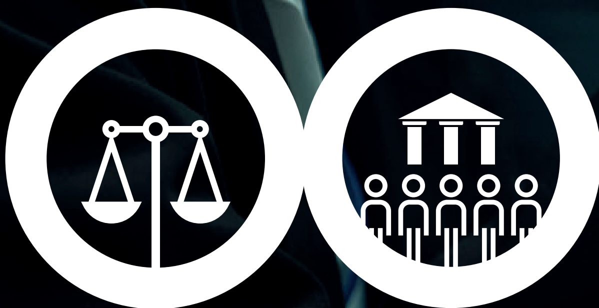
SECTION 1

GOVERNANCE OF EARTH SYSTEM TIPPING POINTS



Section lead authors:
Manjana Milkoreit, Simon Willcock

1.1 Acting on Earth system tipping points: Why and how?

Authors: Manjana Milkoreit, Yulia Yamineva, Sara Constantino, Ahjond Garmestani, Lauren Gifford, Ben Hudson, Margot Hurlbert, Rakhyun E. Kim, Malcolm Rogge, JB Ruhl, Jürgen Scheffran, Niko Soininen, Sebastian Villasante, Simon Willcock

Reviewers: Maja Groff, Louis Kotzé, Saara Leppänen, Jessica Seddon

Key Messages

- **With global warming soon overshooting 1.5°C, developing and implementing effective governance strategies to prevent Earth system tipping points is increasingly urgent and important.**
- **Earth system tipping processes present distinct governance challenges compared to conventional climate change or environmental decline, requiring both governance innovations and reforms of existing institutions.**
- **Precaution, anticipatory governance and systemic risk governance are key approaches for addressing Earth system tipping points.**
- **Amid deepening geopolitical fragmentation and weakening multilateralism, governance responses to Earth system tipping points must focus on fostering a flexible, multi-scale agenda capable of advancing under increasingly challenging political conditions.**

Humanity is now confronting a planetary challenge of unprecedented scale: the stability of the Earth system itself is at risk. Rising human pressures are pushing the Earth towards potential tipping points that could irreversibly shift large Earth system components into far less hospitable conditions for humanity and non-human life. These tipping processes unfold across vast scales of time and space, yet they can be triggered suddenly and some very soon. Their implications for human wellbeing and social stability cannot be overstated, but they are hard to imagine.

Attention to Earth system tipping points (ESTPs) has grown among international organisations, policymakers and publics since the publication of the first Global Tipping Points Report in 2023. However, this increased attention has yet to generate the governance responses–measures, actions and routines across international, national and sub-national systems – necessary to address the specific and severe risks of tipping processes.

Given that up to five tipping points could be crossed at global temperature increases between 1.5°C and 2°C, the prospect of temperature overshoot - warming above 1.5°C - by 2030 raises the stakes for and underlines the urgency of tipping point governance (Milkoreit et al., 2024), especially the need to devise effective prevention strategies (Möller et al., 2024; Wunderling et al., 2022). Governments might assume that simply accelerating their existing efforts to mitigate climate change and biodiversity loss suffice to address tipping point risks, but they do not. **Current approaches must shift fundamentally in quality, speed and magnitude** to minimize the risks of crossing tipping points. Furthermore, a new governance paradigm will be essential to address the impacts of crossing tipping points (Biesbroek et al., 2025; Kim, 2022; Ruhl and Ruhl, 2022).

In this report, we present an updated assessment of the governance implications of ESTPs - needs, options and approaches - considering the latest science on tipping risks and expected impacts (see Section 2) and global political developments over the last two years.

We include insights on the current state of ESTP governance efforts around the world based on research (interviews and text analyses) we conducted across ten countries in 2024/25. We present these findings as a set of case-analytic boxes throughout the section distinguished by background shading and marked with the headline Research Insight: State of Governance.

We also deepen the application of our assessment to specific tipping systems, especially the warm-water coral reefs, the Atlantic Meridional Overturning Circulation (AMOC)/Subpolar Gyre (SPG) ocean currents and the Amazon rainforest.

We define tipping point governance as “the rules, regulations, norms and institutions that structure and guide collective behaviour and actions” related to tipping points (GTPR 2023, Chapter 3.1.) and refer to the concrete governance systems across various levels (especially the international) and various actors, including the private sector and civil society, which address the specific risks of Earth system tipping processes.

1.1.1 Differences between governing climate change and tipping points

Tipping processes transcend familiar categories of risk management and governance, demanding new holistic thinking, systemic approaches and coordinated action at the level of the Earth system.

Earth system governance and Earth system law (Kotzé and Kim, 2019) take this broader perspective, recognizing the planet as a complex, interconnected system prone to surprising and non-linear dynamics (Biermann, 2014; Pattberg and Zelli, 2016). Yet most climate policies and laws continue to assume a predictable, linear process - treating climate change as incremental and reversible (see Chapter 2.4). This overlooks the risks of unintended consequences, accelerating changes and the irreversibility of crossing thresholds.

It also downplays the interconnected nature of various climate and social subsystems and the corresponding need for integrated, cross-domain (e.g. climate, biodiversity, human rights) and transboundary approaches. Addressing these characteristics of tipping processes requires governance approaches that differ, in some cases fundamentally, from existing policies and institutions, which were not designed with Earth system dynamics in mind.

We define a tipping point as occurring when changes in a system become self-perpetuating and difficult to reverse beyond a threshold, leading to substantial, widespread impacts (Armstrong McKay, 2024; Armstrong McKay et al., 2022; Milkoreit et al., 2018). ESTPs refer to such changes in large components of the Earth system, including major ice sheets (the cryosphere), biomes such as coral reefs or forests (the biosphere), ocean currents (the hydrosphere) or monsoons (the atmosphere). They could be catastrophic, for example, resulting in the global-scale loss of capacity to grow major staple crops. Crossing one ESTP can also contribute to triggering another, causing a cascade of accelerating and compounding damage (Wunderling et al., 2024). The characteristics and impacts of such tipping processes are fundamentally different from the ways climate change and other environmental challenges are currently understood. Table 1.1.1 identifies and describes these differences.

Table 1.1.1: Differences between conventional climate change governance and governance for ESTPs

CHARACTERISTIC	DIFFERENCE TO CLIMATE CHANGE	GOVERNANCE IMPLICATIONS
THRESHOLDS = MOMENTS OF COMMITMENT & IRREVERSIBILITY	Once a tipping point is crossed for a certain amount of time, the system is committed to irreversible changes with long-term consequences, regardless of mitigation success (ability to return from temperature overshoot).	• It is imperative to prevent tipping to avoid irreversible changes. Near-term action (or lack thereof) can have long-term consequences. • Measures should be proactive, based on heightened application of the precautionary principle. • The single most important prevention measure is a rapid phase-out of greenhouse gas emissions, methane in particular. Some tipping elements are also affected by more local actions (e.g. deforestation, pollution). • Since prevention success is not guaranteed, impact governance needs to include strategies for anticipating and preparing for 'locked-in' impacts over the long term.
ACCELERATION OF CHANGE	After a tipping point is crossed, the pace of change accelerates due to self-amplifying feedback dynamics. This acceleration can overwhelm adaptation efforts and outpace response capacities (Laybourn et al., 2023).	• Since prevention is not guaranteed, adaptive and transformative capacity building is needed to deal with potentially faster changes after a tipping point. • Proactive measures to increase institutional capacity and resilience are needed before tipping points are crossed. • Governments risk overload, e.g. having to expend significant resources on adaptation and disaster response, undermining mitigation and transition efforts ('derailment risk').
INCREASED MAGNITUDE OF IMPACTS	Crossing tipping points can substantially amplify the severity of climate change impacts, (e.g. massive ice sheet melts causing significant additional sea-level rise).	• Conduct and revise risk and vulnerability assessments that include ESTPs. • Revisit adaptation plans, preparedness strategies and emergency planning to address additional impacts. • There is increased potential for reaching limits of adaptation and experiencing loss and damage. • Increased emphasis on transformative adaptation (e.g. planned relocation).
TREND REVERSALS	The impacts of some tipping processes would reverse the current and expected direction of change in a region (e.g. cooling rather than warming in Northern Europe) (van Westen and Baatsen, 2025).	• Current adaptation plans and preparedness strategies need to be revisited to devise robust approaches that would be effective across multiple possible future trajectories. • Investments in capacity building regarding future thinking and methods (e.g. scenario development) would strengthen public organisations' ability to manage increased uncertainty. • Increased reliance on general resilience principles (e.g. response diversity, reflexivity and continuous learning, ability to rapidly respond to unexpected developments). • There is an immediate need for strategic public communication about the potential of trend reversals due to tipping points.
DIFFERENT DISTRIBUTION OF IMPACTS	The geographic distribution of the impacts of tipping processes differs to some extent from the currently expected impacts of climate change, creating distinct tipping vulnerabilities. This includes additional pressures on already vulnerable regions and peoples, but also significant novel vulnerabilities in the Global North (Thienen et al., 2025).	• New vulnerabilities could change national interests to act and reshape global geopolitical dynamics related to climate change. • Tipping point impact, exposure and vulnerability need to be mapped, revising assessments of climate vulnerability. • Need for the allocation of resources to resilience building, adaptation and loss and damage through national and international funding mechanisms. • New vulnerability distributions should shape the application of equity and justice principles (e.g. allocation of resources and support).
NOVEL IMPACTS	Uncertainty about tipping points implies unforeseen and potentially unprecedented impacts due to complex system dynamics and limited knowledge of long-term Earth system disruptions (Walker et al., 2023).	• Lack of knowledge demands robust monitoring and research to improve predictability while acknowledging that full scientific certainty about some elements is often not attainable. • Flexible and adaptive governance systems are needed that can respond to unforeseen risks and surprises. This includes response diversity – the availability of multiple options in case of failure or unexpected impacts.
CASCADE EFFECTS	Tipping elements are interconnected; crossing one tipping point can trigger others, potentially at lower thresholds than anticipated (Wunderling et al., 2024).	• Risk assessments and prevention strategies need to include (anticipate and consider) cascading potential (systemic risk). • Coordination and policy coherence across sectors and regions is vital to prevent cascading failures. • Actors need to develop measures to halt or slow cascades (e.g. active decoupling of systems).

A critical difference between ESTPs and incremental climate change lies in the **heightened uncertainty** regarding tipping dynamics, especially the location of the tipping point (in time, temperature trajectory or other metrics). For example, uncertainty about the threshold conditions for the collapse of the AMOC is combined with the potential for severe and far-reaching global consequences (Bellomo et al., 2021; Ben-Yami et al., 2024; Jackson et al., 2015; Zhang et al., 2019). Governance systems must grapple with this dual challenge: the irresponsibility of ignoring high-impact risks and the difficulty of acting effectively when the timing, likelihood and specific impacts of these events remain uncertain. For instance, northern Europe could either continue its current trajectory of warming and wetting or face a dramatic drop in temperature and drying within decades (van Westen and Baatsen, 2025). This creates a changing rationale for rapid climate mitigation efforts and profound challenges for adaptation planning, which must now contend with a broader and more divergent spectrum of possible futures and greater uncertainty about these futures.

Because tipping points involve the risk of irreversible changes with severe impacts at large scales, **uncertainty about their timing or thresholds strengthens** - rather than weakens - **the case for precautionary action**. To safeguard societies against these uncertainties, governance must shift toward flexible and anticipatory approaches that build resilience across multiple scenarios and adopt no-regrets policy options that are beneficial regardless of the climate trajectory. This includes new forms and tools of knowledge co-production between science, other forms of knowledge and policy (Wood et al., 2023), establishing monitoring and early warning systems and fostering anticipatory, cooperative multi-stakeholder governance to prepare for surprises.

Effectively responding to these challenges demands a distinct governance agenda for ESTPs, including a rethinking of governance objectives and logics, reforming and in some cases developing new approaches (norms, policies, laws, mechanisms and institutions) and engaging or creating new stakeholders.

1.1.2 Objectives, principles and logics for action

The primary objective of ESTP governance is to prevent the Earth system from crossing tipping points. The action window for prevention is likely very short for several tipping elements, although some of these tipping processes would unfold over multiple decades or even millennia. By creating causal connections between near-term actions and long-term, large-scale changes in tightly connected Earth-human systems, tipping points place a significant burden of responsibility for prevention on today's governance system.

Box 1.1.1: Prioritising the prevention of Earth system tipping points

Preventing the crossing of ESTPs is unlikely with existing measures for climate change mitigation. It requires

- Keeping the **peak global temperature** as close to 1.5°C as possible, i.e. minimising the height of temperature overshoot. Every additional 0.1°C increases the risk of transgressing ESTPs.
- Keeping the **duration of temperature overshoot** above 1.5°C as short as possible (every year counts) and returning global average temperatures to below 1.5°C.
- Minimising temperature overshoot requires (1) **frontloaded mitigation pathways** with the heaviest cuts this and next decade and (2) immediate development and **scaling of sustainable carbon removal capacities.**
- **Addressing non-climate drivers of tipping**, such as deforestation (e.g. Amazon rainforest) and pollution (e.g. warm-water coral reefs).

At the same time, it is important to anticipate, prepare for and navigate the change process to maximally protect communities, societies and ecosystems in harm's way in the event a tipping point is not avoided. Prevention and impact governance are the first and second line of defence against ESTPs. Each of the following two chapters is dedicated to one of these governance domains (Chapter 1.2 to prevention, Chapter 1.3 to impact governance).

The framework depicted in Figure 1.1.1 can guide the development of governance responses to ESTPs (Milkoreit et al., 2024). Reflecting an unfolding tipping process, the framework distinguishes three phases: **Pre-Tipping, Reorganisation, Stabilisation**. In each phase, different governance objectives, logics, activities and actors are dominant.

Prevention is the core focus of the pre-tipping phase and aims to avoid crossing tipping points through precautionary action, especially accelerated GHG emissions reduction, but also measures to address other tipping drivers, such as deforestation (see Chapter 1.2). Adaptation planning, impact anticipation and preparedness are also tasks in phase 1. Once a tipping point is crossed, the tipping element enters a reorganization process that can last from years to millennia (phase 2).

