nature climate change

Perspective

https://doi.org/10.1038/s41558-024-02196-8

'Tipping points' confuse and can distract from urgent climate action

Received: 8 January 2024

Accepted: 24 October 2024

Published online: 3 December 2024

Check for updates

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Tipping points have gained substantial traction in climate change discourses. Here we critique the 'tipping point' framing for oversimplifying the diverse dynamics of complex natural and human systems and for conveying urgency without fostering a meaningful basis for climate action. Multiple social scientific frameworks suggest that the deep uncertainty and perceived abstractness of climate tipping points render them ineffective for triggering action and setting governance goals. The framing also promotes confusion between temperature-based policy benchmarks and properties of the climate system. In both natural and human systems, we advocate for clearer, more specific language to describe the phenomena labelled as tipping points and for critical evaluation of whether, how and why different framings can support scientific understanding and climate risk management.

For nearly two decades, beginning in the umbra of Malcolm Gladwell's 2000 non-fiction bestseller *The Tipping Point*[1], some climate researchers have warned of the dangers of climate tipping points and called for catalysing social tipping points to avert potential catastrophe (Box 1). These calls began with a 2005 American Geophysical Union lecture by Jim Hansen[2] and a 2007 *Nature Climate Change* Commentary by Tim Lenton and Hans Joachim Schellnhuber[3], and progressed into a peer-reviewed literature that now, according to the Web of Science, includes more than 2,200 papers. The literature on tipping points in the climate system saw rapid growth, subsuming concepts such as abrupt change, hysteresis, regime shifts and bifurcations, with a subsequent increase in the study of both the socio-economic consequences of climate tipping points and tipping processes that might lead to decarbonization and greater sustainability. Consistent with the original intent of the climate researchers who established the 'tipping points' framing, many tipping points researchers have integrated scholarly work on climate and social tipping points with calls for policy change, including the more than 200 authors who contributed to *The Global Tipping Points Report 2023*[4]. Tipping points thus have an important place in the imagination of both the public and the climate research community[5].

Defined by the IPCC's Sixth Assessment Report (AR6) as "critical threshold[s] beyond which a system reorganises, often abruptly and/or irreversibly"[6], 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 (AMOC) or a long-term commitment to massive ice-sheet loss would be of grave concern as a change that would dramatically reshape the planet. The tipping point concept is increasingly being applied beyond large-scale Earth system transitions to diverse climate-related social phenomena, including human migration, political disruptions and the adoption of electric vehicles (Table 1 and Supplementary Information)[4,7]. This broad application might imply that tipping points are ubiquitous in natural and social systems and present a unifying way

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BOX 1

Origins of the tipping points framing in climate research

The first scholarly work on tipping points was about social tipping points, specifically the foundational works of Grodzins[25] and Schelling[26] on neighbourhood racial segregation and 'white flight'. The initial uses of the tipping points framing in climate scholarship were influenced by *The Tipping Point*, which compiled examples from social psychology, public health and policing to draw conclusions about the general applicability of a tipping point framework[1]. Prominent climate researchers adopted the concept with the explicit intent of linking science, policy and socio-economic transformation in a holistic framework for responding to the risks of nonlinear, self-sustaining and abrupt climate changes. The tipping points framing emerged in public talks, editorials, commentaries and media coverage about climate change before it developed as a scientific concept in the peer-reviewed literature[19,20].

In an American Geophysical Union lecture in 2005, James Hansen argued that tipping points were integral to assessing dangerous anthropogenic interference with the climate, a core concept in the UNFCCC[2]. He emphasized the dangers of self-sustaining, positive feedbacks that could abruptly and surprisingly accelerate change. In subsequent testimony to a state utilities regulator, he argued that "even the emissions from one Iowa coal plant" could push ice sheets pass a tipping point, while also contending that blocking the proposed plant might serve as a social tipping point leading to policy change[96].

In a contemporaneous *Nature Climate Change* Commentary, Lenton and Schellnhuber similarly joined natural and societal dynamics together with a policy intent to argue that "international climate policy needs to induce a socio-economic tipping to a low or no-carbon economy if we are to avoid climate change tipping points"[3]. This seminal Commentary defined the phrase 'tipping element' by referring to criteria establishing whether they are 'policy relevant', and argued that "climate protection strategies that clearly do not avert the risk of reaching a tipping point can be excluded from policy decisions". All three scientists helped to establish an ongoing practice of counterposing climate tipping points with positive social tipping points.

The rationale of the early adopters of the tipping points frame was also articulated in a foundational 2008 study that acknowledged the scarceness of "convincingly established tipping points" but justified its review of potential tipping elements based on "increasing political demand to define and justify binding temperature targets"[15].

