‘Tipping points’ confuse and can distract from urgent climate action

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Abstract: Tipping points have gained substantial traction in climate change discourses, both as representing the possibility of catastrophic and irreversible physical and societal impacts and as a way to set in motion positive, rapid and self-sustaining responses, such as the adoption of new technologies, practices, and behaviors. As such, tipping points appear ubiquitous in natural and social systems. Here, we critique ‘tipping point’ framings, specifically their insufficiency for describing the diverse dynamics of complex systems; their reductionist view of individuals, their agency and their aspirations; and their tendency to convey urgency without fostering a meaningful basis for climate action. We argue for clarifying the scientific discussion of the phenomena lumped under the ‘tipping point’ umbrella by using more specific language to capture relevant aspects (e.g., irreversibility, abruptness, self-amplification, potential surprise) and for the critical evaluation of whether, how and why the different framings can support accurate scientific understanding and effective climate risk management. Multiple social scientific frameworks suggest that deep uncertainty and perceived abstractness associated with many proposed Earth system ‘tipping points’ make them both unlikely to provoke effective action and not helpful for setting governance goals that must be sensitive to multiple constraints. The mental model of a ‘tipping point’ does not align with the multifaceted nature of social change; a broader focus on the dynamics of social transformation is more useful. Temperature-based benchmarks originating in a broad portfolio of concerns already provide a suitable guide for global mitigation policy targets and should not be confused with physical thresholds of the climate system.

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Introduction

Tipping points have established an important place in the public's and climate research community's imaginations. Defined by the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6) glossary as "critical threshold[s] beyond which a system reorganises, often abruptly and/or irreversibly,"[1] tipping points have come to characterize the potential for climate change to cause large-scale shifts in the Earth system. For example, a shutdown of the Atlantic Meridional Overturning Circulation or a long-term commitment to massive ice sheet loss are of grave concern as changes that would dramatically reshape the planet. The 'tipping point' concept is increasingly being applied beyond large-scale Earth system transitions to other climate-related phenomena across different scales, system types, and behaviours. This includes such diverse social phenomena as human migration, political disruptions, and the adoption of electric vehicles (Table 1).[2,3] This broad application might imply that tipping points are ubiquitous in natural and social systems and present a unifying way to consider how system changes occur, how societies rapidly respond both positively and negatively, and how to govern these changes.

To the contrary, we argue the 'tipping points' framing confuses and distracts from urgently needed climate mitigation and adaptation. We elaborate this perspective by asking three questions: 1) are tipping points well defined?; 2) do tipping points instill the types of urgency that drives societal and political action?; and 3) do tipping points provide a useful basis for setting climate targets and risk management? In all three cases, we conclude that the tipping points framing falls short. Given the deep uncertainty that characterize much of the climate system and human responses to climate change, existing and alternative framings better capture the complexity of natural systems, social systems, and their interactions. While tipping point discourse may increase the public's perception of threats from climate change, the focus on deeply uncertain and often abstract outcomes can paradoxically reduce the willingness to undertake effective climate risk management. Temperature-based targets arising from a broad set of social, economic, and scientific concerns continue to provide the most valuable framing for guiding actions and the trade-offs between mitigation, adaptation and losses and damages.

Critiquing the use of tipping points framing

Tipping points are not well defined and provide an illusion of precise scientific understanding. The 'climate tipping points' concept was originally applied to physical systems to describe irreversible, non-linear, self-amplifying and relatively abrupt changes driven by positive feedback dynamics. However, as the term has evolved to describe increasingly diverse systems, it has come to cover an ever broader and more disparate set of behaviors (Table 1). With its roots in complex system dynamics, the 'tipping point' framing conveys a sense of a precise mathematical construct. In practice, however, the concept has as diverse understandings across disciplines and communities as more obviously vague boundary concepts like 'sustainability' and 'resilience.'[4,5] Attempts to subsume so many issues and behaviours under the same label and common interpretive framework does not advance the science. Rather, it is doubtful that much insight remains in a conceptual framework that has been broadened so much as to encompass rapid reductions not only in the Atlantic Meridional Overturning Circulation and Amazon forest area, but also in social cohesion, clean energy prices and food waste.[3,6–12] Even if the tipping point metaphor is separately meaningful in the many contexts where it is applied, attempts to reconcile these differences to advance knowledge accumulation will be challenging, with attendant harms for assessment and synthesis.