The focus of governance for this specific tipping element shifts to addressing the impacts of the reorganization process, managing potentially rapid change, maintaining and fostering resilience, minimizing harm and tending to losses (Chapter 1.3). This phase requires swift impact responses, crisis management and adaptation strategies to navigate system transformation. Decision-making must balance immediate governance needs (e.g. responding to extreme events, managing migration, adapting health care provision) with long-term stability. While prevention efforts are only meaningful in the pre-tipping phase for a specific tipping element, impact governance evolves across all three phases of the tipping process, shifting from anticipation to response to resilience-building. The third phase (stabilization) focuses on fostering societal sustainability and resilience within the new climatic-ecological conditions of the alternative state of the tipping element, which is likely less hospitable than current pre-tipping conditions.

Different tipping elements can be in different (governance) phases at any given moment in time. For example, while the warm-water coral reef system might be in the reorganization phase in 2030, the Amazon rainforest and the AMOC might still be in the pre-tipping phase. Impact governance for one and prevention efforts for the others would have to occur in parallel.

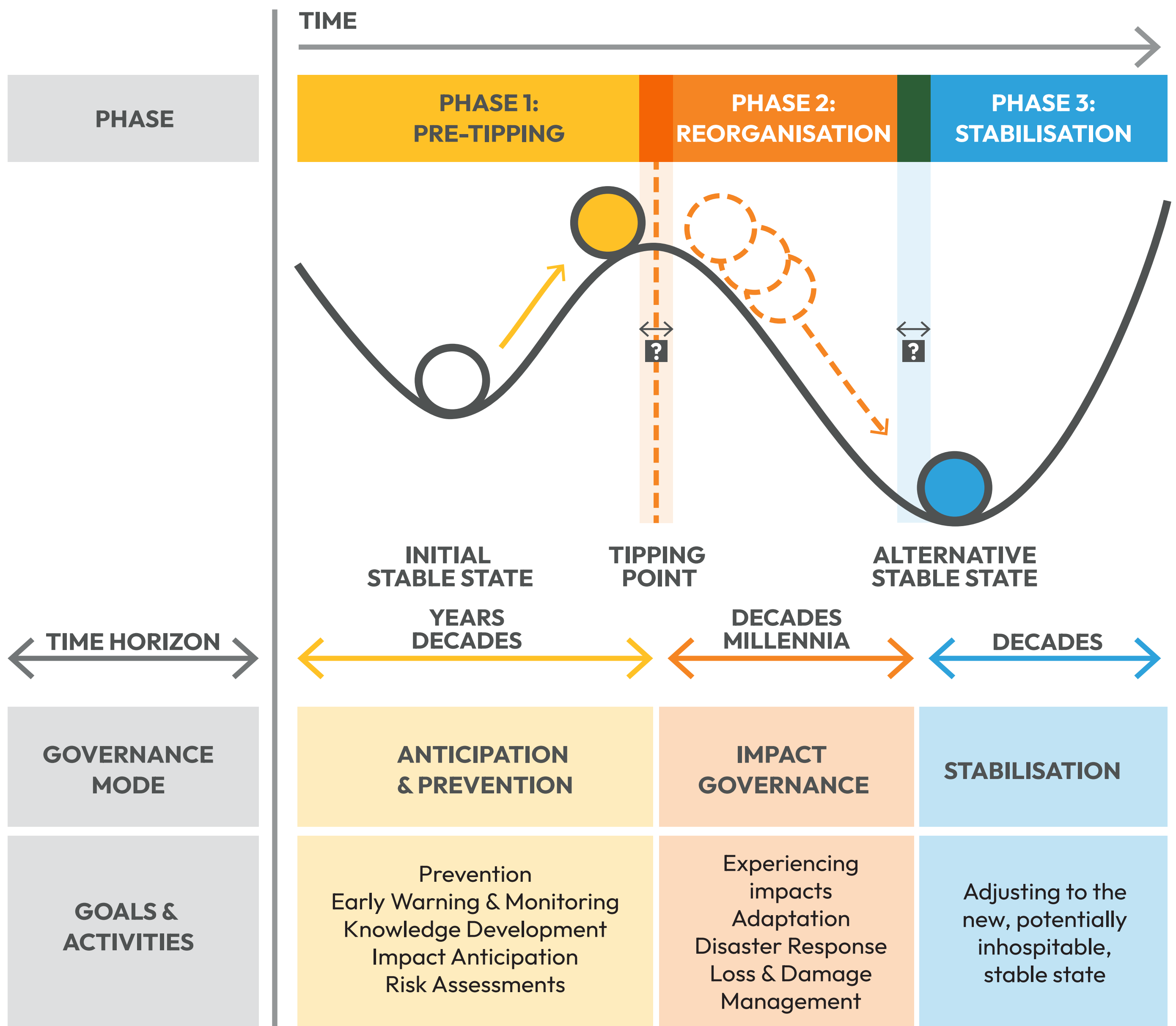


Figure 1.1.1: Three-phase framework for governance of ESTPs

Reprint of Milkoreit et al. 2024: The figure distinguishes three phases of tipping processes (pre-tipping, reorganisation and stabilization). Each phase presents distinct governance challenges and has a corresponding dominant logic (e.g. anticipation and prevention in the pre-tipping phase), specific goals and activities.

Across all phases, **knowledge and learning** play a central role in informing decision-making. Science and other knowledge actors assume key responsibilities for fostering recognition and understanding of nonlinear Earth system dynamics and the risks they present. These actors continuously generate and update the knowledge base without which effective governance responses cannot be devised. Science-policy interactions serve as the bridge that links emerging insights to legitimate and coordinated action.

The framework focuses on each tipping element independently and does not account for cascading tipping effects between systems, e.g. the fact that one tipping process can influence the likelihood and prevention requirements of another. Governance approaches must also be tailored to different tipping systems, as their timelines and intervention needs vary.

Effectively addressing ESTPs requires a specific set of **principles and approaches**. These were discussed in more detail in GTPR 2023, including examples (see Chapter 3.1 GTPR 2023) and are summarised in Table 1.1.2.

Table 1.1.2: Principles and approaches for ESTP governance

Principle/Approach	Definition
Adaptive Governance	Governance that integrates continuous learning, system monitoring and flexible policy adjustments. Recognizes the complexity of human-nature systems and the need for iterative, science-informed decision-making.
Anticipatory Governance	A proactive, forward looking approach using futures capacities and methods (e.g. scenario development) to guide decisions and strategies. Needs to address power imbalances, injustices and expand possibility thinking.
Deep Cooperation	Addressing ESTPs demands strong international, regional and sectoral collaboration. Tipping points may provoke short-term, competitive responses (e.g. resource grabbing, nationalism), which must be countered with sustained global cooperation efforts.
Justice, Equity, Human Rights & Future Care	Fair distribution of responsibilities, harms and benefits within and between nations, peoples, species and generations. This includes Earth system justice (intragenerational, intergenerational, interspecies justice) and common but differentiated responsibilities and capabilities. This demands equitable resource allocation, procedural justice and recognition of affected communities, eco- and Earth systems and institutions dedicated to safeguarding future and non-human interests, all aligned with human rights.
Multi-level Governance & Polycentricity	System of decision-making in which authority and policy responsibilities are distributed across multiple levels of government—local, regional, national and international—with full and effective participation of human rights holders and respect of human rights. Emphasizes collaboration, coordination and power-sharing to address complex challenges that transcend administrative boundaries.
Response Diversity	The presence of multiple governance measures that respond differently to a specific challenge. Response diversity creates redundancy, which incurs costs but prevents systemic failure. Needs coordinated multi-level approaches.
Systemic Risk Governance	Framework for identifying, assessing and managing risks that can trigger disruptions across interconnected systems, such as financial markets, critical infrastructure, or ecosystems. Emphasizes adaptive, multi-stakeholder approaches to enhance resilience, prevent cascading failures and ensure stability in the face of complex and uncertain threats. Apply synergistically climate law, ocean law, biodiversity law and human rights law as a legal basis for systemic risk governance.
Uncertainty & Precaution	Governance of ESTPs must navigate scientific and political uncertainties, including unknown tipping-point and impact timelines. The precautionary principle calls for preventive action despite incomplete knowledge.

Here, we highlight two principles that are particularly relevant in the pre-tipping, vital ***preventative phase*** (see Figure 1.1.1) with a view to the impending global temperature overshoot.

Anticipatory Governance embraces a stronger future orientation through disciplined engagement with possible futures. It takes seriously the deep uncertainties of ESTPs and marks a shift away from likelihood to risk severity as the primary driver for action. It utilizes diverse methods of collective future engagement, such as participatory scenario development or serious gaming, to generate and inform proactive measures. Governance time horizons are expanded beyond political cycles, with decisions that are made with long-term impact horizons. This multi-temporality involves assessing and acting upon intra- and inter-generational impacts and necessitates expanding governance actors to include younger and future generations.

Systemic Risk Governance encompasses those risks that have the potential to compound and cascade within and between different systems (such as climate, food, water, health, finance, social cohesion, technologies, etc.). The resulting crises feed into each other, increasing their severity and/or likelihood and risk escalating into potentially catastrophic harms to human societies and ecosystems. Chapter 2.4 sets out a framing of systemic risk in the context of ESTPs. This includes their direct consequences on the biophysical environment (e.g. agriculture, buildings, infrastructure), as well as the subsequent cascading consequences (e.g. financial crises, mortality, trade disruption, social unrest) (IPBES, 2024).

Governing such dynamics requires a holistic, systemic approach to assessing and responding to ESTP risks. Those undertaking assessments and those designing and implementing responses must utilise an enhanced understanding of systems interconnections and risk transmission channels, develop policies and responses that can address multiple risks simultaneously, particularly at the most fragile points of systems and their interconnections and envision pathways to transformation away from risky system conditions.

ESTP governance also must contend with tipping dynamics in social systems. It is useful to distinguish between two kinds of social tipping points, each having very different implications for ESTP response. Positive tipping points (see Section 3) involve self-amplifying feedback dynamics that drive social systems (e.g. economic sectors, consumer behaviour or social norms) towards a desirable state (Tàbara et al., 2018; Winkelmann et al., 2022). Such deliberate dynamics in social systems could potentially be leveraged for ESTP prevention efforts (Chapter 1.2) and potentially adaptation and resilience building (Chapter 1.3). The second type of social tipping dynamics concerns negative social tipping points, where self-amplifying feedbacks after a threshold drive undesirable social change, e.g. political polarization, social unrest and conflict. This type of tipping creates additional challenges for the domain of impact governance (Chapter 1.3).

1.1.3 Current context: Science and global governance reforms in times of a weakening global order

2024 was the first calendar year with average global temperatures exceeding 1.5°C above pre-industrial levels (Bevacqua et al., 2025). Critical carbon sinks, such as the Arctic tundra and Northern boreal forests, are now shifting to become carbon sources, amplifying global warming (Kelly et al., 2024; Migliavacca et al., 2025; Pan, 2024). Additionally, unusual ocean heat extremes—still not fully understood by scientists—signal nonlinear response in Earth's systems and recent observations put in question the previously assumed linearity of temperature changes (Hansen et al., 2025). These developments signal declining system resilience and suggest that the world is entering a more turbulent and unpredictable climatic era, in which the decline of natural systems could accelerate with severe implications for human wellbeing (McElwee et al., 2025).

Amid a steady longer-term decline in global environmental diplomacy, 2024 and 2025 saw some developments in global governance aimed at addressing the long-term risks of planetary change. The UN Summit of the Future in September 2024 adopted the Declaration on Future Generations and commitments to foster governance across all scales that is more future-oriented and intergenerational. The UN Secretary-General announced plans to establish a UN Envoy for Future Generations and the European Commission included intergenerational fairness in its policy portfolio, further institutionalizing intergenerational relations. Climate litigation was on the rise and several international courts and tribunals provided advisory opinions on the legal obligations of states related to climate change: the International Court of Justice (ICJ AO 2025), the Inter-American Court of Human Rights (IACHR AO 32/25) and the International Tribunal on the Law of the Sea (ITLOS AO 31/2024). At the same time, effective mechanisms for enforcing state obligations are lacking in international law.

Recent global political trends, especially a rise of right-wing, nationalist, anti-science and protectionist governments in many parts of the world have weakened the potential for multilateral cooperation on both climate change and tipping processes, as major powers prioritize sovereignty and national gain over collective action. Geopolitical fractures and realignments further erode consensus, potentially compromising multilateral, cooperative institution building. Conflicts divert attention and resources away from climate action, while domestic political agendas reduce public, governmental and private sector support for environmental policies. In this landscape, where major actors fail to identify and act on their shared interests, global governance efforts to address ESTPs may face serious constraints, emphasising the importance of subnational and non-state actors and ad hoc coalitions. Smaller scale, minilateral initiatives (e.g. the G7) have been and may remain feasible under current conditions and can provide a platform for expanding to larger scale agreements (O'Brien et al., 2025).

1.1.4 Deep dives: Four tipping-point case studies

Throughout this report, three key tipping systems - the Amazon rainforest, the world's warm-water coral reefs, the Atlantic Meridional Overturning Circulation (AMOC) coupled with the Subpolar Gyre (SPG) and mountain glaciers - serve as case studies to deepen understanding and promote practical relevance of the Report. We briefly introduce these four cases here, highlighting the comparative insights they provide specifically for ESTP governance. Section 4 includes a dedicated case study chapter for each of them and Section 2 provides more details on the tipping dynamics, risks and impacts of these and other identified tipping elements in the Earth system.