Criticism of the often unclear and confusing scope of the tipping points frame has been persistent over its history. Indeed, in its initial surge of popularity, a 2006 editorial in *Nature* voiced this concern, while also critiquing the framing for overemphasizing deeply uncertain science and the risk that focusing on tipping points might lead to fatalism[97].

to consider how system changes occur, how societies rapidly respond (both positively and negatively) and how to govern these changes.

We critique the tipping points framing from a consequentialist viewpoint. Given that the adoption of this frame is a choice by the research community, we interrogate this choice both with respect to its intellectual merit (in terms of whether it effectively contributes to knowledge cumulation) and its broader societal impact (whether it supports societal climate action that is consistent with scientific understanding of socio-ecological systems). We conclude that it falls short on both counts. While many of the phenomena bundled under the tipping points banner are systemically important and well worth studying, the tipping points framing does not necessarily highlight—and may even obscure—their most critical or consequential aspects.

We elaborate on this stance, asking: (1) are tipping points well defined?; (2) do climate tipping points and negative social tipping points instil the types of urgency that drive societal and political action?; and (3) do climate tipping points provide a useful basis for setting climate targets and risk management? In all three cases, we find that the evidence favours the negative.

Tipping points are not well defined

In climate scholarship, the concept of tipping points was originally applied to physical systems to describe irreversible, nonlinear, 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 behaviours (Table 1). With its roots in complex system dynamics and its use of the mathematically precise concept of a 'point', the tipping point framing conveys a sense of precision. In practice, however, the concept has understandings across disciplines and communities that are as diverse as more obviously vague boundary concepts like sustainability and resilience[8–10]. Attempts to subsume so many issues and behaviours under the same label and common interpretive framework do not advance scientific understanding. In fact, it is doubtful that much insight can be drawn from a conceptual framework that has been broadened so much that it encompasses rapid reductions not only in the AMOC and Amazon forest area, but also in social cohesion, clean energy prices and food waste[4,11–17]. Even if the tipping point metaphor is separately meaningful in the many contexts in which it is applied, attempts to reconcile these differences to advance knowledge cumulation 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[18–20]. In the conception of tipping points popularized by Malcom Gladwell, which predated the broad use of the label in climate research, tipping points are both self-sustaining and abrupt[1]. 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. Summer Arctic sea-ice loss—the first proposed climate tipping point described in the scientific literature, now generally not regarded as a tipping point but nonetheless often included in tipping point reviews—seems to be neither irreversible nor self-amplifying (that is, the decline in sea-ice area is linear in forcing)[21]. Indeed, the AR6 Working Group I report often avoids talking about tipping points in isolation, preferring to talk about the concept together with the concepts of 'irreversibility,' 'abrupt changes' and 'surprises'[22].

In addition to the challenges around defining its key features, the tipping points framing can also generate misunderstandings or oversimplifications of dynamics. Taken at face value, a tipping point is a point at which changes become unavoidable—even if the threshold of external forcing or temperature change associated with the tipping point is unknown and subject to epistemic uncertainty, adopting the tipping point framing linguistically implies that such a unique threshold exists. Yet this may not be the case even in archetypal examples of climate tipping points, such as the collapse of the AMOC. With low confidence, a recent review assigned a tipping threshold for the

Table 1 | Examples of tipping points from diverse applications highlight the range of distinct dynamics that are being subsumed into this framing

Description	Core definitional framing	Examples in the literature	References
Climate or ecosystem tipping points	"A critical threshold beyond which a system reorganizes, often abruptly and/or irreversibly"[6], most often associated with self-amplifying system shifts driven by positive feedbacks	Large-scale changes in atmosphere/ocean circulation (for example, the collapse of the AMOC), commitment to large-scale ice-sheet loss, Amazon rainforest die-off	11,15,84
Negative social tipping points	Critical thresholds at which a small change can trigger substantial, harmful, feedback-driven and often irreversible transitions or bifurcations[17]	Anomie, conflict, displacement, radicalization and polarization, financial destabilization and a broader set of outcomes related to societal and economic breakdown (for example, mass migration)	4,16,17,85–88
Positive social or socio-ecological tipping points	Sensitive points where a small intervention can trigger self-reinforcing feedbacks that accelerate beneficial systemic change[89]	Adoption of renewable energy and electric vehicles, avoiding food loss and waste, shifts to plant-based diets	4,12–14,68,89–92
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	10,93–95

AMOC at some point between 1.4 °C and 8.0 °C of warming[11]. While this is a very broad range, if a threshold actually exists, it ought to be theoretically knowable. It can exhibit epistemic uncertainty (science may not know where the tipping point is), but not aleatoric uncertainty (identically forced histories ought to exhibit the same threshold behaviour). However, in at least some global climate models, AMOC collapse is aleatoric, with AMOC sometimes collapsing and sometimes not under identical GHG trajectories[23]. This is consistent with AMOC being a tipping element that exhibits bifurcations, but inconsistent with a tipping point that has a critical threshold that can be defined in terms of external forcing.