However, our challenge to the tipping points framing begins with its original formulation. The use of the 'tipping point' concept in climate discourse is derivative of a broader cultural understanding of this concept, and its application even in natural systems may serve to confuse as much as to enlighten.[13–15] In the conception of tipping points popularized by

Malcom Gladwell, which predates the broad use of the label in climate research, tipping points are *both* abrupt and irreversible.[16] By contrast, in the Earth system, 'tipping points' may not be both and are sometimes neither. For example, ice sheet loss is irreversible and self-amplifying but not abrupt on human timescales, while summer Arctic sea ice loss – though often included in lists of tipping points – appears to be neither irreversible, abrupt, nor self-amplifying (i.e., it is linear in forcing).[17] Indeed, the AR6 Working Group 1 report often avoids talking about "tipping points" in isolation, rather preferring to talk about the concept together with the concepts of "irreversibility," "abrupt changes," and "surprises."[18]

Table 1: Examples of "tipping points" across diverse applications highlight the range of distinct dynamics that are being subsumed into this framing.

Description	Core definitional framing	Examples in literature	Ref
Climate or ecosystem tipping points	A critical threshold beyond which a system reorganises, often abruptly and/or irreversibly,[1] most often associated with self-amplifying system shifts driven by positive feedbacks	Large scale changes in atmosphere/ocean circulation (e.g., collapse of the Atlantic Meridional Overturning Circulation), commitment to large-scale ice-sheet loss, Amazon die-off	6,10,19
Negative social tipping points	Critical thresholds at which a small change can trigger substantial, harmful, feedback-driven and often irreversible transitions or bifurcations[12]	Anomie, conflict, displacement, radicalization and polarization, financial destabilization, and broader set of outcomes related to societal and economic breakdown (e.g. mass migration).	3,11,12,20–23
Positive social or socio-ecological tipping points	Sensitive points where a small intervention can trigger self-reinforcing feedbacks that accelerate beneficial systemic change[24]	Adoption of renewable energy and electric vehicles, avoiding food loss and waste, shifts to plant-based diets	3,7–9,24–28
Adaptation or risk tipping points	Thresholds (not necessarily abrupt or irreversible) that exceed the tolerances of current risk management strategies and require the adoption of a new approach	Sea-level rise exceeding the design tolerance of protective structures, accelerating extinctions, groundwater depletion, mountain glacier melting, unbearable heat, insurance market collapse	29–32

In addition to the challenges around defining its key features, the tipping points framing can also generate misunderstandings or oversimplifications of dynamics, especially those that are present in socio-ecological systems.[33] Part of the appeal of social tipping points is the appearance of a theoretically simple model to explain complex phenomena. In fact, the use of tipping points for societal applications is perhaps closer to the original examples from Morton Grodzins and Thomas Schelling, who argued for and modeled 'tipping' behavior in 'white flight' and neighborhood segregation, than the Earth system context.[34,35] However, even in this original context of neighborhood segregation, the tipping point model is disputed in light of empirical evidence.[36]

More generally, socio-ecological systems are always evolving, such that tipping points are often not a very helpful characterization of the actual dynamics of the system and can even serve to obscure the importance of ongoing changes. In ecosystems, thresholds are challenging to detect.[37] In social systems, large changes that may appear abrupt often result from the accumulation of small and large events that have deep roots spanning decades. Attributing such changes to a single or final factor ignores contributions that can only be identified through a historical and critical lens. The irreversibility of such changes can also only be assessed with historical perspective, as they are often accompanied by continued social and political contestation.[38–43] By neglecting the complexity of societal change, many discussions of social tipping points, especially those that are categorized as negative tipping points, reify a mistaken sense of inevitability.[5]