Collapse of the Atlantic Meridional Ocean current (AOC) and Subpolar Gyre (SPG): The AMOC is a critical system of ocean currents in the Atlantic Ocean, extending from the tropics to the North Atlantic. It plays a vital role in regulating global climate by transporting warm surface water northward and cold deep water southward. In its stable state, the AMOC maintains relatively mild climates in Europe and influences weather patterns worldwide. This circulation could weaken or collapse, leading to profound environmental changes—such as significant North Atlantic cooling, altered precipitation patterns, a shift of the tropical rain belt affecting the Amazon rainforest and disruptions to Monsoons in West Africa and Asia—which would have wide-ranging human and social impacts. These include threats to food security from reduced agricultural productivity and fisheries collapse, heightened risks to water availability and economic losses from damaged infrastructure, disrupted trade and energy system instability.

Closely related to the AMOC is the formation of deep water in the Subpolar Gyre (SPG), a large system of rotating currents in the northern North Atlantic. While smaller in scale, a collapse of deep-water formation in the SPG would have similar—though more geographically concentrated—consequences, particularly for European and North Atlantic climates. Impacts could include regional cooling, changes in storm tracks and disruptions to marine ecosystems with consequences for agriculture and food security, fisheries, infrastructure and public health.

The AMOC and SPG are closely interconnected. A collapse of SPG deep convection would leave only deep convection in the Greenland-Iceland-Norwegian Seas driving the AMOC and a weakening of the gyre would affect the density and flow of waters that drive overturning circulation. This interdependence underscores the importance of viewing these tipping elements not in isolation but as part of a tightly coupled Earth system, where regional changes can cascade into global consequences.

Dieback of the Amazon rainforest: The Amazon rainforest plays a vital role in regulating the Earth's climate by storing carbon, recycling moisture through evapotranspiration and generating rainfall that sustains ecosystems across South America. If deforestation and climate-change induced drought push the Amazon beyond a tipping point, large parts of the rainforest could shift irreversibly to a savanna-like state. Such dieback would release massive amounts of carbon into the atmosphere, further accelerating global warming.

The consequences would extend well beyond the forest itself. Regionally, the Amazon strongly influences South America's hydrology through its role in sustaining atmospheric rivers—bands of moisture that carry rainfall across the continent. Dieback would weaken these systems, reducing water availability for major agricultural regions in Brazil, Argentina and beyond, with cascading impacts on biodiversity, food production, hydropower generation and urban water supplies. Globally, loss of the Amazon's moisture recycling could alter atmospheric circulation patterns, including shifts in tropical rainfall belts and monsoons in Africa and Asia, with implications for agriculture, desertification and water security on multiple continents.

Human and societal impacts would be profound. In South America, reduced agricultural productivity threatens rural livelihoods and national economies, while respiratory illness from forest fires and altered patterns of infectious disease would undermine public health. Globally, disruptions to South American agricultural exports such as soy, maize, beef and coffee could destabilize global food markets, increasing price volatility and food insecurity in other regions. The Amazon's unparalleled biodiversity—harbouring around 10% of known species—would face irreversible loss, undermining global ecological resilience and the future availability of genetic resources for medicine, food and adaptation. Indigenous peoples and local communities, whose cultural identities, traditions and survival are closely tied to the rainforest, would face existential threats to their ways of life. Migration would increase, as people seek out more stability in water, food and cultural systems.

Dieback of warm-water coral reefs: Tropical coral reefs are predominantly found in shallow, warm ocean waters near the equator, with significant formations in regions such as the Great Barrier Reef in Australia, the Coral Triangle in Southeast Asia and the Caribbean Sea. These vibrant ecosystems support roughly a quarter of all marine species and provide critical coastal protection and livelihoods for millions of people. In their healthy state, coral reefs sustain rich biodiversity, fisheries and tourism economies. However, rising ocean temperatures, acidification, overfishing and pollution can lead to coral bleaching and mortality. Crossing a tipping point could result in the widespread collapse of reef ecosystems, causing a dramatic loss of marine biodiversity, diminished fish stocks and weakened coastal defences against storms and erosion.

The human and societal consequences would be severe. Regionally, hundreds of millions of people across the tropics rely on coral reefs for food security, employment and coastal protection. A collapse would jeopardize fisheries that provide both protein and income, disrupt tourism economies and expose coastal communities to intensified storm damage, sea-level rise and groundwater salination. Public health could also suffer from increased malnutrition, reduced income for healthcare and trauma from more frequent disasters.

Melting of mountain glaciers: Mountain glaciers are found on every continent, from the Andes and the Rockies to the Alps, Himalayas and East Africa. In many of these regions, glaciers are critical components of their regional hydrological systems, acting as natural reservoirs that store water throughout the year, releasing it as meltwater in warmer seasons. They regulate river flows, sustain ecosystems and provide a crucial water supply buffer during dry periods. However, rising global temperatures are driving rapid glacier retreat worldwide. In many regions, glaciers are retreating and continued warming threatens the near-total disappearance of smaller glaciers within this century. Some mountain glaciers display tipping dynamics, i.e., ice loss accelerates after a threshold and is lost irreversibly.

The impacts of widespread glacier melt are far-reaching. Regionally, hundreds of millions of people in South America and Asia depend on glacier-fed rivers such as the Ganges, for drinking water, irrigation and hydropower. Accelerated melting initially increases river flows, heightening the risk of floods, glacial lake outburst events and landslides. As glaciers shrink, water availability in dry seasons declines, threatening food production, energy security and urban water supplies. Local communities, particularly Indigenous peoples and mountain cultures, face profound disruptions to livelihoods and cultural identities tied to glaciers. The decline of iconic glaciers also represents a loss of cultural and natural heritage, with implications for tourism economies and human identity.

These four systems illustrate the diversity of tipping elements in the Earth system and the broad challenges they pose. Analysing their similarities, differences and linkages provides key insights for effective governance responses. The AMOC, Amazon Rainforest and coral reefs occupy distinct geographic regions with unique ecological and climatic roles. Each case highlights who—countries, regions and communities—will be most affected by a given tipping process. Collectively, they show that tipping impacts will reach every country and person while also underscoring their uneven distribution. This highlights the need for governance approaches tailored to each system and the importance of equity and justice in ESTP governance.

These systems also differ in their timelines and uncertainties, emphasizing why temporality matters for governance. Each tipping system is subject to different levels of scientific uncertainty and varying degrees of knowledge about expected impacts. Coral-reef tipping is imminent, unfolding over 10-15 years, the Amazon could reach its tipping point well before 2050, while AMOC tipping may occur sometime between 2030 and 2100, unfolding over multiple decades. Different timelines demand different actions—for example, preparing communities for coral reef loss while accelerating emissions reductions to prevent AMOC collapse. Examined together, their temporalities underscore both the urgency of immediate action and the need for long-term strategies. Additionally, their interconnectedness means one tipping event could trigger others, amplifying global climate risks—such as AMOC disruptions altering Amazon rainfall and accelerating dieback or vice versa.

1.1.5 A Guide to Section 1

Following this introduction, the governance section of the Report contains four chapters. The following two chapters cover prevention of ESTPs and impact governance—two distinct governance domains. Chapter 1.4 explores the link between ESTP governance and human rights. The final chapter (1.5) explores actors, their agency and potential strategies to address the risks of ESTPs.

1.2 Governance to prevent Earth system tipping points

Authors: Simon Willcock, Claudia Wieners, Hugues Chenet, J.B. Ruhl, Manjana Milkoreit, Jürgen Scheffran, Yulia Yamineva, Ahjond Garmestani, Ida Edling Müller, Ashwin K Seshadri, Ajay Gambhir, Silvia Montagnani, Kirsty Tooke, Grace Ellsworth, Danielle Young, Bregje van der Bolt, Sara Constantino

Reviewers: Maja Groff, Louis Kotzé, Jessica Seddon

Key Messages

- **The risk of activating tipping processes exists at current levels of warming and increases with every 0.1°C and every year of overshooting the globally agreed goal of 1.5°C.**
- **Current climate mitigation measures are not sufficient to prevent tipping events; they need to be accelerated and coupled with measures addressing non-climate drivers, such as deforestation of the Amazon rainforest.**
- **Preventing tipping points requires 'frontloaded' mitigation pathways that minimise peak global temperature, the duration of the overshoot period above 1.5°C, and the return time below 1.5°C with immediate, comprehensive fossil-fuel phase out efforts.**
- **Sustainable carbon dioxide removal approaches need to be rapidly scaled up to help return the global mean temperature to and then below 1.5°C.**

1.2.1 The case for prevention

Given the substantial risks posed by Earth system tipping points (ESTPs; see Section 2), the Global Tipping Points Report (2023) highlighted that prevention should be the core goal and logic of a new and urgently needed global governance agenda. Up to five tipping points (in the warm-water coral reefs, Greenland Ice Sheet, West Antarctic Ice Sheet, North Atlantic Subpolar Gyre (SPG), and Permafrost) could be transgressed at the current level of warming, with a further five becoming at risk at 1.5°C (Armstrong McKay et al. 2022; Figure 1.2.1). The 1.5°C threshold will be reached within a few years (Bevacqua, Schleussner & Zscheischler, 2025), which means that the prevention window for some of these tipping processes may be closing quickly (e.g. there is consensus that the uncertainty range for the tipping point of the warm-water coral reefs has an upper bound at 2.0°C; Figure 1.2.1). The length of time it will remain open is different for each tipping system, depending on its specific drivers, especially the trajectory of global mean temperature and associated changes in regional means and variability, as well as other factors such as pollution, deforestation, and other more regional stressors (Global Tipping Points Report 2023).

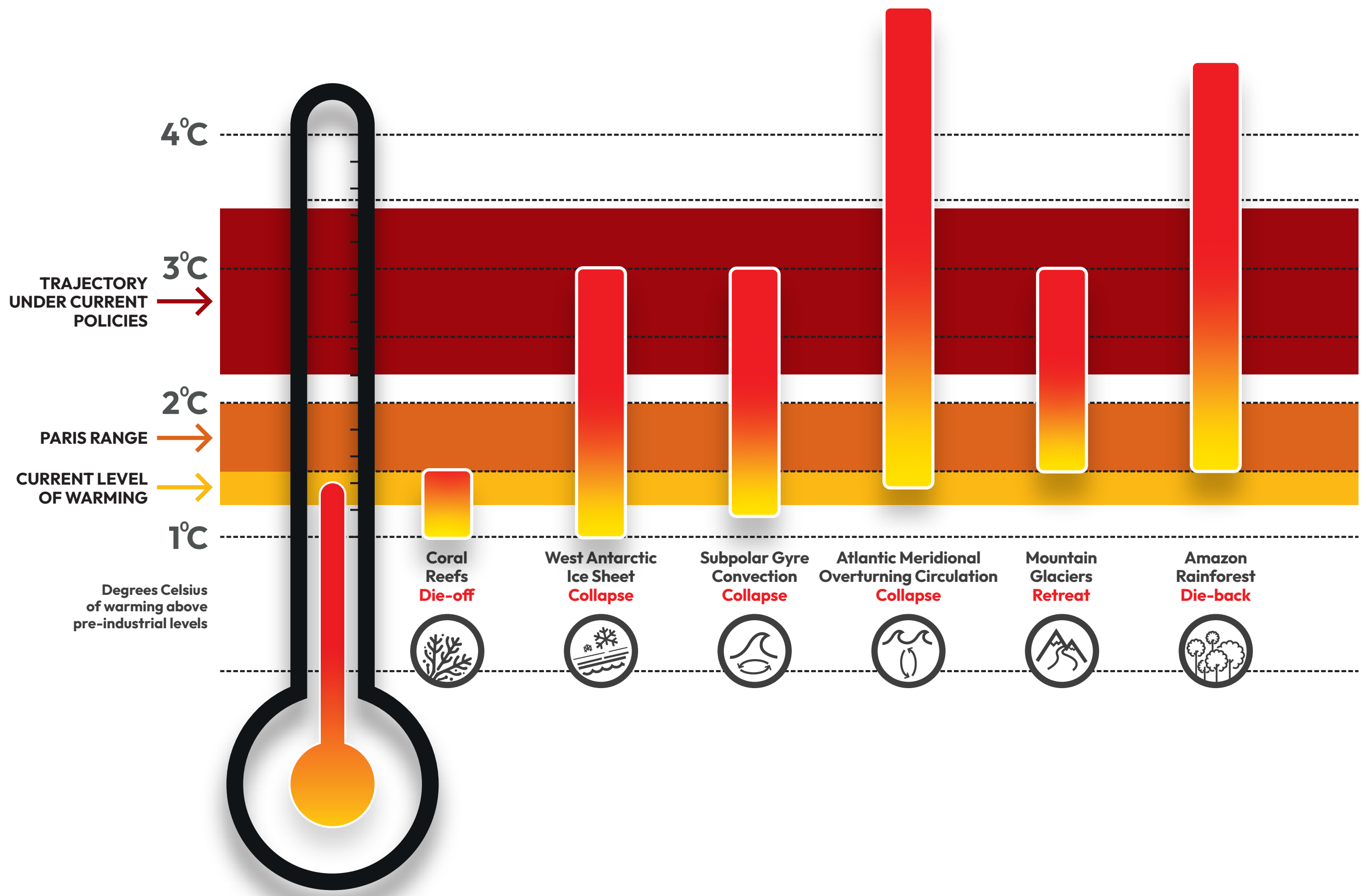


Figure 1.2.1: Risks of Earth system tipping points increase with global warming. Sources: Global Tipping Points Report 2025 and Armstrong McKay et al., 2022

When devising prevention strategies, it is useful to divide ESTPs into two groups: i) those that are predominantly climate-driven (e.g. Atlantic Meridional Overturning Circulation - AMOC collapse) and therefore are not sensitive to anything but climate mitigation as a prevention strategy, and possibly geoengineering (discussed in full below); and ii) those with a mix of climate and non-climate related drivers (e.g. Amazon rainforest dieback; Table 1.2.1; Figure 1.2.2). Both groups, but especially the latter, require coordination of efforts (e.g. goals and timelines, information flows, institutional linkages) and governance across policy domains and scales (e.g. global climate mitigation and national forest and agricultural policies). Figure 1.2.2 identifies relevant drivers for three case studies we explore throughout the report.

