencies also highlight that climate change is caused by a vast network of past and present decisions by individuals and institutions, leading to a "fragmentation of agency", and in turn responsibility [28]. Beliefs about efficacy and agency are a strong predictor of proactive adaptation [81]. Addressing climate change is a collective action problem, and people matter more than they think, not least through the social movements they create. For instance, social conformity can cause local changes in values or actions to spread, destabilizing existing norms [10,62].

Individualism and neoliberal politics obscure the fundamentally social and interconnected nature of cognition, and the interdependence of humanity's well-being with that of the biosphere [72].

Environmental decision-making must thus grapple with tremendous uncertainty, conflicting priorities and power asymmetries in how priorities are represented. The uncertain and contested nature of sustainability transitions gives psychological and political agency to narratives, which highlight certain

contingencies, responsibilities, priorities and pathways over others.

The psychological and political agency of narratives in sustainability transformations

Under deep uncertainty, decisions about the future are motivated less by accurate anticipations and risk-assessments than collectively held narratives [2]. Narratives in public discourse reveal the structure of shared or hegemonic knowledge on a topic, including underlying value systems and norms [30,88]. They also shape our understanding of the world, possible futures and the steps needed to achieve those futures in the face of tremendous uncertainty by highlighting certain relationships and contingencies [65,84]. The social-psychological "infrastructure" they create is a basis for how people understand change, their agency in that process and their sense of "being-in-the-world" [46]. Thus narratives have the capacity to create and dismantle sustainability pathways. As such, studying the role of narratives in the construction of cultural identities, values, beliefs and importantly actions is gaining traction in the social sciences and climate research [57,60,69,83].

Scientists, journalists, politicians, activists and other actors tell stories using written or spoken words, images, and statistics to make sense of observations or events. How these observations are framed can have dramatic repercussions, inciting fear or hope, action or inaction, and uncertainty or clarity [12,20,25]. These social products resonate with different communities, and can consolidate or fracture collective consciousness. Discourse and narrative analysis can be used to identify shifting climate narratives [25]. Researchers have studied competing storylines around the destabilization of socio-technical regimes and energy transitions [51,70,71]. The analysis of transition narratives can reveal which values are represented, in service of which outcomes, and how they are socially constructed as narratives evolve. For example, narratives and discourse around adaptation in the Global South have been criticized for reproducing existing power structures and vulnerabilities [58]. Climate solution narratives alternately locate responsibility with individuals or policymakers; argue that "it's too late", call for incrementalism, or emphasize the need to "act now"; embrace technosalvation (e.g., new energy sources) or call for systemic change, including calls for violent protest [53].

Narratives are also embedded in cultural artifacts, and communicated through folklore, songs, customs, and oral traditions that transmit norms across generations. Recent research has shown that the lasting effects of folklore on gender roles, risk preferences and trust are visible in the structure of societies today [57]. Folklore also reflects salient features of the physical environment, including crop- and water-related motifs in fertile areas and accounts of earthquakes in risk-prone areas, likely shaping knowledge and values around social-ecological dynamics.

Models, statistics, and their visualizations might also be considered narrative devices alongside other images, and can be crafted in service of certain narratives, highlighting some relationships over others. For example, the "warming stripes" graphic of annual temperature change created in 2018 by Ed Hawkins succinctly conveys the rapid heating of the earth system in the anthropocene. Depicting minimal scientific content—each chronological stripe in the graph is assigned a shade of blue (cooler years) or red (warmer years)—the intense concentration of red towards the right side of the image makes climate change perceptible to a broad audience, without directly invoking partisan ideologies or distrust in experts [21]. Robust Decision-Making (RDM) frameworks are increasingly used to inform decisions under the deep uncertainty of climate change. They involve the iterative construction and updating of scenarios along divergent future pathways to identify ones that are robust to uncertainty [93]. Scenarios, like narratives, describe a wide range of possible futures, and render the assumptions, courses of action and causal relationships they depend on visible and explicit [91].