Within the context of political decision making, social tipping points also highlight the issue of who is defining the thresholds and the desirability of the outcomes. The election of a Solidarność government in Poland in 1989 can, in retrospect, be viewed as a "tipping point initiating the processes of the domino-like collapse of the Eastern European communist regimes"; whether it was a positive or negative tipping point differs from the perspective of a democrat and a Soviet apparatchik.[44] Likewise, when OPEC Secretary-General Haitham Al Ghais warned OPEC members during December 2023's UN Framework Convention on Climate Change Conference of the Parties that "undue and disproportionate pressure against fossil fuels may reach a tipping point with irreversible consequences," he clearly had a different view about the desirability of such a 'tipping point' than other attendees.[45] Framing a complex social situation as a negative social tipping point can foster a sense of catastrophe or societal collapse.[46] Such a portrayal may encourage disengagement or actions to preserve the existing social structure, regardless of its inequities, rather than helping identify pathways to more desirable futures.[47]

The tipping points framing does not provide clear entry points to drive climate action: Even if tipping points fail to describe the complexity of natural systems, social systems, and their interactions, one proposed reason to support the tipping points framing is the perception that it generates an actionable sense of urgency. In fact, the history of the use of climate 'tipping point' discourse is clear: the climate scientists who initially adopted the term did so seeking a communication strategy to draw attention to the potential for climate change to have sweeping impacts on the Earth system, with the aim of increasing urgency around climate change mitigation.[15]

However, the social science literature suggests that the tipping points framing is actually poorly aligned with the conditions that would drive anticipatory action.[48] While 'tipping point' warnings have had some success in drawing attention to the types of catastrophic risks that are attendant with ongoing global warming, a recent survey of the British public found both low levels of awareness and a higher level of doubt about the effectiveness of societal response to tipping points than climate change in general.[49] These types of beliefs of low collective efficacy have been associated with lack of response and action.[50] Similarly, social psychology indicates that anticipatory action will be most likely to manage threats that are perceived as relatively certain and as proximal in space and time; by contrast, Earth system tipping points are diffuse, uncertain global phenomena.[51–53]

Previous experience with the conditions that promote collective action indicate that democracies are more likely to act after collective recognition of a crisis, and often after identifiable focusing events that provide political openings for policy communities that have already recognized remedies.[48,54,55] Unlike the myriad climate change-enhanced extreme events – intense heat waves and flooding, widespread wildfires, and protracted droughts – that already provide a near constant supply of proximal, imminent, crisis-generating potential focusing events, Earth system tipping points are generally abstract and hard to recognize at the moment they are occuring. Though science fiction might envision a globally recognizable ‘day the West Antarctic ice sheet collapsed’ as a potential global focusing event leading to dramatic climate policy change, this is simply not the nature of the phenomena.[56]

Instead, more concrete focusing events are likely to open policy windows that could be used for addressing the risks associated with tipping points. The best opportunities to address the potential impact of rapid ice-sheet melt, for example, are likely to come as part of coastal adaptation in the wake of focusing events created by extreme coastal flooding; the best opportunities to address potential disruptions of monsoons are likely to come as part of adaptation planning in the wake of extreme monsoonal floods or droughts. Such risk management can be more easily implemented by aligning efforts with a broader range of peoples’ values and participatory structures, rather than the fear-based motivations that a tipping-points focus tends to invoke.[57–59]

Tipping points framings are not useful for climate policy and governance: While concerns about nonlinear, tipping point-like responses arguably have contributed to the adoption of temperature-based policy targets, like the 1.5°C and 2.0°C objectives in the Paris Agreement, these goals were set largely along multiple lines of evidence of economic harms and societal salience, such as protecting those in more vulnerable contexts.[60] By contrast, the uncertainty in tipping points greatly limits their usefulness for target setting and risk management.

In theory, a ‘tipping point’ threshold might be known with great precision — for example, we *could* know that sustained global-mean warming exceeding precisely 1.50°C would lead to an irreversible commitment to Greenland and Antarctic ice-sheet collapse, global coral reef die-off, glacier melt, permafrost thaw, and Labrador Sea convection shutdown. Indeed, such is implied by the title of a recent assessment article, “Exceeding 1.5°C global warming could trigger multiple climate tipping points.”[6] If this were known precisely to be the case, then it might justify great effort to limit global-mean warming to 1.49°C, even – for example – invoking ‘emergency’ climate intervention measures such as stratospheric aerosol injection to avoid crossing this point of no return.[61,62]

However, this is not what the substance of ref. 6 (and other assessments) have found. Rather, ref. 6 found that the world may have *already* crossed the tipping points associated with five processes, and that the likelihood of crossing these and others will continue to grow with warming. They did not identify any special physical salience of the titular 1.5°C threshold, but rather confirmed that the thresholds for tipping into catastrophe are highly uncertain. Such highly uncertain thresholds provide no rationale for emergency climate intervention to keep warming strictly below policy targets.