Table 1.2.1: Climate- vs. multi-driver (including climate) Earth system tipping elements. ESTPs can be divided into two groups: those that are nearly entirely climate-driven and are not sensitive to anything but mitigation as a prevention strategy (e.g. AMOC collapse), and those with a mix of climate- and non-climate-related drivers

ESTPs predominantly driven by climate	ESTPs driven by a mix of climate and non-climate drivers
Glacier retreat (although one driver [black carbon] is regionally generated)	Boreal forests
Ice Sheets (Greenland and East & West Antarctica)	Coral reefs
Ocean circulation (AMOC, SPG and Southern Ocean)	Dryland degradation
Permafrost thaw (except for a small contribution from vegetation change)	Lake browning
Sea ice loss (although one driver [black carbon] is regionally generated)	Mangroves
	Marine regime shifts (fisheries etc)
	Monsoon
	Savannah degradation
	Temperate forests
	Tropical forests

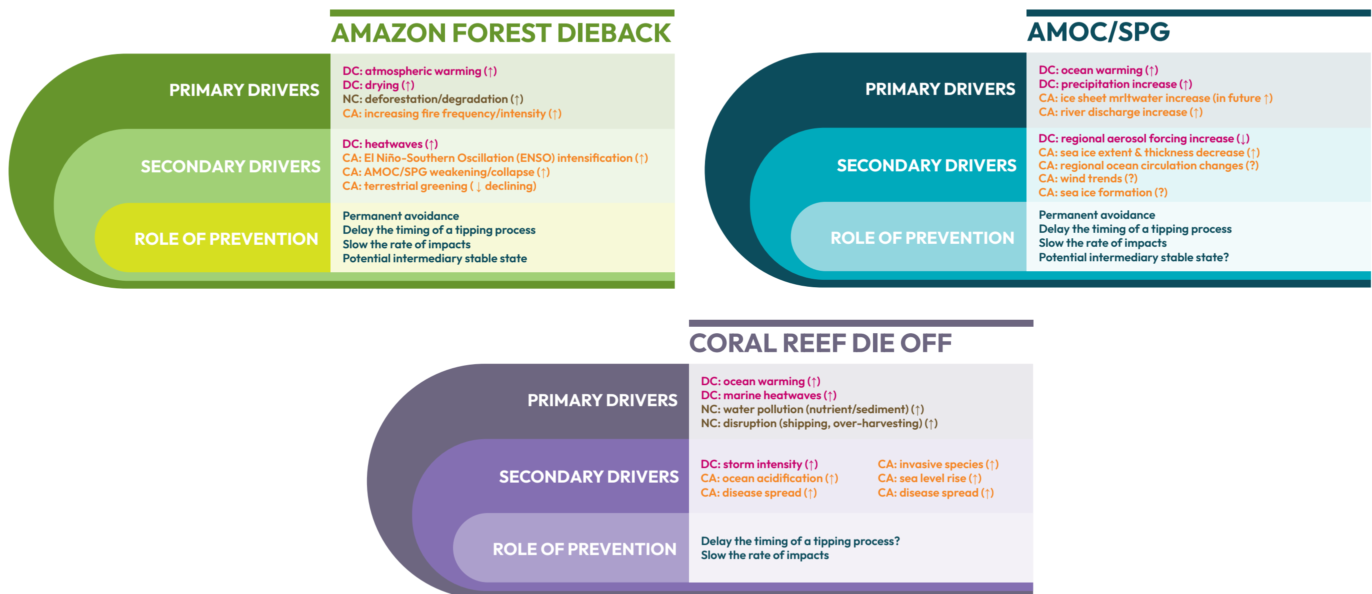


Figure 1.2.2: Multiple drivers of ESTPs. Primary (more important) and secondary (less important) drivers of the ESTPs focussed on in this report, and the role prevention can play for each. DC: Direct climate driver (direct impact of emissions on meteorological variables via radiative forcing; pink); CA: Climate-associated driver (including second-order and associated effects of climate change; orange); NC: Non-climate driver (brown). Drivers can enhance (↗) or counter (↘) tipping. Prevention efforts can have a variety of goals: complete success (permanent avoidance); delaying the timing of a tipping process – i.e. moving the time when the critical threshold is reached further into the future (e.g. beneficial for anticipatory adaptation planning); slowing the rate at which the impacts of crossing a tipping point unfold, somewhat easing the corresponding adaptation challenges; and, if a tipping system has multiple stable states, prevention efforts might fail to avoid the first tipping point, leading to significant changes until the system settles in its first alternative stable state, but might succeed in averting further tipping to the next state.

In most cases, global temperature increase is a key driver, **placing accelerated climate change mitigation at the heart of effective prevention strategies**. Entering the domain of temperature overshoot has important implications for prevention efforts (Wunderling et al., 2023; Möller et al., 2024). Tipping risk increases with every additional 0.1°C of overshoot above 1.5 °C and strongly accelerates for peak warming above 2.0°C (Möller et al. 2024; Figure 1.2.1). **Reducing the risk of tipping-point transgression requires a global collective effort to minimise both the peak temperature and the length of the overshoot period, while returning the global mean temperature to or below 1.5°C with sustainable carbon removal technologies**. As every tenth of a degree of warming increases tipping risks (Figure 1.2.1), **an immediate, inclusive, and comprehensive effort is required to phase out anthropogenic greenhouse gas emissions as quickly as possible**. Although mitigation would be required even in the absence of tipping threats, the severity and potential irreversibility of tipping points provide a strong additional reason to phase out greenhouse gas emissions swiftly and, in particular, limit temperature overshoot. As long as uncertainties remain large, a precautionary standard assumption is that every additional tenth of a degree of warming, and every additional year of temperature overshoot, increases tipping risk and should be avoided.

Global mitigation pathways should peak as close to 1.5°C as possible and return to, or even below, 1.5°C as soon as possible. This requires frontloading emission reductions, maximising efforts in the remaining 2020s and early 2030s. It also demands immediate scaling of investments in developing sustainable carbon removal capacities, which are necessary to bring the global temperature back down from its peak. Furthermore, any additional stresses experienced during the overshoot period will mean ESTPs occur sooner (Willcock et al., 2023), emphasising the importance of simultaneously managing non-climate drivers (Table 1.2.1; Figure 1.2.1).

Key factors holding back progress on climate mitigation (including, for example, power, financial interests, political economy and obstruction) are well understood and discussed elsewhere (e.g. Global Tipping Points Report 2023; Willis et al., 2022). While current political developments are making globally coordinated action even more difficult, slow progress at the global level under current processes/architecture must not be an excuse to delay action. Change can and should still be pursued at local, regional, national and supranational (e.g. EU, AU, ASEAN) levels (Box 1.2.1), as well as through novel international governance upgrades such as highly effective "smart coalition" approaches (Climate Governance Commission, 2023). For example, individual countries or trading blocs investing in electric vehicles and/or renewable energy can reduce global production costs and may make it more likely that other regions or nations will adopt these technologies (Mercure et al., 2024).

Box 1.2.1: Research Insight: State of Governance
ESTPs in European policy discourse: linking risk to governance

Over the past several years, government and parliamentary actors in Norway, Germany, and the UK have increasingly referenced climate tipping points in connection with the 1.5°C global temperature goal. Across these countries, the prospect of transgressing critical thresholds—such as Amazon forest dieback or ice sheet collapse—is being used to emphasize the urgency of rapid emissions reductions. However, there are notable differences in how this risk is translated into policy direction.

In all three countries, tipping points are largely framed as looming, irreversible threats that amplify the case for delivering on existing climate commitments—particularly mitigation targets under the Paris Agreement. Parliamentary actors and civil society groups use the language of tipping points to stress the need for faster and more ambitious climate action. For example, Norwegian officials and NGOs cite tipping risks to argue for embedding the 1.5°C target more deeply in law and policy. In the UK, political leaders frequently invoke tipping points to highlight the inadequacy of current emissions plans and the consequences of falling short.

Yet across contexts, the discourse remains anchored in reinforcing current goals rather than evolving them. Whilst current goals are helpful, more is needed. Tipping points are deployed as rhetorical devices to raise the stakes, not as drivers of new governance strategies. Despite acknowledging that these risks mark a fundamentally different class of climate threat—abrupt, nonlinear, and irreversible—there is little recognition that preventing or managing them may require distinct institutional reforms, risk governance mechanisms, or anticipatory planning. In short, tipping points have entered the political lexicon without a corresponding set of actionable ideas for how they should reshape policy and governance.

This reveals a growing gap between scientific understanding and institutional response/creativity. Strengthening the link between tipping point science and concrete governance innovation, to forge new ground in order to safeguard human flourishing, will be essential to address the unique challenges these risks pose—and to ensure that the invocation of urgency leads to more than rhetorical momentum.

Here, we provide guidance to assist governance actors (Chapter 1.5), especially those at national and international-scale, in preventing the transgression of ESTPs. We highlight specific examples of governance required to prevent irreversible transitions of the AMOC (Box 1.2.2) and Amazon rainforest (Box 1.2.3). These contrasting case studies were chosen to illustrate possible preventative action across distinct types of ESTPs based on: drivers (i.e. mostly climate drivers for AMOC vs significant non-climate drivers for the Amazon), time horizons (more distant vs urgent), and the need for multi-scale governance (predominantly international vs across scales). We did not focus on coral reef die-off as it may not be possible to prevent this ESTP (Table 1.2.1), instead, urgent impact governance should be prioritised (Chapter 1.3) in the case of this ESTP.

Box 1.2.2: An introduction to preventing the AMOC ESTP

The AMOC and Subpolar Gyre (SPG) ESTPs are only subject to climate-related drivers. For both, a reduction in surface water density in the North Atlantic can cause tipping, because it prevents surface waters from sinking (AMOC) or being mixed with deeper waters (SPG; also relevant for AMOC; Gregory et al., 2016; Golledge et al., 2019; Armstrong-McKay et al., 2022). All of these dynamics are driven by increases in atmospheric temperature. Anthropogenic aerosols (e.g. from shipping emissions) partly counteract this because they cool the ocean surface (Hassan et al., 2021). See AMOC Case Study for more details.

As AMOC and SPG have no non-climate drivers equivalent to deforestation in the Amazon (see Box 1.2.3), **ambitious climate mitigation - net phase out - is the key measure to prevent their tipping**. Key to this is strengthening international cooperation and climate action at national, regional and local scales and ensuring implementation of commitments.There is some evidence that AMOC tipping is sensitive to the rate of warming and not just the magnitude (Lohmann & Ditlevsen 2021), so limiting the rate of global temperature rises could be a key governance target.

Box 1.2.3: An introduction to preventing the Amazon ESTP

The Amazon forest is losing resilience and large parts of the Amazon could change to a contrasting degraded state, such as non-forest flammable ecosystems (Boulton et al., 2022). Flores et al., (2024) summarise the latest knowledge of when the Amazon forest may pass critical thresholds, with tipping points expected: i) after increases in global temperature of between 2 and 6°C, ii) if precipitation drops below 1,000-1,800mm per year, iii) if seasonality increases, resulting in a maximum cumulative water deficit of ~350-450mm, iv) if dry season length increases to between 5 and 7 months, or v) if deforestation reaches 10-20% of the original forest biome. However, if two or more of these thresholds are approached simultaneously, then a tipping point may occur before any of these individual thresholds are crossed (Cooper et al., 2020; Willcock et al., 2023). See Chapter 4.1 for more details.

Preventing these undesired ecosystem transitions in the Amazonian system requires not only limiting temperature and precipitation changes, but also regional and national land-use management. Given these multiple drivers operating from global to sub-national scales, the Amazon ESTP requires coordinated cross-scale approaches (polycentric prevention).

1.2.2 Building on existing governance frameworks

Existing institutions and governance measures across scales provide important entry points for ESTP prevention efforts. The international climate change regime complex, including governance of short-lived climate pollutants (SLCPs) and emerging activities related to carbon dioxide removal (CDR) and other geoengineering approaches, is particularly important for addressing climate-related drivers of tipping processes.

International climate change governance

Global climate change governance is centred around the Paris Agreement and the United Nations Framework Convention on Climate Change (UNFCCC). None of the elements of the Paris Agreement regime are specifically designed to address the risks associated with tipping points (Global Tipping Points Report 2023). The current implementation of the Agreement also falls short of achieving its temperature goals, both the overarching goal of keeping global warming to well below 2°C above pre-industrial levels and the more ambitious one of 1.5°C (United Nations Environment Programme, 2024). This matters for ESTP prevention since some tipping points could be triggered within the range of 1.5°C-2.0°C (Figure 1.2.1).

Addressing tipping-point risks within the Paris Agreement would focus on 'pursuing efforts' to limit global temperature rise to 1.5°C, and to keep them 'well below' 2.0°C. Given the 1.5°C threshold will be reached within a few years (Bevacqua et al., 2025), **actors at all levels must strive for every 0.1°C warming that can be avoided below 2.0°C** (Chapter 1.5). This requires interpreting Article 4 of the Paris Agreement ('reach global peaking of greenhouse gas emissions as soon as possible') as to minimise temperature overshoot, rethinking acceptable mitigation pathways to minimise the overshoot period, including risks of ESTPs in Nationally Determined Contributions (NDCs) and the Global Stocktake, and substantially strengthening its review and transparency frameworks (Global Tipping Points Report 2023). For example, **the second Global Stocktake process could explicitly address to what extent collective prevention efforts have limited the risk of passing ESTPs**. Further, **the risk of ESTPs should be considered as part of a third Periodic Review (UNFCCC 2024) of the adequacy of the long-term global temperature goal and the progress towards achieving it**, as well as under the Mitigation Work Programme (Global Tipping Points Report 2023).

The single most important prevention measure is to phase out net greenhouse gas emissions rapidly. Thus, there is a need to transition away from fossil fuel use, not only in the energy system, but across societies, although this is not unique to ESTP governance (Iyer et al., 2022).