This oversimplification is even more of an issue in socio-ecological systems[24]. Part of the appeal of social tipping points is the appearance of a theoretically simple model to explain complex phenomena. The use of tipping points for societal applications is perhaps closer than the Earth system context to the original examples used by Morton Grodzins and Thomas Schelling (see Box 1 for further details), who described and modelled tipping behaviour in neighbourhood racial segregation and white flight—the idea that mid-twentieth-century American neighbourhoods 'tipped' from supermajority white to supermajority Black once they reached a threshold non-white population[25,26]. However, even in this original context, the tipping point model of racial segregation is disputed in light of empirical evidence[27].

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, and a focus on singular thresholds can obscure important levels of complexity and heterogeneity[28,29]. In both ecological and 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. Their irreversibility can only be assessed with historical perspective, and in social systems they are often accompanied by continued social and political contestation[30–33]. 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[9].

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 normative labelling of 'positive' and 'negative' tipping points can obscure the unevenly distributed effects of disruptive changes, which have the potential for substantial equity implications[34]. For example, when Haitham Al Ghais, the Secretary General of the Organization of the Petroleum Exporting Countries, warned during the UNFCCC Conference of the Parties in December 2023 that "undue and disproportionate pressure against fossil fuels may reach a tipping point with irreversible consequences," he expressed that this was a potential negative tipping point, while negotiators and activists advocating for a fossil fuel phase-out might have viewed this as a potential positive tipping point[35].

Framing a complex social situation as a negative social tipping point can also foster a sense of catastrophe or societal collapse[36]. Such a portrayal may encourage disengagement or actions to preserve the existing social structure, regardless of its inequities, rather than helping to identify pathways to more desirable futures[37]. For example, some scholars have argued that apocalyptic imagery, like that associated with climate tipping points, has linked the logics of security and risk management in a manner that has not addressed the root drivers of climate change but instead reinforced the governmental machinery of securitization and risk management in global climate politics[37,38].

Urgency alone does not translate to 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 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 (Box 1)[20,39].

However, the broader social science literature suggests that, while the fear created by climate tipping points and climate-driven negative social tipping points is likely to be effective in driving attention or online engagement, climate tipping points are actually poorly aligned with the conditions that would foster empowerment to act or anticipatory action[40–42]. Specific studies on the effectiveness of climate tipping points in fostering action are limited, but a recent survey of the British public found both lower levels of awareness and a higher level of doubt about the effectiveness of societal responses to tipping points than climate change in general[43]. More equivocally, an experimental survey in which three randomly assigned groups of the public were either provided linear, nonlinear (tipping point) or no climate change information found that there were no statistically significant differences between the linear and nonlinear treatment groups in terms of beliefs about efficacy or perceptions of the controllability of climate

change and catastrophic impacts[44]. 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, climate tipping points are diffuse, uncertain global phenomena[45–47].

In democracies, policy change is more likely after collective recognition of a crisis, often triggered by focusing events that provide political openings for existing policy communities that have already recognized remedies[41,48]. Unlike the myriad of climate change-enhanced extreme events (for example, intense heat waves and flooding, widespread wildfires and protracted droughts) that provide a near constant supply of proximal, imminent, crisis-generating potential focusing events, climate tipping points are generally abstract and hard to recognize while they are occurring. They are thus ill suited to create focusing events.

Instead, more concrete hazards are likely to open policy windows for addressing climate risks, including those associated with tipping points. Policy windows to address the potential impact of rapid ice-sheet melting, for example, are likely to open as part of coastal adaptation in the wake of extreme coastal flooding and policy windows 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 focus on climate tipping points and negative social tipping points tends to invoke[49,50].

Limited utility for policy and governance

While concerns about nonlinear, tipping-point-like responses arguably have contributed to the adoption of temperature-based policy targets, such as the 1.5 °C and 2.0 °C objectives of 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[51]. By contrast, the uncertainty in climate tipping points greatly limits their usefulness for target setting and risk management.

In theory, a climate 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 convective shutdown in the Labrador Sea. If this were 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[52,53].

However, despite a provocative title stating that 'Exceeding 1.5 °C global warming could trigger multiple climate tipping points', this is not what was found in a recent review[11]. The authors instead concluded 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. The review did not identify any special physical salience of the titular 1.5 °C threshold, but instead 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. Interview and survey data suggest that confusion between tipping points and politically negotiated temperature targets was common among international climate negotiation participants in 2017[54]. This confusion is also reflected in common phrases such as 'the 1.5 °C tipping point' (Supplementary Tables 3–7). This confusion might not only lead to calls for potentially harmful emergency measures, such as geoengineering intended to keep the global mean surface air temperature below this precise (but arbitrary) level, but also to 'doomism' that can sustain political paralysis and harm mental health[55]. Such paralysis can delay efforts to limit climate change, as well as 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, the false alarm effect may reduce the credibility of future claims should those catastrophic outcomes fail to occur when the perceived thresholds are crossed[56,57].