Another danger arises when precise policy targets are conflated with precise physical thresholds of abrupt and irreversible change. If this confusion does not lead to calls for potentially harmful emergency measures, it can lead to ‘doomism’ that can sustain political paralysis and harm mental health.[63] Such paralysis can delay not only efforts to limit climate change, but also adaptation efforts to limit harm to human and natural systems. Furthermore, if science is wrongly perceived as identifying precise thresholds for catastrophic outcomes when true thresholds are deeply uncertain, it may undermine the credibility of future claims should those catastrophic outcomes fail to occur when the perceived thresholds are crossed.

Even where physical thresholds can be an informative description of behavior in physical systems, such as ice sheets, their use can still sometimes mislead. For instance, due to humans’ ability to adapt, a committed multiple metre increase in sea level that takes many centuries to realize, as may occur due to ice losses from the Greenland ice sheet, bears far less dramatic implications than the same increase over one or two centuries, as could occur due to losses from the Antarctic ice sheet.[17]

Alternatives to tipping points that better support climate policy and action

Recent calls for a special report from the IPCC on tipping points could be interpreted as a signal that the scientific community is united in this formulation.[3] This critique focuses on the strong counterarguments, looking at the unintended consequences of the tipping points framing and the need for a more critical lens in this discourse. In some cases, alternatives to tipping points already exist and are clearly preferable in communicating science and supporting climate policy and action. In other cases, we propose a research agenda that refocuses on risk, solutions, transformations, and communication.

Clarify communication around tipping points across disciplines. As tipping points will to some extent continue to be part of climate discourse, researchers and communicators should be clear as to when they are simply invoking the term rhetorically – as synonymous with a threshold, a 'point of no return' or a metaphorical 'straw that broke the camel's back' – and when they intend to invoke the full system dynamics analytical framework associated with feedback-driven, abrupt, irreversible change. It may reduce confusion if researchers avoid attempts to use tipping points as a unifying framework to cumulate knowledge across fundamentally different systems, and instead accept the term in interdisciplinary contexts as a fuzzy, boundary-spanning concept akin to "sustainability." They should also consider whether the tipping points framing brings into focus the most relevant system behaviours. For example, researchers of positive social tipping points should consider whether the term 'leverage points' more clearly communicates the most salient aspects of the concept as they use it.[64]

Be more specific about the traits of proposed tipping points. To capture deep uncertainty and support climate risk management, employ a 'low- or unknown-likelihood, high-impact' (LLHI) 'surprise' framing. While there is value in studying the set of Earth system shifts currently bundled under the label of 'tipping points,' they differ sufficiently that a single label can confuse more than it can enlighten. Being more specific about the traits of abruptness, irreversibility, and feedback-driven self-amplification, rather than bundling these three characteristics, would increase clarity. Beyond these key traits, tipping points are often discussed almost interchangeably with 'low- or unknown- likelihood, high-impact' (LLHI) 'surprises,' which can play key roles in frameworks for decision-making under deep uncertainty.[18] However, for the LLHI framing, it is not the potential 'tipping point' nature of such outcomes that makes their consideration valuable – it is simply the potential high impact in combination with deep uncertainty. The use of LLHI storylines allows for descriptions of these outcomes while explicitly avoiding implied precision or inevitability. The LLHI concept can be communicated to the public by phrases such as "potential surprises" (as in the US Fourth National Climate Assessment) while avoiding the misleading interpretations that "tipping points" can foster.[65]. Other formulations are conceivable but each would need to take in account both scientific accuracy and research findings on their effectiveness at communication.