Strategic narratives

There is a growing interest in the strategic design and use of narratives due to their unique persuasive capacities. Narratives are political, they create an interface between elites and the public, though they take on a life of their own once in the public realm [9]. A recent article argues that a unified strategic narrative is needed to close the action gap on climate change [8]. The authors provide a taxonomy of narratives that attempt to motivate or stall climate action, including a focus on: scientific fact and certainty about anthropogenic climate change; existential threats or catastrophic outcomes of inaction; loss of polar bears and charismatic megafauna; transformations towards "green" lifestyles; and tradeoffs between climate action and economic prosperity. They propose a framework for constructing narratives to mobilize audiences, which includes engaging a range of actors, providing coherent explanations of government strategy and harnessing behavior change. Relatedly, intersectional approaches foster inclusiveness by emphasizing the social and distributional benefits of climate action [39].

Narratives of human agency and action

In 2000 Eugene Stoermer and Paul Crutzen named the current geological epoch characterized by the influence of humans on the Earth's surface the Anthropocene [17]. The Anthropocene narrative has

crossed disciplinary boundaries, entered public discourse, and informs models of governance and behavior [26,61,73]. It highlights the exceptional agency of humans in reshaping the earth's surface, and our dependence on the earth system for our own well-being. A focus on human agency may engender mitigative action, but also obscures that agency and vulnerabilities to climate change are unequally distributed. A narrative built around environmental justice might instead foreground unequal agency and responsibility for anthropogenic changes and the great economic divergence that has emerged over this period [52,61].

Narratives of transformation have also emerged in recent years [74]. They counter the "top-down" focus on technocratic solutions or on "doom and gloom", turning attention to "bottom-up" drivers of change and their potential to destabilize existing regimes, the creation of shared visions, and the opportunities of climate action for economic and other outcomes [36,79]. However, these narratives also differ substantially in the change they envision. Often these storylines focus on prospects for green growth (or "green capitalism")—economic growth that is decoupled from carbon emissions—and are evident in policies like The Green New Deal. In contrast, degrowth narratives (referred to as "green austerity" by some) point to the need for a more fundamental transformation of society, including substantial behavioral changes by those who consume most [68]. Other transformations narratives call for an end to capitalism altogether, focusing on just transitions - addressing climate change and social inequities at once -

and eco-socialist pathways to achieving them [92]. Transformation narratives are also prominent in the growing genre of climate fiction (cli-fi), which creates psychologically immersive and visceral experiences of possible futures—including dystopic ones resulting from inaction and utopic ones resulting from systemic change (see Box A).

Narratives of delay, uncertainty and inaction

Deep uncertainty also creates room for counter-narratives that seed doubt around anthropogenic climate change or the need for climate action [54]. These range from denial about the role of anthropogenic factors [23] to climate skepticism [33] to debates about what actions are needed, who is responsible and how costs and benefits should be allocated [4,37]; W. F. [45,54]. Analysis of media, advertisements, lobbying and political discourse have surfaced the following themes: individualism, technological optimism, greenwashing, and appeals to social justice [4,37,41,67]. Lamb et al. (2020) [45] refer to this latter category as climate delay discourses, and develop a typology that reveals their underlying logic and assumptions. They identify four strategies: redirect responsibility; push for non-transformative solutions; emphasize the downside of climate policies; surrender to climate change. These narratives justify inaction while accepting the existence of climate change, arguing that the negative effects of mitigation outweigh the benefits. For example, they might focus on population growth as a driver of climate change rather than consumption, obscuring unequal consumption and responsibility for emissions worldwide [45].