Even where physical thresholds can be an informative description of behaviour in physical systems, such as ice sheets, their use can still sometimes mislead. For instance, due to the ability of humans to adapt, a committed multiple-metre increase in sea level that takes many centuries to occur bears far less dramatic implications than the same increase over one or two centuries[21].

Recommendations for future directions

Scientific framings that are intended to be policy relevant ought to be subject to scientific scrutiny. In this Perspective, based on theory, data and our professional experience, we have presented several testable hypotheses regarding the communicative effects of the tipping points framing. For example, we hypothesize that climate tipping points and negative social tipping points promote fear-based responses and doomism. We suggest, on the basis of existing social science models, that climate tipping points are poorly aligned with conditions that promote policy change. Similarly, we propose that framing social change in terms of tipping points promotes overly simplistic and unidimensional theories of change. We further hypothesize that the common misidentification of the 1.5 °C benchmark as a tipping point reflects a confusion in public perception, and that the failure of an obvious tipping point to materialize as the 1.5 °C benchmark is crossed may lead to a reduction in scientific credibility. To the extent that the tipping points discourse continues, the communicative effects of the tipping points framing should be a more common topic of empirical study.

While framing choices should be informed by research, existing evidence of the confusion created by the tipping points framing is already strong enough to merit reframing work that is currently organized under the tipping points banner in ways that are likely to advance scholarly and societal understanding more effectively. We offer five recommendations for reform and reframing below.

Clarify communication across disciplines

As tipping points will continue to be part of climate discourse to some extent, researchers and communicators should be clear 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 the most relevant system behaviours into focus. For example, researchers of positive social tipping points should consider whether the term 'leverage points', which emphasizes the opportunity for directed interventions to lead to larger changes, more clearly communicates the most salient aspects of the concept[58].

Be more specific about traits of proposed tipping points

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. Furthermore, tipping points are often discussed almost interchangeably with unknown-likelihood, high-impact (ULHI)

surprises, which can play key roles in frameworks for decision-making under deep uncertainty[22,59].

Unfortunately, existing terminology can obscure the difference between low-likelihood and unknown-likelihood outcomes. For example, AR6 Working Group I notes that their use of the phrase 'low-likelihood, high-impact outcomes' includes outcomes whose probability is "not well known (as in the context of deep uncertainty)"[60]. Given that many proposed tipping points involve low-confidence, unknown-likelihood outcomes, rather than outcomes known to have low likelihoods, we suggest clarifying this terminology to more clearly distinguish between low-likelihood outcomes and ULHI outcomes. The use of ULHI storylines allows descriptions of ULHI outcomes while explicitly avoiding implied precision or inevitability[61]. The ULHI concept can be communicated to the public by phrases such as 'potential surprises' (as used in the US Fourth National Climate Assessment[62]) while avoiding the misleading interpretations that tipping points can foster.

AR6 Working Group I already took steps to adopt a ULHI framing in describing physical climate change, with a well-developed 'low'-likelihood, high-impact storyline for rapid ice-sheet loss and less fully developed storylines for high-climate-sensitivity outcomes and a large volcanic eruption. The IPCC's Seventh Assessment Report could extend this approach by distinguishing between low-likelihood and unknown-likelihood outcomes and recognizing that the deep uncertainty around ULHI outcomes demands a methodologically plural approach for constructing storylines; an approach dominated by model intercomparison is inadequate when the failure of models to adequately characterize the phenomenon in question is a defining trait. More broadly, mainstreaming the consideration of ULHI 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 climate tipping points 'impact governance'[4]. From an impact preparedness perspective, it is indeed useful to consider potential responses to ULHI outcomes—not because they fit some definition of tipping point, but simply because they are of high potential impact and their likelihood is challenging to assess[63].

Advance understanding of nonlinear societal changes

Effective climate mitigation and adaptation require substantial economic, political and social changes. Thus, enhancing our 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[64], discussions of positive social tipping points may 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 in 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 socio-ecological 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 instead focusing on the 'social tipping dynamics' of societal transformation[65] and is increasingly emphasizing human agency—the ability to act to change the system dynamics (even if often in unintended ways)[66,67]. This work recognizes that social tipping processes, to the extent that they exist, will always be situated in broader social change processes[68]. 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, especially as there is no reason to specify a priori that only nonlinear, self-amplifying societal changes are the most appropriate responses to the Earth system changes[34].

Improve discourse around governance and risk management

The meaningful use of tipping point discourse in governance would require specificity about the actions different entities would take if, and only if, they knew that a tipping point was about to be crossed, while recognizing the real-world constraints on those entities[69]. In some cases, this is clear and already part of adaptation practice. For example, high-end sea-level rise projections associated with ULHI ice-sheet collapse are already included in national or regional coastal adaptation planning in some places; they need no special tipping points governance[70–72]. For most other proposed climate 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[73–78]. Tipping processes should 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 ULHI outcomes and to decision-relevant deep uncertainty wherever it arises[79].