Further, **an increased focus on reducing short-lived climate pollutants (SLCPs)** can lead to particularly rapid reductions in global temperature increase, thus minimising overshoot and the risk of ESTPs (Global Tipping Points Report 2023). Several institutions and initiatives address SLCPs at global and regional levels, including the Climate and Clean Air Coalition, the Global Methane Pledge, and the Arctic Council (Yamineva et al., 2023). Individual SLCPs are integrated into legal frameworks under the Gothenburg Protocol (black carbon), the Kigali Amendment to the Montreal Protocol (HFCs), and the UN Framework Convention on Climate Change (UNFCCC)/ Paris Agreement (methane). Despite these efforts, there remains significant potential for stronger action on SLCPs, particularly on methane and black carbon emissions (UNEP & CCAC, 2021; Sun et al 2022). The Norwegian Ministry of Climate and Environment has recently justified pursuing and funding international collaborative efforts to reduce SLCPs, e.g. methane, black carbon (soot) and hydrofluorocarbons (HFCs), due to tipping-point risks. Since SLCPs have a shorter lifespan than CO2, and emission reductions of this kind can have a short-term climate effect, they argued: "This is essential for achieving the Paris Agreement's temperature goals and reduces the risk of crossing irreversible climate tipping points in the Arctic, which will have major global consequences." (Norwegian Government Prop 1 S., 2024, p. 181).

Although many nations have enacted laws and policies advancing decarbonization to meet global climate goals, no existing national efforts are devoted specifically to preventing major tipping point events (Global Tipping Points Report 2023). The novel threats and risks from ESTPs warrant more urgent and robust implementation of existing national climate change mitigation laws and policies, as successful decarbonization is critical to their prevention. This alone, however, does not provide for direct governance of the prospect of crossing near-term tipping points (Box 1.2.4).

Intentional and specific integration of ESTP governance into national policies is needed, including the support of coordinated monitoring systems and a commitment to accelerating decarbonization. This is crucial to reducing the potential for crossing tipping points, even if emissions reduction goals are being met. While efforts to reform existing laws and enact new national and international laws are to be pursued (Box 1.2.4), **given the urgency, ESTP-informed interpretations of existing laws should be leveraged to implement such measures immediately;** see Garmestani et al. (2019) and Maxwell et al., (2021) for examples.

Box 1.2.4: The potential of rights of nature approaches to prevent ESTPs

Under international law, states have committed to take effective measures to address climate change, preventing and reducing greenhouse gas emissions to limit global temperature rise in line with the best available science and pursuing climate justice (ICJ, 2025). These obligations have several legal foundations, including the Paris Agreement, the UN Convention on the Law of the Sea (ITLOS, 2024), human rights stipulations (IACHR, 2025), and the principles of international law. These obligations could be interpreted to also include the prevention of ESTPs (Ritz, 2024), which constitute 'dangerous anthropogenic interference with the climate system' according to the UNFCCC (Lenton, 2011).

However, the current system of international law lacks effective enforcement mechanisms and has thus far proven ineffective in shaping states' behavior to address climate change. Given these failures, arguments for a reform of international law have been developed based on a recognition of Earth system functioning (e.g. du Toit & Kotzé, 2022; Hall, 2023).

Constructing a global legal system built on science-based Earth systems thinking, combined with learning from diverse Indigenous laws (García Ruales, 2024; RiverOfLife et al., 2020; Tănăsescu, 2020), offers new opportunities to protect Earth system tipping elements, such as forests, ice sheets, coral reefs, or ocean currents - for example, by recognizing them as legal entities with inherent rights. Rights of nature approaches (Borràs-Pentinat, 2025) have already been adopted in jurisdictions like Bolivia, Ecuador, Aotearoa/New Zealand, Spain, and India, often as a result of Indigenous advocacy efforts (O'Donnell et al., 2020; Corrigan & Oksanen, 2021) and they can focus on specific entities, such as rivers, mountains, or glaciers. Many of the legal approaches adopted include participatory elements, whereby local human guardians or councils are appointed to speak for the ecosystem and represent it in court (Chapron et al., 2019; O'Donnell & Talbot-Jones, 2018).

The traction that rights of nature are now gaining across the globe is evident in the prominence accorded to them as a necessary corollary to recent environmental human rights developments in the submissions of all five of the UN's regional groupings to the Stockholm+50 summit (Morrow, 2025). However, we acknowledge that rights provisions alone can be symbolic and ineffective unless paired with clear state duties, standing rules, remedies, monitoring and finance (Corrigan & Oksanen, 2021), and representation can be achieved without conferring legal personhood (Chapron et al., 2019; O'Donnell & Talbot-Jones, 2018).

Whilst ambitious and complex, recognising the rights of Earth system tipping elements to persist as they have done in Holocene conditions could both increase the inclusion of Indigenous and local knowledge, and create accountability mechanisms in international law - both key factors in transformations towards sustainability and justice (IPBES, 2024) and in efficacious responses on the ground. This could contribute to the prevention of tipping points especially for tipping elements that are not exclusively climate driven, but also have local and regional-scale drivers. For example, Amazon Indigenous peoples, whose stewardship is vital for safeguarding the stability of the Amazon rainforest (Science Panel for the Amazon, 2021), could cooperate to become the legal representatives of the forest, which could strengthen drastically needed forest protection and limit tipping risks (Borràs-Pentinat, 2025; Flores et al., 2024; Edling Müller, 2025). Whilst these measures are not a panacea, an international legal system with effective access to justice for Earth system tipping elements could have similar governance effects to those of the global climate litigation movement (Setzer & Higham, 2025): it could provide additional legal pathways to address climate policy failure or insufficiency, although substantial progress would be required before this could be operationalised.

Other relevant international governance

ESTPs need to be integrated into existing international governance frameworks, such as those for oceans and biodiversity. Although many ESTPs are directly linked to these domains (e.g. Amazon rainforest or coral reef dieback to biodiversity loss; AMOC to ocean governance), coordinated governance and supporting research remain limited. Strengthening these connections is essential, and emerging frameworks such as the planetary commons (Rockström et al., 2024) may provide a basis for more effective coordination.

Box 1.2.5: International Governance Opportunities to Prevent AMOC Tipping

The first and foremost prevention measure for AMOC is climate mitigation, with the aim to minimise magnitude and duration of possible temperature overshoot beyond 1.5°C. The mechanisms of the Paris Agreement can be used to consider safe mitigation pathways. Parties can include AMOC risks and relevant mitigation and action plans in future Nationally Determined Contributions (NDCs) and Biannual Transparency Reports (BTRs), and include an assessment of collective progress towards AMOC collapse prevention in future Global Stocktakes.

The acceleration of global mitigation action must be combined with the rapid development and scaling of sustainable carbon removal capacities, which could be fostered by minilateral diplomacy or transnational initiatives. There are some indications that Solar Radiation Modification (SRM) as a secondary intervention could reduce the AMOC tipping probability under certain conditions, but would require reliable international governance structures itself (Futerman et al., 2025).

It is uncertain whether AMOC tipping could be reliably detected in advance. Due to high internal variability, decades of observations may be needed to detect trends (Lobelle et al., 2020), hence consistent funding of ongoing (deep sea) observations and additional observations in the relatively under-monitored South Atlantic are vital (Chidichimo et al., 2023). It may be possible to construct early-warning signals from the behaviour of AMOC variability (Van Westen et al., 2024). Such signals may come too late to trigger prevention measures, especially since mitigation is a long-term process, but they may help adaptation (Chapter 1.3).

Box 1.2.6: International Governance Opportunities to Prevent Amazon Forest Tipping

There are opportunities for the UNFCCC, alongside global biodiversity governance (e.g. Convention on Biological Diversity, Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services), to provide a context for preventive governance measures regarding the Amazon rainforest. The Paris Agreement's ambition cycle (Nationally Determined Contributions, Global Stocktakes, transparency and support mechanisms) can be deployed to minimise the magnitude and duration of any temperature overshoot (Wunderling et al., 2023). Future Nationally Determined Contribution (NDC) revisions, not only from Amazonian nations, should specifically consider the risk of Amazon forest die-back and to what extent national mitigation plans, policies and decarbonisation strategies contribute to its prevention. The Global Stocktake provides a platform for an assessment of collective progress in prevention efforts, i.e. to what extent tipping risks driven by global temperature increase are minimized. International efforts should continually monitor the risk to the Amazon, e.g. using satellite data to detect early warning signs of tipping (Boulton et al 2022).

Slowing deforestation and degradation requires strong governance efforts outside the international climate change regime. **We need net-zero forest loss on the remains of the Amazon forest, combined with restoring at least 5% of the biome** (Flores et al, 2024). Strengthening the forest stewardship of Indigenous peoples and local communities is critical to preventing both deforestation, degradation and carbon emissions from the Amazon (Walker et al., 2020). Indigenous peoples, local communities and their vital knowledge are crucial to conservation, restoration and sustainable forest use, whilst regionally connected governance strategies should be designed with their participation (Science Panel for the Amazon, 2021). Containing a large proportion of the Amazon forest, governance within Brazil is particularly important. Approximately 60% of the Amazon forest is in Brazil, and water from Brazilian forests is recycled by the forest and provided to the western parts of the Amazon forest (Flores et al, 2024). For example, Brazil's Action Plan for the Prevention and Control of Deforestation in the Legal Amazon (PPCDAm) has a crucial role in limiting deforestation rates (Global Tipping Points Report 2023). This will require regional governance structures, such as the Amazon Cooperation Treaty Organization, to avoid the displacement of deforestation from one region in Brazil to another, or to another Amazonian country (e.g. using The Great Green Wall as a guidance framework). International funds will be required to support these sub-national, national, and regional efforts (e.g. the Amazon Fund supports local community, NGO and governmental initiatives in promoting sustainable development). Considering the fragmented and anthropocentric nature of current Amazon governance, the region needs transformative governance structures, such as the establishment of an Andes–Amazon–Atlantic Corridor, where ecologically and socioculturally connected forest areas are conserved in line with Indigenous, local and scientific knowledge (Pereira & Terrenas, 2022; Beveridge et al., 2024).

Carbon dioxide removal governance

Rapid emission reductions have to be complemented with the immediate scaling up of sustainable carbon dioxide removal (CDR) capacities. **There is no way to limit overshoot and permanently reduce global temperature - which is vital to minimise the risk of ESTPs - without CDR and sequestration/utilisation technologies that reach net negative emissions at a global scale**. As such, CDR technologies are now an inevitable part of all strategies to minimise ESTP risks, although governance efforts may only subtly differ from wider climate mitigation activities (Box 1.2.7, Mace et al, 2021). However, **CDR should not become a tool to deal with or justify additional future emissions, but the excess already in the atmosphere.** This excess far exceeds current CDR capacities and CDR is not costless in economic or ecosystem terms (Smith et al., 2023).

CDR approaches are at varying levels of readiness. Mature and scalable approaches include nature-based solutions such as forestation and soil carbon sequestration (Griscom et al., 2017; Bossio et al., 2020). In addition, pilot projects of bioenergy (e.g. biomass waste) with carbon capture and storage show promise (Fuss et al., 2018). By contrast, operation plants performing direct air capture work and trials using enhanced weathering show promise, but are currently economically unfeasible on large scales (Realmonte et al., 2019; Beerling et al., 2020). **A collective effort to develop and scale CDR with government funding is needed, but should not reduce decarbonization efforts**. This would benefit from a cooperative international - possibly minilateral - approach, pooling investments in research and development, developing required infrastructure, and creating the framework conditions for sustained long-term private investment and sector expansion. A new transnational initiative including governments, private sector actors, science, NGOs and the financial industry might be a suitable platform for these activities.

Box 1.2.7: Reforestation in the Amazon as a form of carbon dioxide removal

Forestation could prevent an Amazon forest tipping point whilst also increasing resilience, with a target of restoring at least 5% of the biome recommended (Flores et al, 2024). Within only a few decades (Poorter et al., 2021), forest conservation and reforestation (e.g. through improved land rights for Indigenous peoples, promoting agroforestry, and improved governance) could: i) restore diversity and redundancy in a system (e.g. species diversity), ii) maintain moisture-recycling feedbacks, iii) improve local drought resilience, and iv) reduce non-climate stressors (Table 1.2.1). By planting the right trees in the right places or ringfencing key areas to allow for natural regeneration, there is potential for reforestation to trigger a positive tipping point through climate and ecological feedbacks that trigger enhanced natural regeneration that then surpasses the active reforestation efforts (Figure 1.2.3). Thus, future reforestation efforts should be focussed on the spatial locations and ecological processes most likely to maintain and enhance important moisture and regeneration feedback loops (Figure 1.2.3).