Box A. Climate Imaginaries and Institutional Innovation

Cli-fi is shorthand for climate fiction, a growing body of literary and cinematic work that addresses the impacts of anthropogenic climate change. Well-known authors of cli-fi include Margaret Atwood, Octavia Butler and Kim Stanley Robinson, among many others. Cli-fi scholars Andrew Milner and J.R. Bergmann argue that while cli-fi has roots in mythology—with its stories of great floods—and science fiction—which, following on the 19th century discovery of past ice ages, has often imagined global cooling—cli-fi has emerged as a distinctive phenomenon alongside growing awareness of the anthropogenic heating of the world and rampant social inequities [59]. Though often rooted in scientific observations and projections, cli-fi can speculate on the unfolding effects of climate change in more expansive ways, while also creating psychologically immersive experiences of that change. In its worldbuilding, it can tie projections of the physical impacts of climate change (flooding, drought, etc.) to the lived experience of individual protagonists, the interdependence of the climate crisis on exploitative economic and social structures, and the institutional and geopolitical transformations that may be brought on by the climate crisis.

While much of cli-fi is dystopic or apocalyptic, it can also put forward hopeful and empowering alternatives to "climate dread," including imagining the kinds of institutional and social transformations that will be necessary to meet the challenges of climate change. For example, addressing climate change requires redistribution of attention and resources to intermediate and longer-term time horizons. This must happen while simultaneously addressing current and past inequities. Institutional innovations that protect the interests of constituencies with limited political power, including future generations, are needed—yet are today rare [3,34]. Recent efforts include sovereign wealth funds and other attempts to insulate decision-making from short-term political pressures, mandating discount rates that place greater weight on the future, or the state appointment of public guardians for the future [5,66]. Kim Stanley Robinson's cli-fi novel, "The Ministry for the Future", is centered around a governing body with the mission of advocating for "all living creatures present and future who cannot speak for themselves". The novel, set in the near-future, reinvisions governing institutions needed to protect the interests of those with limited voice, as well as economic and monetary policy, offering both a critique of existing political and economic systems and plausible alternatives.

Discourses of inaction and doubt often come from co-ordinated and institutionalized efforts by powerful actors with vested interests in the current system, such as the fossil fuel sector, utilities, and even philanthropic organizations [7,22,23,29]. An analysis of communications from ExxonMobil finds a growing emphasis on doubt about anthropogenic climate change, and our ability to address it [78]. Discourse analysis of corporate responsibility and sustainability reports by major oil companies finds a narrative turn from climate change as a phenomenon that can be addressed to one that emphasizes risk and unpredictability, and relocates climate change to the future [38].

These narratives are effective in part because they reinforce epistemological and ethical challenges, build on legitimate concerns and fears, and prey on tendencies identified in the literature on decisions under uncertainty, such as discounting and loss aversion. They also generally favor the status quo, which may be more palatable than narratives about transformation but which would lock us into scenarios where even more difficult tradeoffs are eventually needed. Narratives of denial, delay or doubt co-opt broader norms, even those unrelated to climate change. Linguistic analysis suggests that these narratives build on the scaffolding provided by the network of norms surrounding other social issues and a hierarchy of more abstract meta-narratives about freedom, responsibility, and social fracture [47].

Conclusion

The complex, interdependent and adaptive relationship between nature and society creates uncertainty. While a "transformation" is needed, which futures to prioritize and how to achieve them is highly contested. Narratives are powerful sense-making devices—they can clarify signals from social-ecological systems, describe its potential for transformation, and highlight certain values, priorities and pathways over others [86]. As such, they have political and psychological agency, unifying or balkanizing society and promoting action or inaction by the contingencies and values they emphasize. They can also be strategically deployed to shape environmental publics, in part by capitalizing on epistemological and ethical challenges. While hegemonic narratives can reinforce existing systems, and their inequities and power relations, they are also increasingly unable to make sense of a rapidly changing world. This could create an opening for alternative narratives that envision more systemic change, which could in turn mobilize the public and shape governance responses. The study of decision-making under uncertainty should embrace the analysis of narratives to understand how shared knowledge and values are constructed, and how collective action emerges, despite an incomplete understanding of the underlying system [1].

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This paper utilizes the challenges posed by the deep uncertainty associated with climate change, physical processes, technological developments, and human responses to describe and illustrate the operations and advantages of robust decision making algorithms and procedures.