Clarify the distinction between temperature-based policy benchmarks and physical thresholds

The AR6 cycle underscored the clear urgency of climate action and the value of staying within the temperature limits of the Paris Agreement, including the specific importance of limiting warming as close as possible to 1.5 °C (ref. 80). Precise policy targets such as those in the Paris Agreement can indeed serve as valuable milestones, despite uncertainty in their physical consequences[81]. 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[82].

Climate change is already causing demonstrable and obvious harm around the world. Tipping point discourse to the contrary, there is no specific increment of temperature increase 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[83]. Appropriate policy reactions must instead recognize that every fraction of a degree of warming 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.

References

1. Gladwell, M. *The Tipping Point: How Little Things Can Make a Big Difference* (Abacus, 2000).
   This book popularized the concept of tipping points.
2. Hansen, J. E. *Is There Still Time to Avoid 'Dangerous Anthropogenic Interference' with Global Climate? A Tribute to Charles David Keeling* https://www.columbia.edu/~jeh1/2005/Keeling_20051206.pdf (2005).
3. Lenton, T. M. & Schellnhuber, H. J. Tipping the scales. *Nat. Clim. Change* **1**, 97–98 (2007).
4. Lenton, T. M. et al. *The Global Tipping Points Report 2023* (2023).
   This report attempted to synthesize the literature on Earth system tipping points, social tipping points and their governance.
5. Milkoreit, M. Social tipping points everywhere?—Patterns and risks of overuse. *Wiley Interdiscip. Rev. Clim. Change* **14**, e813 (2023).
6. Matthews, J. B. R. et al. in *Climate Change 2021: The Physical Science Basis* (eds Masson-Delmotte, V. et al.) 2215–2256 (IPCC, Cambridge Univ. Press, 2021).
7. Franzke, C. L. E. et al. Perspectives on tipping points in integrated models of the natural and human Earth system: cascading effects and telecoupling. *Environ. Res. Lett.* **17**, 015004 (2022).