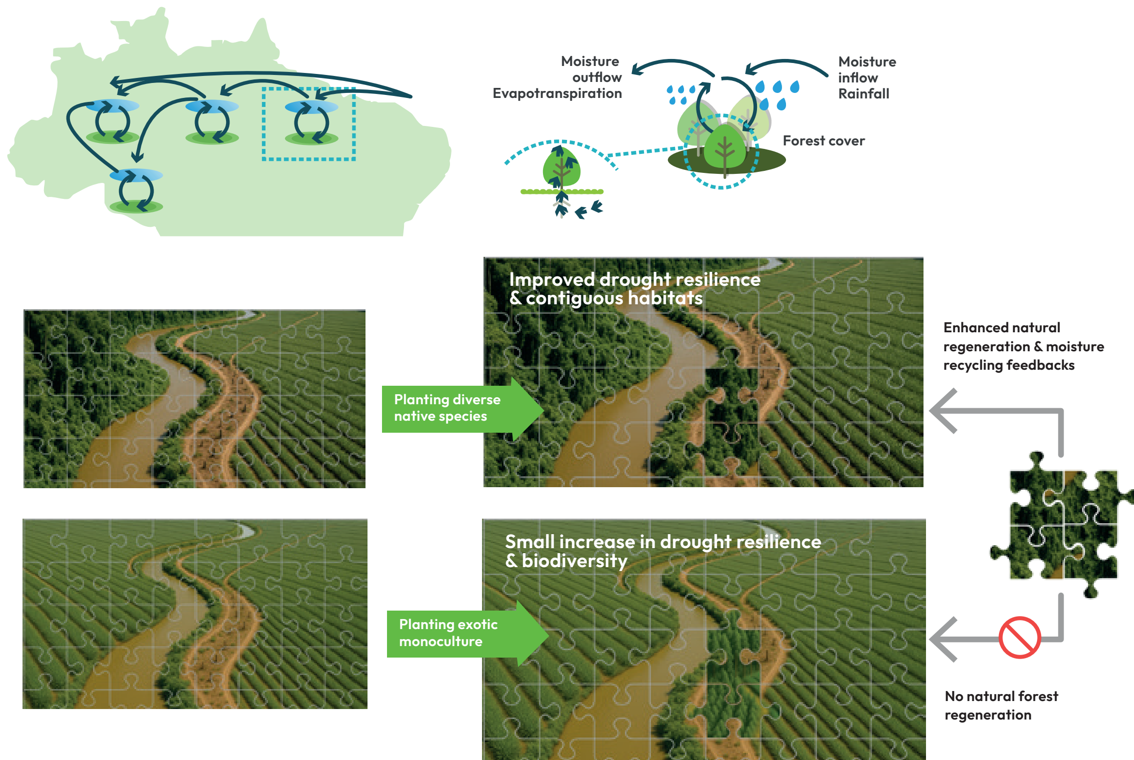


Figure 1.2.3: The location and type of reforestation efforts are important for triggering potential positive tipping points to increase the resilience of the Amazonian forest. Whilst exotic plantations can reduce pressure on natural forest, planting native species in key locations can enhance natural regeneration and moisture recycling feedbacks and increase the resilience of existing forests (Zemp et al 2017).

Solar radiation modification governance

Geoengineering methods, particularly Solar Radiation Modification (SRM; National Academies of Sciences, Engineering, and Medicine., 2021), may reduce climate drivers for some tipping points but have uncertain effects on others and pose significant physical and political risks. The term SRM includes a number of approaches: Stratospheric Aerosol Injection (SAI) places reflective particles in the stratosphere and is inherently global, Marine Cloud Brightening (MCB) uses sea water or other aerosols to enhance cloud reflectivity and has more local impacts (with long-distance teleconnections), Cirrus Cloud Thinning (CCT) thins higher clouds to allow more energy to escape into space. In some cases, the term also includes efforts to change the earth's reflectivity (albedo) by maintaining sea ice, shifting to lighter crops, and/or lighter surfaces. None of these are alternatives to mitigation and adaptation but, at best, temporary additional measures. SAI could reduce global warming, a key driver for tipping points like ice sheets and ocean currents, but its effects are uncertain for others (e.g. the Amazon) and may exacerbate risks such as ocean acidification and monsoon drying (Irvine et al., 2019; Futerman et al., 2025; Hirasawa et al., 2023; Asutosh et al., 2025). Widespread use of MCB could also affect global mean temperature, and with significant effects on precipitation. SRM itself, particularly SAI, carries severe risks, including unintended side effects, the possibility of abrupt termination, political challenges (such as the need for unilateral action) and creating a distraction from mitigation (Felgenhauer et al., 2022).

No geoengineering technology is currently available for deployment on scales that would affect global average temperature. Using SRM as an emergency response when tipping is imminent is risky, as detecting tipping points in time may be impossible (Lenton 2018). A gradual, preventative approach could allow testing and adjustments, but robust **SRM governance mechanisms must be in place first** (Biermann et al., 2022; Gupta et al., 2024).

As SAI or large-scale use of MCB would have global effects, its governance must be international. No comprehensive framework currently exists. Some international agreements, such as the Convention on Biological Diversity and the London Convention on ocean dumping, have been applied to different forms of geoengineering, but their scope is limited. The UN General Assembly's 2021 resolution (UNGA A/Res/76/112) addresses atmospheric modification, requiring environmental impact assessments. The Montreal Protocol addresses activities that affect stratospheric ozone, which SAI would. Other governance mechanisms, including the Vienna Convention and UNFCCC, have been proposed. Reports from COMEST (2023), the UN Human Rights Council (A/HRC/54/47), UNEP (2023), and the Climate Overshoot Commission highlight ethical and human rights concerns but also advocate cautious SRM exploration. In December 2024, the EU's Group of Chief Scientific Advisors called for a multilateral treaty on SRM governance, including a non-use agreement, a moratorium on large-scale deployment, monitoring of undeclared SRM activities, but also rigorous, ethical research (European Commission, 2024).

National policies remain fragmented. For example, the US has some SRM research guidelines, while Mexico bans outdoor experiments. In August 2024, opposition from Indigenous leaders and environmental advocates led to the cancellation of the SCoPEx outdoor experiment in Sweden, underscoring SRM's governance and ethical challenges.

We recommend a moratorium on SRM deployment and large-scale experiments, alongside international efforts to assess SRM's benefits and risks. The London Protocol, which bans large-scale ocean iron fertilization but allows regulated small-scale experiments, may serve as a model. **SRM research should be transparent, inclusive, and build capacity in the Global South to ensure informed participation.** Much of the current understanding of SRM and its potential impacts is based on insights from climate models, which vary in the way that they represent key processes in clouds and aerosol-related climate feedbacks and are limited in their ability to represent more complex ecological feedbacks between temperature, precipitation, solar radiation, and levels of CO_2 (National Academies of Sciences, Engineering, and Medicine., 2021). The impacts of SRM are also highly dependent on the specific strategies (e.g. for SAI, the injection sites; Bednarz et al., 2025) being used. Some SRM risks will only become apparent after deployment, making responsible governance essential.

An effective governance framework for SRM is a priority, but there are key inter-related rationales for continuing research. The technological barriers to entry for development and deployment of different SRM methods, including SAI, are lower than the current scientific uncertainty about these potential interventions. While a moratorium on deployment is appropriate, ongoing research on SRM is crucial to understand the full range of potential impacts of coordinated use and to anticipate the effects of non-ideal, unilateral, uncoordinated or competitive deployments. SAI deployment in particular would have global physical effects. There is a risk that a climate emergency framing, including those that leverage the risk of ESTPs such as AMOC collapse, may drive non-ideal development and deployment as an 'emergency' response. Geopolitical uncertainty and competition may also contribute to a competitive race to develop and deploy SRM (Nielsen 2025). Additional research to explore potential effects of non-ideal SRM interventions may help anticipate physical risks of both scenarios.

Box 1.2.8: AMOC, the Amazon and the SRM dilemma

Limited modelling evidence suggests that global or northern-hemisphere Solar Radiation Management (SRM) may reduce AMOC weakening by surface cooling and reducing meltwater influx (Tilmes et al., 2020, Fasullo et al., 2018, Xie et al., 2022, Pflüger et al., 2024, Bednarz et al., 2025). Hence, it would probably reduce tipping risk (Futerman et al 2025; Figure 1.2.1). Other geoengineering technologies could also possibly contribute to AMOC and SPG tipping prevention, e.g. Marine Cloud Brightening (MCB; Hirasawa et al., 2023).

When viewed in isolation, the threat of AMOC collapse could motivate SRM deployment, either preventatively to reduce tipping drivers, or as an "emergency brake" if tipping seems imminent. The latter approach is particularly risky, since it is unclear whether AMOC tipping could be detected in time for SRM to be effective (Lenton 2018). If SRM were used to cool the globe while an already-weakened AMOC fails to recover, the North Atlantic region could be severely over-cooled (Pflüger et al, 2024, Schwinger et al 2022). However, SRM may be less effective, and potentially counterproductive, for the Amazon rainforest (below) and, as outlined above, SRM carries massive political risks. **Any potential decision on SRM should be driven by a holistic, systemic consideration of its risks and benefits, not its presumed efficacy for one particular tipping element.**

However, we caution against Solar Radiation Management (SRM) as the impact it may have on the Amazon is likely to be complex (i.e. reduced transpiration but also reduced growth and carbon absorption) and is poorly understood (Futerman et al, 2025). For coral reefs, SRM may reduce the primary driver of ocean warming, but might slightly increase the secondary driver of ocean acidification, although the impact on aragonite saturation, the key variable of interest, may be limited (Futerman et al 2025). Finally, Futerman et al. (2025) list some tipping points for which the effect of SAI is simply unknown due to absence of research; for these, negative (or positive) effects cannot be excluded. **The potential impact of any SRM on all ESTPs must be debated prior to the establishment of SRM actions by or within any nation**.

1.2.3 The role of the finance sector in preventing ESTPs

In order to support the above prevention strategies, a number of wider transformations across a variety of sectors are needed. We highlight the crucial role of finance in this context.

The finance sector has a critical role in the governance of ESTPs, given the influence that financing multinationals and other companies has on their activities, including those activities that increase tipping risks as a result of greenhouse gas emissions and environmental degradation (Box 1.2.9). **A broad suite of globally coordinated policy measures across fiscal, financial, industrial, and environmental policy areas is likely needed to shift global financial flows away from such harmful activities, to better prevent ESTPs** (Ameli et al., 2025, Kedward et al., 2023).

The problem of finance with respect to Earth systems

Financial efforts to mobilize 'green' investment have been inadequate to date. While having grown steadily over the last decade, current volumes of climate mitigation finance are still far below what is needed, and have to increase at least sixfold in the next 10 years to be aligned with a net-zero pathway (CPI, 2024; UNEP, 2024). Similarly, 'nature-positive' financial flows are nowhere near sufficient to fill the biodiversity conservation and restoration financing gaps (Gonon et al., 2024, CBD, 2025). From the perspective of mainstream finance's shortsightedness, it is still more financially profitable to destabilize the Earth system than to protect it, preventing any significant redirection of financial flows (Kotzé & Adelman, 2022). 'Environmental, Social and Governance investing', despite two decades of progress, has not achieved mainstream adoption and has had no discernible impact on this issue. Moreover, dedicated market-based mechanisms such as voluntary carbon markets and biodiversity offsets have also failed to catalyze meaningful action. They often suffer from poor quality, lack of integrity, and narrow scope, typically focusing on a single environmental output, such as immediate carbon sequestration, without addressing broader systemic risks on a longer time horizon. This has created a false sense of progress while allowing business-as-usual finance to continue contributing to nature degradation.

Finally, the most substantial progress has certainly been made in the area of financial risk management: since 2015 (e.g. Carney, 2015) the financial sector repeatedly acknowledged that it cannot be immune to the materialisation of climate change and biodiversity loss on its own activities, via direct and indirect impacts on, e.g., risk of default and degraded performance of financial assets. Hence, it should be in its 'rational economic interest' to fight against these and stop fueling deleterious economic activities (cf. Box 1.2.9), to avoid monetary value destruction and propagation towards a whole financial system destabilisation. Unfortunately, while indeed awareness and knowledge on climate- (and biodiversity-) related financial risks have progressed considerably over the past decade, this has not yet been sufficient to reverse the financial sector's harmful trajectory (NGFS, 2024).

Possible fixes - extending the financial risk approach

Because risk analysis underpins nearly all decision-making in the finance sector, incorporating tipping elements into assessments of climate- and biodiversity-related asset risks is a natural next step to better connect finance with Earth system stability (Kotzé & Adelman, 2023). Central banks and supervisory authorities have begun exploring the implications of environmental change for financial stability, but these efforts remain narrowly framed (Box 1.3.3). Scenario exercises still concentrate on median climate trajectories, with little attention to systemic disruptions such as tipping points (FSB, 2025). Likewise, financial risks arising from the deep dependencies of economic activities on ecosystem services remain largely absent from current models (Hadji-Lazaro et al., 2024). To address this gap, financial risk governance must move beyond marginal or isolated changes and take seriously the possibility of ESTPs. Only then will risk frameworks reflect the true scale of ecological risks and support precautionary, forward-looking financial governance (Trust et al., 2025).

However, even if the calculation of such financial risk figures eventually becomes achievable, it would not automatically translate into financial decisions that would contribute to preventing breaches of ESTPs. Indeed, a risk estimate deemed insufficiently material would not trigger much change. However, even if this were the case, it could lead to a risk management decision based on hedging or diversifying the risk, without implying a reduction in the source of the risk, i.e. without seeking to prevent the tipping point from being breached. Moreover, risk aversion is not everything: in an anticipatory move to avoid financial assets exposed to ESTPs, shifted financial flows may also divert away from essential economic activities, which would result in negative impacts (e.g. harming food security) even before ESTPs materialise.

Therefore, the fundamental limitations of financial risk approaches motivate an explicit proactive stance, involving precautionary actions to prevent the risk upfront, rather than merely managing it after occurrence (Chenet et al., 2021, 2022; Kedward et al. 2023; Marsden et al. 2024).

Recognising such an endogenous role of the financial system in the construction of environment-related financial risk is a critical step (Kreibiehl et al., 2022), as it positions finance not as a neutral intermediary but as a structurally embedded force whose reorientation is necessary to support ecological sustainability – an imperative that also reinforces the long-term resilience of the financial system itself.

Box 1.2.9: The impact of the finance sector on ESTPs

Banks financing the fossil fuel industry (and investors investing in it, as insurers insuring it or financial services providers working with it) directly contribute to increasing the supply of oil, gas, or coal, and thereby, the concentration of greenhouse gases in the atmosphere, which is the first-factor precipitating climate tipping points such as the collapses of the West Antarctic Ice Sheet or Atlantic Meridional Overturning Circulation (AMOC).

As well as financing leading to rising greenhouse gases, deforestation in the Amazon is driven by financial investments in agrifood industries, which accelerates forest dieback, undermining carbon and water cycle regulation and leading to widespread economic losses along the value chain and across sectors reliant on these services (Marsden et al., 2024).