AR6 Working Group 1 already took steps to adopt a LLHI framing in describing physical climate change, with a well-developed LLHI storyline for rapid ice sheet loss and less fully developed LLHI storylines for high climate-sensitivity outcomes and a large volcanic eruption. The Seventh Assessment Report could extend this approach by recognizing that the deep uncertainty around LLHI outcomes demands a methodologically plural approach for constructing storylines; an approach dominated by model intercomparison (e.g., ref. 66) is inadequate when the failure of models to adequately characterize the phenomenon in question is a defining trait. More broadly, mainstreaming consideration of LLHI storylines and the use of decision-making under deep uncertainty approaches in climate risk management would achieve many of the goals desired by advocates of Earth system tipping points 'impact governance.'[3] It is indeed useful from an impact preparedness perspective to pre-emptively consider potential response to LLHI outcomes, and this utility does not depend on the tipping point framing.[67]

Advance understanding of non-linear societal changes and how social transformations have and can occur. Climate mitigation and adaptation require substantial economic, political and social changes. Thus, enhancing understanding of how these changes occur, how to limit negative outcomes, and how to accelerate positive outcomes is especially critical. While analyses of negative social tipping points often develop models of inevitability and rely on conceptualizations of migration and violent conflict that are not well supported in the literature,[68] discussions of positive social tipping points can be valuable to the extent that they clarify the potential for rapid shifts in the social system, such as abrupt shifts in electric vehicle adoption or of social beliefs about what is favourable or possible. However, as discussed above, the 'tipping point' schema generally conveys an oversimplified sense of the dynamics of socioecological transitions, which arise from multiple causes and whose irreversibility or inevitability can only be assessed in historical retrospect. In fact, recent work has argued for rejecting the term 'social tipping point' and rather focusing on the 'social tipping dynamics' of societal transformation[69] and is increasingly emphasizing human agency – the ability to act to change the system dynamics (even if often in unintended ways).[70] These authors recognize that social tipping points, to the extent they exist, will always be situated in broader social change processes.[28] A broader research agenda that focuses on transformation pathways and elaborates key leverage points could be useful, informative, and decision-relevant. However, we remain skeptical that there is any further value in attempting to link Earth system changes and social changes within a unifying 'tipping points' paradigm focused on abrupt, irreversible, self-amplifying change.

Improve the discourse around governance and risk management to incorporate tipping point behaviours more appropriately. Meaningful use of 'tipping point' discourse in governance would require specificity about the actions different entities would take if they knew a tipping point was about to be crossed that they would not take without that knowledge, while recognizing the real-world constraints on those entities.[71] In some cases, this is clear, and already part of adaptation practice. For example, high-end sea-level rise projections associated with LLHI ice-sheet collapse are already included in some national or regional coastal adaptation planning;[72–74] they need no special 'tipping points' governance. For most other proposed tipping points, however, anticipatory adaptation approaches have yet to be identified, and the only actions on the table beyond faster mitigation are emergency solar radiation management or large-scale cryosphere geoengineering.[3] Tipping points should at most be just one of many elements within climate risk management frameworks that focus on clear consideration of the costs, benefits, and uncertainty in all systems, including deliberate attention to LLHI outcomes and to decision-relevant deep uncertainty wherever it arises.[75,76]

Continue to employ temperature milestones as key policy benchmarks for motivating global progress toward a stable climate, while being clear that these benchmarks are not known physical thresholds. The AR6 cycle underscored the clear urgency of climate action and the value of staying within the temperature limits of the Paris Agreements, including the specific importance of limiting warming to as close as possible to 1.5°C.[77,78] Precise policy targets such as those in the Paris Agreement can indeed serve as valuable milestones. As the pioneering economist William Baumol wrote half a century ago about uncertain environmental harms, "given the limited information at our disposal, it is perfectly reasonable to act on the basis of a set of minimum standards of acceptability."[79]

However, these temperature targets should be acknowledged as policy benchmarks intended to limit cumulative harm, not inherent thresholds of the Earth system that cannot be exceeded without catastrophe. Climate change is already causing demonstrable and obvious harm around the world. Tipping point discourse to the contrary, there is no fraction of a degree that science can identify as the boundary between our current, already-dangerous climate and a future catastrophic climate, and no justification for doomism and paralysis while the world continues to warm.[80] Rather, appropriate policy reactions must recognize that every fraction of a degree matters. The scientific community needs to focus on solutions that can provide clear, actionable paths for managing risk and creating opportunities today, while limiting and ultimately reversing future risk growth.

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