8. Brand, F. S. & Jax, K. Focusing the meaning(s) of resilience: resilience as a descriptive concept and a boundary object. *Ecol. Soc.* **12**, 23 (2007).
9. Milkoreit, M. et al. Defining tipping points for social-ecological systems scholarship—an interdisciplinary literature review. *Environ. Res. Lett.* **13**, 033005 (2018).
The authors critique and synthesize socio-ecological tipping point definitions.
10. Eberle, C., O'Connor, J., Narvaez, L., Mena Benavides, M. & Sebesvari, Z. *Interconnected Disaster Risks: Risk Tipping Points* (United Nations University–Institute for Environment and Human Security, 2023); https://doi.org/10.53324/WTWN2495
11. Armstrong McKay, D. I. et al. Exceeding 1.5 °C global warming could trigger multiple climate tipping points. *Science* **377**, eabn7950 (2022).
This paper assesses Earth system tipping points and their likelihoods, timescales and impacts.
12. Aschemann-Witzel, J. & Schulze, M. Transitions to plant-based diets: the role of societal tipping points. *Curr. Opin. Food Sci.* **51**, 101015 (2023).
13. David Tàbara, J. et al. Positive tipping points in a rapidly warming world. *Curr. Opin. Environ. Sustain.* **31**, 120–129 (2018).
14. Lenton, T. M. Tipping positive change. *Phil. Trans. R. Soc. B* **375**, 20190123 (2020).
15. Lenton, T. M. et al. Tipping elements in the Earth's climate system. *Proc. Natl Acad. Sci. USA* **105**, 1786–1793 (2008).
This paper formalizes the concept of tipping elements.
16. Scheffran, J., Guo, W., Krampe, F. & Okpara, U. Tipping cascades between conflict and cooperation in climate change. *EGUsphere* https://doi.org/10.5194/egusphere-2023-1766 (2023).
17. Spaiser, V. et al. Negative social tipping dynamics resulting from and reinforcing Earth system destabilisation. *Earth Syst. Dyn.* **15**, 1179–1206 (2024).
18. Kopp, R. E., Shwom, R., Wagner, G. & Yuan, J. Tipping elements and climate-economic shocks: pathways toward integrated assessment. *Earths Future* **4**, 346–372 (2016).
This paper critically reviews the climate tipping points literature, arguing for greater definitional clarity and a focus on pathways to economic impacts.
19. Russill, C. Climate change tipping points: origins, precursors, and debates. *Wiley Interdiscip. Rev. Clim. Change* **6**, 427–434 (2015).
20. Russill, C. & Nyssa, Z. The tipping point trend in climate change communication. *Glob. Environ. Change* **19**, 336–344 (2009).
The authors provide a contemporaneous perspective on the formation of the climate tipping point framing.
21. Fox-Kemper, B. et al. in *Climate Change 2021: The Physical Science Basis* (eds Masson-Delmotte, V. et al.) 1211–1362 (IPCC, Cambridge Univ. Press, 2021).
22. Chen, D. et al. in *Climate Change 2021: The Physical Science Basis* (eds Masson-Delmotte, V. et al.) 147–286 (IPCC, Cambridge Univ. Press, 2021).
23. Romanou, A. et al. Stochastic bifurcation of the North Atlantic circulation under a midrange future climate scenario with the NASA-GISS ModelE. *J. Clim.* **36**, 6141–6161 (2023).
24. York, R. & Clark, B. The problem with prediction: contingency, emergence, and the reification of projections. *Sociol. Q.* **48**, 713–743 (2007).
25. Grodzins, M. Metropolitan segregation. *Sci. Am.* **197**, 33–41 (1957).
26. Schelling, T. C. Dynamic models of segregation. *J. Math. Soc.* **1**, 143–186 (1971).
27. Easterly, W. Empirics of strategic interdependence: the case of the racial tipping point. *B. E. J. Macroecon.* **9**, 25 (2009).
28. Hillebrand, H. et al. Thresholds for ecological responses to global change do not emerge from empirical data. *Nat. Ecol. Evol.* **4**, 1502–1509 (2020).
29. McClanahan, T. R. Reconsidering and rescaling climate change predictions for coral reefs. *Nat. Clim. Change* **14**, 779–781 (2024).
30. Raven, R., Schot, J. & Berkhout, F. Space and scale in socio-technical transitions. *Environ. Innov. Soc. Transit.* **4**, 63–78 (2012).
31. Rosenfeld, M. J. Moving a mountain: the extraordinary trajectory of same-sex marriage approval in the United States. *Socius* **3**, 2378023117727658 (2017).
32. Smith, A., Stirling, A. & Berkhout, F. The governance of sustainable socio-technical transitions. *Res. Policy* **34**, 1491–1510 (2005).
33. Geels, F. W., Kern, F. & Clark, W. C. System transitions research and sustainable development: challenges, progress, and prospects. *Proc. Natl Acad. Sci. USA* **120**, e2206230120 (2023).
34. van Ginkel, K. C. H. *Exploring Climate Change Induced Socio-economic Tipping Points to Support Decision Making* (Vrije Univ. Amsterdam, 2022).
35. Al Gais, H. *Letter from OPEC Secretary General* SGO/2023/OC0975 (2023).
36. Kemp, L. et al. Climate endgame: exploring catastrophic climate change scenarios. *Proc. Natl Acad. Sci. USA* **119**, e2108146119 (2022).
37. Tuana, N. From a lifeboat ethic to Anthropocenean sensibilities. *Environ. Phil.* **17**, 101–123 (2020).
38. Methmann, C. & Rothe, D. Politics for the day after tomorrow: the logic of apocalypse in global climate politics. *Secur. Dialogue* **43**, 323–344 (2012).
39. Crucifix, M. & Annan, J. in *Contemporary Climate Change Debates* (ed. Hulme, M.) 23–35 (Routledge, 2019).
40. O'Neill, S. & Nicholson-Cole, S. "Fear won't do it": promoting positive engagement with climate change through visual and iconic representations. *Sci. Commun.* **30**, 355–379 (2009).
41. Shwom, R. L. & Kopp, R. E. Long-term risk governance: when do societies act before crisis? *J. Risk Res.* **22**, 1374–1390 (2019).
42. Vlasceanu, M. et al. Addressing climate change with behavioral science: a global intervention tournament in 63 countries. *Sci. Adv.* **10**, eadj5778 (2024).
43. Bellamy, R. Public perceptions of climate tipping points. *Public Underst. Sci.* **32**, 1033–1047 (2023).
44. Formanski, F. J. et al. Tipping points ahead? How laypeople respond to linear versus nonlinear climate change predictions. *Climatic Change* **175**, 8 (2022).
45. Rickard, L. N., Yang, Z. J. & Schuldt, J. P. Here and now, there and then: how 'departure dates' influence climate change engagement. *Glob. Environ. Change* **38**, 97–107 (2016).
46. Ballard, T. & Lewandowsky, S. When, not if: the inescapability of an uncertain climate future. *Phil. Trans. R. Soc. A* **373**, 20140464 (2015).
47. Sundblad, E.-L., Biel, A. & Gärling, T. Cognitive and affective risk judgements related to climate change. *J. Environ. Psychol.* **27**, 97–106 (2007).
48. Birkland, T. A. Focusing events, mobilization, and agenda setting. *J. Public Policy* **18**, 53–74 (1998).
49. Bellamy, R. & Hulme, M. Beyond the tipping point: understanding perceptions of abrupt climate change and their implications. *Weather Clim. Soc.* **3**, 48–60 (2011).
50. Graham, S. et al. The social values at risk from sea-level rise. *Environ. Impact Assess. Rev.* **41**, 45–52 (2013).
51. Randalls, S. History of the 2 °C climate target. Wiley Interdiscip. *Rev. Clim. Change* **1**, 598–605 (2010).
52. Markusson, N., Ginn, F., Singh Ghaleigh, N. & Scott, V. 'In case of emergency press here': framing geoengineering as a response to dangerous climate change. *Wiley Interdiscip. Rev. Clim. Change* **5**, 281–290 (2014).
53. Futerman, G. et al. The interaction of solar radiation modification and Earth system tipping elements. *EGUsphere* https://doi.org/10.5194/egusphere-2023-1753 (2023)