Possible fixes - beyond the financial risk approach: finance as a tool for positive tipping

The financial system is, in fact, not just a neutral optimisation tool for capital allocation but an active driver of ecosystem destabilisation through their role in shaping incentives, norms, and governance structures (Galaz et al., 2018; Crona et al., 2021). This calls for deliberately and urgently steering the financial system toward serving clearly defined socioeconomic and ecological purposes, chief among them, the urgent need to prevent ESTPs. Such a reorientation requires reconfiguring financial incentives, governance frameworks, and regulatory mandates to ensure that capital allocation supports a just transition and economic activities that maintain ecological stability, rather than perpetuating short-term, profit-driven degradation.

For this, it is indispensable to integrate the multiple relational, intrinsic and instrumental values of ecosystem services (IPBES, 2022) into financial decision-making, through different types of indicators (biophysical, sociocultural, monetary), i.e. not only through prices. Ecosystems do not just store carbon, but also provide water regulation, pollination, disease buffering, cultural value, and much more. The values of the multiple ecosystem services can no longer be ignored. Properly valuing these services, including their role in systemic resilience, is essential. Biodiversity must indeed be recognised not only for its intrinsic value but as a form of 'natural insurance' for our socioeconomic systems. Diverse ecosystems are more resilient to shocks, better able to maintain function, and more likely to buffer societies and economies from systemic breakdowns (Loreau et al., 2021). Eroding biodiversity thus increases long-term financial risk, a dynamic not yet reflected in credit ratings, insurance models, or asset pricing. Without such a macro-ecological systemic approach to finance, investments in so-called 'green assets' may continue to overlook the functional complexity of ecological systems, and continue to stress them towards fatal levels, resulting in tipping points.

Thus, the finance sector's role in preventing or delaying tipping points is central to governance efforts. Preventing ESTPs "for real" will require vastly increased investment compared to current commitments, which are completely insufficient to achieve a net-zero emission reduction trajectory with low-temperature overshoot, nor to fill the climate adaptation or biodiversity conservation and restoration financing gaps (Möller et al., 2024; UNEP, 2024; Gonon et al., 2024, CBD, 2025). **Doing so needs massive redirection of finance from emissions-increasing and ecosystem-degrading activities, such as investment in fossil fuels and deforestation-linked agroindustry, towards low-carbon investment, adaptation and ecosystem resilience and regeneration** (Eker et al., 2023; Kreibiehl et al., 2022, Kedward et al., 2023).

Yet, finance can only flow at scale if structural reforms are introduced, including the enforcement of ESTP boundaries as financial thresholds in, for example, credit allocation and pension holdings, the integration of long-term environmental risk into macroprudential rules, and the prioritisation of public finance to de-risk early-stage, regenerative investments. As finance is only a propellant for the ecological transition, it is crucial that genuine coordination occurs between monetary, fiscal, industrial, and environmental authorities.

Thus, the financial system requires a change of governing paradigm to deliver an economy of sustainability. For this, the whole incentive mechanism within the financial system must be inverted: it cannot be profitable anymore to destroy ecosystems and precipitate ESTPs. Finance must instead be seen as an instrument to trigger systemic socioeconomic changes towards decarbonisation and nature regeneration, and hence towards long-term prosperity: finance as a '**positive tipping**' catalyst (Section 3).

Simultaneously recognising this shaping role that finance has on the economy and accounting for ESTPs and potential cascades in financial risk analysis will illuminate the scale of risks for both the biosphere and the socioeconomic sphere, justifying core regulatory intervention able to integrate the real values of nature into financial operations. Such a change is necessary to drive more concerted action to shift financial flows away from the root problem (activities causing ESTPs) and towards the potential solution (activities preventing ESTPs and contributing to building a resilient socioeconomic and financial system). This highlights the importance of coordinated, systems-level regulation that supports just transitions, acknowledges the financial system's role in actively shaping and amplifying ecological degradation/regeneration, and prioritises long-term stability over short-term optimisation.

1.2.4 Conclusions

For most ESTPs, rising global temperatures are a primary driver, making accelerated climate change mitigation essential to prevention. A coordinated, urgent effort is needed to rapidly phase out greenhouse gas emissions. Reducing the risk of crossing tipping points requires minimising both peak warming and the duration of any temperature overshoot, while striving to return global temperatures to or below 1.5°C. This necessitates strengthening the 1.5°C goal within the Paris Agreement and integrating ESTP-specific considerations, such as assessing how national and collective actions have mitigated tipping point risks, into the Global Stocktake.

Limiting temperature overshoot—and thereby reducing the risk of ESTPs—is impossible without carbon dioxide removal (CDR) and sequestration technologies that achieve net negative emissions on a global scale. For example, forestation efforts could enhance the Amazon's resilience while also reducing its tipping risk, with at least 5% of the biome recommended for restoration. Governments must invest in the development and scaling of CDR technologies, but not at the expense of immediate decarbonization efforts. We also emphasize the need to prioritize CDR efforts and to target short-lived climate pollutants (SLCPs), as removing these gases can yield rapid global cooling effects.

Geoengineering, particularly Solar Radiation Modification (SRM), may help reduce climate drivers for some tipping points but carries uncertain consequences for others and poses significant physical and political risks. SRM can only ever be a supplementary measure—it cannot replace climate mitigation and adaptation. We recommend a moratorium on its deployment and large-scale experiments, alongside rigorous international research to assess both its risks and potential benefits.

The financial sector, in particular, plays a key role in governing tipping points. Through its influence in shaping economic dynamics, it is an active driver of ecosystem destabilisation, but it is also reciprocally exposed to ESTPs. Thus, accounting for ESTPs cascading risks in financial analysis has the potential to reveal the scale of potential economic consequences – thereby justifying to "change the rules" so that financial markets can play their role in driving the redirection of capital away from harmful activities and toward those that prevent breaching ESTPs. Achieving this requires a broad suite of globally coordinated policy measures across fiscal, financial, industrial, and environmental domains to catalyse a systemic paradigm shift that embeds the real values of ecosystems into financial decision-making.

There is an urgent need to connect different risk assessment frameworks to develop multi-scale prevention strategies for specific tipping processes. Scientists, policymakers, and practitioners must collaborate to assess risks, manage trade-offs, and identify synergies between existing governance and actions to prevent ESTPs across time horizons (Table 1.2.2).

Table 1.2.2: Short- and medium-term ESTPs prevention governance measures

Time horizon	Priority actions
Short-term (0–5 years)	• Include ESTP risks in the 2nd Global Stocktake (2028), 3rd round of NDCs (2030), and national climate, biodiversity policies • Rapid phase-out of methane, black carbon, and other SLCPs • Accelerate CDR development through a new minilateral or transnational initiative and funding • Create monitoring/early-warning systems • Integrate tipping risk into financial risk assessments
Medium-term (5–10 years)	• Embed ESTPs prevention permanently in Paris Agreement's' full ambition cycle • Review and adjust global mitigation pathways to minimize overshoot • Strengthen Indigenous land rights and halt deforestation in Amazon & other critical biomes • Scale CDR capacities • Strengthen cross-scale governance • Reform financial flows • Build systemic resilience in agriculture, forestry, and fisheries to reduce non-climate stressors • Take measures to prevent unwanted SRM deployment while building governance mechanisms and assessing SRM potential benefits and risks

1.3 Impact governance for Earth system tipping points

Authors: Ben Hudson, Manjana Milkoreit, Carlo Aall, Hugues Chenet, Frank Dentener, Ajay Gambhir, Ahjond Garmestani, Sirkku Juhola, Claire Mellier, Silvia Montagnani, Malcolm Rogge, Rosa Roman Cuesta, J.B. Ruhl, Ashwin K. Seshadri, Viktoria Spaiser, Johnny Stormonth-Darling, Bregje van der Bolt, Sebastian Villasante, Tabby Watson, Simon Willcock

Reviewers: Maja Groff, Jessica Seddon

Key Messages

- **Societies need governance efforts that anticipate and prepare for the specific impacts of Earth system tipping points before tipping points are crossed – these impacts differ from the observed and expected impacts of climate change.**
- **Governments should assess and reduce vulnerability to the impacts of Earth system tipping processes, build resilience, and include tipping impacts in climate adaptation policy and planning and related policy domains.**
- **Governments, intergovernmental organisations, economic and financial actors should integrate Earth system tipping points into risk assessments across scales.**
- **Justice – intragenerational, intergenerational and interspecies – must be at the centre of Earth system tipping point impact governance.**

As global temperatures approach 1.5°C, with the prospect of inevitable overshoot, crossing Earth system tipping points (ESTPs) is a plausible near-term reality. While prevention must remain a priority (see Chapter 1.2), societies must also be prepared to deal with the consequences of tipping points that may no longer be avoidable, such as widespread dieback of tropical coral reefs. This chapter addresses that emerging need: how to govern the wide-ranging and potentially irreversible impacts of crossing ESTPs, including disruptions of food systems, human health impacts, damage to critical physical infrastructure, changes in water availability, displacement of populations, and the destabilisation of economies and political systems. These effects have implications for the full spectrum of the sustainable development and human security agenda (IPBES, 2024).

As outlined in Chapter 1.1 (Table 1.1.1), tipping processes unfold in ways that differ from expected climatic changes and defy conventional policy planning — they are nonlinear, often abrupt and irreversible, and characterised by cascading effects across systems. The probabilities of tipping, details of the specific location of tipping points, pace of change, and precise distribution of impacts are often highly uncertain; however, this does not mean that such impacts are unlikely to occur. Table 1.3.1 illuminates the specific implications of these challenges for impact governance.

Table 1.3.1: Tipping process characteristics and their implications for impact governance

Tipping Process Characteristic	Implications for impact governance	Warm-water coral reefs	AMOC
Thresholds (moments of commitment and irreversibility)	Once a tipping point is crossed, a return to the prior state may no longer be possible. Governance must then shift from prevention to managing the post-tipping reorganisation.	Once thermal thresholds are crossed, there are limited prospects for restoration or recovery; adaptation must focus on alternative livelihoods.	AMOC collapse commits Europe and parts of Africa and the Americas to long-term regional climate disruption; governance must plan for persistent change.
Acceleration of change	Rapid changes reduce lead time for response and strain institutional capacities. Governance must be anticipatory, flexible, and early warning enabled.	Coral degradation can move from gradual stress to collapse within years.	Once initiated, AMOC weakening may rapidly disrupt temperature and precipitation patterns across continents.
Increased magnitude of impacts	Impacts may exceed adaptive capacity or lead to adaptation tipping points, requiring switches in adaptation strategy. Governance must include contingency planning, emergency preparedness, and systemic adaptation strategies.	Slow decline (bleaching and recovery) and partial loss vs. complete loss; adaptation to declining subsistence on fish or coral-related tourism might need to switch towards alternative forms of economic activity and potential migration.	Increased sea-level rise may render current adaptive solutions, e.g. seawalls, ineffective, therefore demanding migration from affected areas or planned relocation of communities and infrastructure.
Trend reversals	Earth system tipping could lead to trend reversals (e.g. cooling rather than warming in some regions), which may invalidate current adaptation pathways or make them maladaptive. Governance must identify and implement no-regrets strategies that are robust to trend changes (e.g. better insulated buildings and less energy reliance for both heating and cooling).	Not applicable.	AMOC weakening could cool parts of Europe and the North Atlantic, reversing regional warming trends and invalidating warming-based adaptation plans.
Different distribution of impacts	Tipping points produce uneven and shifting risk profiles and can alter geopolitical power relations. Governance must assess who is newly exposed and ensure equitable and just support.	Coral-dependent communities in the tropics are disproportionately affected, but also the tourism industries and economies of countries across the Pacific (including Australia) and the Caribbean.	Northern and Western Europe, West Africa, and parts of North and South America would be differentially impacted by disrupted rainfall and temperature patterns. AMOC tipping would disproportionately impact a specific group of geopolitical allies (UK, US and Western Europe).
Novel impacts	Governance must be open to emerging, poorly understood challenges. Monitoring across many systems and impacts, adaptive learning systems, participatory planning, and innovation capacity are key.	Unidentified.	An abrupt AMOC collapse may disrupt jet stream dynamics and create a southward shift in the intertropical rain belt; it could trigger food instability at a scale not seen in modern times.
Cascade effects	The risk of cascading impacts across systems will require systemic governance that can address multiple challenges across multiple systems simultaneously, and directly intervene to dampen or break amplifying feedbacks. There is a risk of derailment, giving rise to concerns about whether governance can adequately manage the cascade of consequences while also pursuing mitigation priorities within the limits of finite resources.	Coral collapse may destabilise broader marine food webs, reduce fish catch, decrease food security and income, disrupt coastal economies, and lead to poverty and migration.	AMOC tipping may affect Amazon rainforest stability, the West African Monsoon, and shift the Intertropical Convergence Zone. This could make some regions, including densely populated ones, less liveable, leading to poverty, migration, political tensions and conflicts.

The aim of impact governance is to address these distinct challenges through policies, institutions, and coordinated actions that: reduce harm; protect communities, ecosystems, and societies; enable effective adaptation; and foster resilience and stability in the face of large-scale and systemic disruptions caused by tipping dynamics in the Earth system.

Box 1.3.1: ESTP impact governance objectives

Minimising harm from tipping processes by:

- Developing anticipatory capacities
- Monitoring and learning about Earth system changes and human impacts
- Fostering resilience, adaptation and preparedness
- Managing transformations towards sustainability and equity
- Managing impact cascades

ESTP impact governance must be capable of addressing the interconnected and often unpredictable nature of these challenges through collaborative decision-making and multi-level cooperation. It requires multi-level governance systems that connect institutions and processes at the international, national and sub-national levels. Appropriate responsibilities need to be identified and divided across the different levels of governance, facilitating cross-scale linkages and information flow within and across levels (Schweizer and Juhola 2024).