54. Milkoreit, M. in *Global Challenges, Governance, and Complexity* (ed. Galaz, V.) 274–302 (Edward Elgar, 2019).
55. Mann, M. E. *The New Climate War: The Fight to Take Back Our Planet* (Scribe Publications, 2021).
56. LeClerc, J. & Joslyn, S. The cry wolf effect and weather-related decision making. *Risk Anal.* **35**, 385–395 (2015).
57. Trainor, J. E., Nagele, D., Philips, B. & Scott, B. Tornadoes, social science, and the false alarm effect. *Weather Clim. Soc.* **7**, 333–352 (2015).
58. Meadows, D. *Leverage Points: Places to Intervene in a System* (Sustainability Institute, 1999).
59. Lempert, R. J. et al. The use of decision making under deep uncertainty in the IPCC. *Front. Clim.* **6**, 1380054 (2024).
60. IPCC: Summary for Policymakers. In *Climate Change 2021: The Physical Science Basis* (eds Masson-Delmotte, V. et al.) 3–32 (Cambridge Univ. Press, 2021).
61. Shepherd, T. G. et al. Storylines: an alternative approach to representing uncertainty in physical aspects of climate change. *Climatic Change* **151**, 555–571 (2018).
62. Kopp, R. E. et al. in *Climate Science Special Report: Fourth National Climate Assessment* Vol. 1 (eds Wuebbles, D. J. et al.) 411–429 (US Global Change Research Program, 2017).
63. Wood, R. A. et al. A climate science toolkit for high impact-low likelihood climate risks. *Earths Future* **11**, e2022EF003369 (2023).
64. Cissé, G. et al. in *Climate Change 2022: Impacts, Adaptation, and Vulnerability* (eds Pörtner, H.-O. et al.) 1041–1170 (IPCC, Cambridge Univ. Press, 2022).
65. Stadelmann-Steffen, I., Eder, C., Harring, N., Spilker, G. & Katsanidou, A. A framework for social tipping in climate change mitigation: what we can learn about social tipping dynamics from the chlorofluorocarbons phase-out. *Energy Res. Soc. Sci.* **82**, 102307 (2021).
66. Gaupp, F., Constantino, S. & Pereira, L. The role of agency in social tipping processes. *EGUsphere* https://doi.org/10.5194/egusphere-2023-1533 (2023).
67. Graham, S. et al. An interdisciplinary framework for navigating social–climatic tipping points. *People Nat.* **5**, 1445–1456 (2023).
68. Tàbara, J. D., Lieu, J., Zaman, R., Ismail, C. & Takama, T. On the discovery and enactment of positive socio-ecological tipping points: insights from energy systems interventions in Bangladesh and Indonesia. *Sustain. Sci.* **17**, 565–571 (2022).
69. Barrett, S. & Dannenberg, A. Sensitivity of collective action to uncertainty about climate tipping points. *Nat. Clim. Change* **4**, 36–39 (2014).
70. Kopp, R. E. et al. Communicating future sea-level rise uncertainty and ambiguity to assessment users. *Nat. Clim. Change* **13**, 648–660 (2023).
71. Stammer, D. et al. Framework for high-end estimates of sea level rise for stakeholder applications. *Earths Future* **7**, 923–938 (2019).
72. van de Wal, R. S. W. et al. A high-end estimate of sea level rise for practitioners. *Earths Future* **10**, e2022EF002751 (2022).
73. Condie, S. A. et al. Large-scale interventions may delay decline of the Great Barrier Reef. *R. Soc. Open Sci.* **8**, 201296 (2021).
74. Bickel, J. E. Climate engineering and climate tipping-point scenarios. *Environ. Syst. Decis.* **33**, 152–167 (2013).
75. Helwegen, K. G., Wieners, C. E., Frank, J. E. & Dijkstra, H. A. Complementing CO_2 emission reduction by solar radiation management might strongly enhance future welfare. *Earth Syst. Dyn.* **10**, 453–472 (2019).
76. Heutel, G., Moreno-Cruz, J. & Shayegh, S. Climate tipping points and solar geoengineering. *J. Econ. Behav. Organ.* **132**, 19–45 (2016).
77. Keefer, B., Wolovick, M. & Moore, J. C. Feasibility of ice sheet conservation using seabed anchored curtains. *PNAS Nexus* **2**, pgad053 (2023).
78. Wolovick, M. J. & Moore, J. C. Stopping the flood: could we use targeted geoengineering to mitigate sea level rise? *Cryosphere* **12**, 2955–2967 (2018).
79. New, M. et al. in *Climate Change 2022: Impacts, Adaptation, And Vulnerability* (eds Pörtner, H.-O. et al.) 2539–2654 (IPCC, Cambridge Univ. Press, 2022).
80. IPCC *Special Report on Global Warming of 1.5 °C* (eds Masson-Delmotte, V. et al.) (Cambridge Univ. Press, 2018).
81. Baumol, W. J. On taxation and the control of externalities. *Am. Econ. Rev.* **62**, 307–322 (1972).
82. Asayama, S., Bellamy, R., Geden, O., Pearce, W. & Hulme, M. Why setting a climate deadline is dangerous. *Nat. Clim. Change* **9**, 570–572 (2019).
83. Moser, S. C. The work after 'It's too late' (to prevent dangerous climate change). *Wiley Interdiscip. Rev. Clim. Change* **11**, e606 (2020).
84. van Nes, E. H. et al. What do you mean, 'tipping point'? *Trends Ecol. Evol.* **31**, 902–904 (2016).
85. van Ginkel, K. C. H. et al. Climate change induced socio-economic tipping points: review and stakeholder consultation for policy relevant research. *Environ. Res. Lett.* **15**, 023001 (2020).
86. Martin, H. A. et al. Climate-induced economic damages can lead to private-debt tipping points. Preprint at *HAL Open Science* https://hal.science/hal-04224077 (2024).
87. McLeman, R. Thresholds in climate migration. *Popul. Environ.* **39**, 319–338 (2018).
88. Spadaro, P. A. Climate change, environmental terrorism, eco-terrorism and emerging threats. *J. Strateg. Secur.* **13**, 58–80 (2020).
89. Lenton, T. M. et al. Operationalising positive tipping points towards global sustainability. *Glob. Sustain.* **5**, e1 (2022).
90. Fesenfeld, L. P., Schmid, N., Finger, R., Mathys, A. & Schmidt, T. S. The politics of enabling tipping points for sustainable development. *One Earth* **5**, 1100–1108 (2022).
91. Moser, S. C. & Dilling, L. in *Creating a Climate for Change: Communicating Climate Change and Facilitating Social Change* (eds Moser, S. C. & Dilling, L.) 491–516 (Cambridge Univ. Press, 2007).
92. Otto, I. M. et al. Social tipping dynamics for stabilizing Earth's climate by 2050. *Proc. Natl Acad. Sci. USA* **117**, 2354–2365 (2020).
93. Kwadijk, J. C. et al. Using adaptation tipping points to prepare for climate change and sea level rise: a case study in the Netherlands. *Wiley Interdiscip. Rev. Clim. Change* **1**, 729–740 (2010).
94. Haasnoot, M., Kwakkel, J. H., Walker, W. E. & ter Maat, J. Dynamic adaptive policy pathways: a method for crafting robust decisions for a deeply uncertain world. *Glob. Environ. Change* **23**, 485–498 (2013).
95. van Ginkel, K. C. H., Haasnoot, M. & Wouter Botzen, W. J. A stepwise approach for identifying climate change induced socio-economic tipping points. *Clim. Risk Manag.* **37**, 100445 (2022).
96. Hansen, J. E. Direct testimony in Re: Interstate Power and Light Company Docket No. GCU-07 (Iowa Utilities Board, 2007); https://www.columbia.edu/~jeh1/2007/IowaCoal_20071105.pdf
97. Reaching a tipping point. *Nature* **441**, 785 (2006).

Acknowledgements

R.E.K., E.A.G. and M.O. were supported by US National Science Foundation award number 2103754, as part of the Megalopolitan Coastal Transformation Hub (MACH). This is MACH contribution number 41. R.L.S. was supported by US National Science Foundation award number 2334276. D.N.S. acknowledges the Bristol Next Generation Visiting Researcher Programme. C.A. acknowledges the contribution of support from the Swiss Agency for Development and

Cooperation (project number 7F-10240.01.01). The views expressed herein are those of the authors, and do not necessarily reflect the views of their institutions or funders.

Author contributions

R.E.K., E.A.G. and R.L.S. conceptualized the Perspective. All authors contributed to writing and refining the text.

Competing interests

The authors declare no competing interests.

Additional information

Supplementary information The online version contains supplementary material available at https://doi.org/10.1038/s41558-024-02196-8.

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Peer review information *Nature Climate Change* thanks the anonymous reviewers for their contribution to the peer review of this work.