Existing institutions for climate impact governance, such as adaptation and disaster response mechanisms, are not designed for—and are poorly equipped to manage—the systemic, cascading, and cross-scale disruptions triggered by ESTPs (Biesbroek 2025; Dryzek 2016; Young 2021). Meeting these challenges requires a fundamental shift in governance: from managing known risks to navigating deep uncertainty; from short-term crisis response to long-term resilience and justice; and from single- to multi-scale approaches. Institutional change must proceed along three complementary paths: strengthening existing systems to withstand escalating pressures, reforming outdated and inadequate policies and institutional structures, and innovating mechanisms to address novel risks and governance gaps. Only by pursuing this integrated strategy can impact governance meet the demands of a future shaped by irreversible Earth system transformations. Pursuing this integrated strategy requires acknowledging that, as much as there is no relevant historical analogue for the future impacts of tipping points on human society (and on other species), there is also no analogue for the governance systems needed to effectively and equitably manage them. Norms and principles inherent in today's conceptions of governance may need to be revisited, recalibrated, or entirely transformed in an ongoing undertaking of adaptive governance.

While the need for impact governance is increasingly urgent, many facets of ESTP impacts are not yet well understood. Consequently, there is a pressing need for knowledge generation regarding the social, economic, political and cultural impacts of different tipping systems, which can inform systematic risk assessment and decision-making. While these knowledge gaps persist and shrink with expanding scientific efforts over the coming years and decades, governance efforts need to advance with the help of anticipatory approaches and tools that can effectively bridge the state of science - what we do know - and the need for action (Wood et al. 2023).

This Chapter tackles these issues by providing an actionable multi-phase framework (1.3.1) and assessing current progress across five key tasks of impact governance (1.3.2), then turning to the urgent challenge of tipping point risk assessment (1.3.3) and the need for justice in ESTP impact governance (1.3.4), before concluding (1.3.5).

1.3.1 A multi-phase impact governance framework

To support effective ESTP impact governance, we draw on a multi-phase framework (Milkoreit et al. 2024) that aligns governance objectives with the evolving dynamics of tipping processes by differentiating three phases of a tipping process: pre-tipping, reorganisation and stabilisation (see Figure 1.3.1). Here we focus on pre-tipping and reorganisation.

Before the tipping point: Anticipation and preparedness

For most known tipping elements, the world is currently in the pre-tipping phase. Impact governance must begin in this phase and not wait for confirmed tipping. Action should not be delayed in the hope that prevention measures will be successful. Tasks and activities in the pre-tipping phase include:

- **Research and learning** about tipping systems and societies' interactions with them to improve the foundations for governance.
- **Monitoring and early warning systems** to detect loss of stability.
- **Risk and vulnerability assessments** to identify exposure hotspots, cascading risk potential, and the distribution of vulnerabilities across space and time.
- **Strengthening existing institutions and capacities** at multiple scales to fortify them against the strain of rapid change and derailment risk.
- **Reforming and integrating existing policies and institutions** for climate adaptation, disaster response, loss and damage, global food security, migration, international financial stability and others in light of expected ESTP impacts.
- **Anticipatory adaptation** to strengthen resilience in vulnerable systems and communities before impacts occur.
- **Governance innovation** through inclusive co-development including greater integration across policy domains (climate, biodiversity, oceans, etc.), and the design of novel institutions and approaches to meet tipping-specific governance needs.

This phase is also the window for integrated planning: linking impact governance, especially adaptation, and prevention efforts, embedding justice into responses, and building institutional capacity for more turbulent futures.

(When) Realising that the tipping point has been crossed

Complex governance challenges arise from the temporal dynamics between ESTP crossings and their societal recognition. Scientific confirmation of a crossing may emerge years or decades after the actual tipping point has been breached and may not manifest as a single, clear signal. In addition to muddled scientific signals over extended time periods, recognising the passing of a tipping point as a social fact poses severe challenges because tipping systems and dynamics are largely invisible to human senses, unfold across vast spatial and temporal scales beyond lived experience, and are likely to encounter political contestation and communication dynamics similar to but more severe than those that have long complicated climate change governance. The current state of the global discourse related to coral reef degradation provides evidence for the challenges in establishing a tipping point as a scientific, social and political fact.

However, once this scientific knowledge becomes accepted social reality, certain actors, particularly from the financial and insurance markets, may respond rapidly to the anticipated future impacts of the tipping process, even when those biophysical changes will unfold over decades or centuries. For instance, assets such as coastal property facing inevitable loss from accelerated sea-level rise could experience immediate repricing based on projected long-term (e.g. 50-year) impacts rather than current or expected near-term (e.g. 10-year) conditions (Hilson and Arnall, 2024, pp861-862). These financial reactions to the awareness of ESTP crossings could unfold much faster than the biophysical impacts themselves, potentially triggering undesirable cascading effects across interconnected social systems including finance, insurance, food trade, local economies, and other critical sectors, creating secondary tipping dynamics that compound the original Earth system disruption. Beyond these rapid responses, impact governance moves into a new phase after the transgression of a tipping point has been recognised.

After the tipping point: Adaptation, crisis response, loss & damage

Once a tipping point is crossed, the system 'shifts gear' and enters a phase of accelerating change towards a new system state. Impacts of the tipping process are continuous and the irreversible reorganisation of the Earth system to a new (e.g. ice-free) state becomes certain. Governance needs to shift towards continuous adaptation and responsiveness to the prolonged reorganisation of the system (e.g. accelerating sea-level rise) with a view to the expected new stable state.

This is a potentially turbulent phase that could continue for decades or centuries until a new stable system state is reached. The failure of preventive and anticipatory action in the pre-tipping phase will have significant costs in this reorganisation phase — economically, socially, and politically. The level of anticipatory investment in capacity before tipping will have some effect on the degree of disruption or process control in this phase (Desmet et al. 2018). Tasks and activities in this phase include:

- **Implementation of policies and active institutions:** Governance instruments continuously respond to impacts through adaptation and with measures to address loss and damage.
- **Adaptive decision-making and learning:** Institutions frequently adapt their goals and measures to the observed changes in affected systems based on iterative learning.
- **Building and maintaining public trust and cohesion:** Transparent, inclusive communication and participatory processes for engagement, learning and empowering communities, ensuring the legitimacy of decisions and fostering social cohesion during prolonged periods of uncertainty and disruption.
- **Crisis response coordination:** Mechanisms to manage crises, such as, extreme weather events and concurrent impacts (e.g. food shortages, migration, supply chain disruptions).
- **Cascading risk containment:** Identifying and interrupting feedback loops that may trigger additional tipping points.

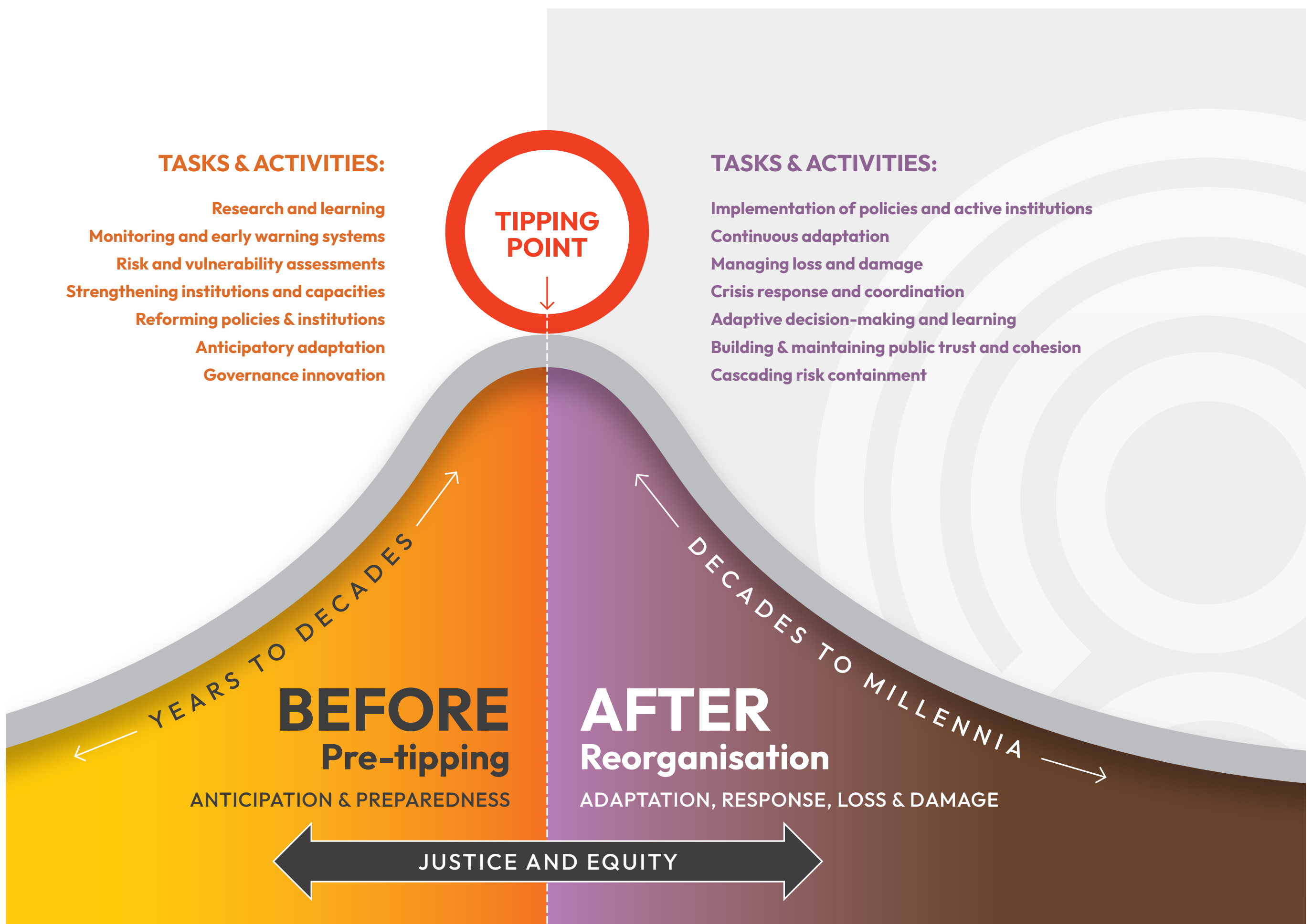


Figure 1.3.1: Multi-phase impact governance for ESTPs. We distinguish the Pre-tipping phase (before the tipping point is reached) and the Reorganisation phase (after the tipping point has been crossed). Each phase has distinct governance implications and time horizons. We identify key tasks for each phase, with justice and equity as a cross-cutting concern.

Cascading dynamics: Anticipating and containing systemic ripples

Tipping points rarely occur in isolation. A destabilisation in one Earth system component can increase the likelihood of tipping events elsewhere, creating what is known as a tipping cascade (Wunderling et al., 2024). For example, the potential collapse of the AMOC could raise the risk of tipping the West African Monsoon (WAM) or accelerating Amazon Rainforest dieback (see chapter 2.2). Such an Earth system tipping cascade can, depending on the speed at which it unfolds, trigger impact cascades across socio-economic systems. For example, a weakened or collapsed AMOC would alter temperature and precipitation patterns, undermining agricultural productivity in vulnerable regions (e.g. Northern Europe), threatening food security and disrupting the agricultural sector. This could be compounded by adverse food-system impacts of changes in the WAM in West Africa and the Amazon (e.g. diminishing atmospheric rivers) in South America. Impaired agricultural production across multiple world regions would have knock-on effects on global food trade, raising prices of staple crops and potentially spreading food insecurity to regions otherwise unexposed to the direct and cascading effects of AMOC collapse. Effective governance must therefore anticipate both the physical interlinkages among tipping elements and the socio-economic ripples that follow.

Rather than simply reacting to tipping cascades as they occur, societies that acknowledge threshold crossings can proactively design interventions to avert or contain the most damaging systemic ripple effects.

1.3.2 Progress and recent developments in ESTP impact governance

The first Global Tipping Points Report made five recommendations to initiate ESTP impact governance. These were:

1. Existing impact governance frameworks and mechanisms need to be adjusted and significantly expanded to address the risks posed by crossing ESTPs. More resources and funding should be made available, especially if and when an Earth system tipping point has been crossed.
2. Adaptation governance needs to significantly strengthen anticipatory work and adopt a multitemporal perspective tied to the scale and dynamics of specific tipping systems.
3. Governments should advance the institutionalisation of global migration governance, building on the Global Compact for Safe, Orderly and Regular Migration.
4. Science and governance actors should co-develop early warning systems to monitor both the biophysical changes (especially indicators for tipping-point transgression) and potential societal impacts of ESTPs. For that purpose, investments in the quality and availability of data should be made, including data from low-income countries.
5. Governments should increase the use of participatory approaches to impact governance, involving local/Indigenous communities and knowledge.

While most of these recommendations have seen little progress, some advances have been made with respect to recommendation 4 - the development of monitoring and early warning capacities at the science-policy interface and recommendation 5 - fostering participatory governance approaches.

Monitoring and early warning systems (Recommendation 4)

In 2024, the UK Advanced Research and Invention Agency (ARIA) launched the Forecasting Tipping Points call, allocating £81 million to 26 projects to develop an early warning system and new models monitoring the Greenland Ice Sheet and the Subpolar Gyre. The EU's Horizon Europe programme provided new funding lines for tipping points research that will strengthen the necessary scientific capacity. The Climate Governance Commission and the High-level Advisory Board on Effective Multilateralism have been fostering a proposal for enhancing international Earth system monitoring scientific capacity. At the same time, monitoring capacity in the US has been recently reduced due to funding cuts and the dismantling of key scientific institutions like NOAA.

While methodological challenges persist (Dakos et al., 2024), integrated early warning systems offer a promising approach to support adaptive governance with information flows and frequent learning loops between science and policy-making (Galaz et al., 2016; Pescaroli et al., 2025). Rather than pursuing or waiting for precise predictions, which is neither feasible nor necessary, detecting critical slowing down and other system-specific indicators can serve as early warning signals, enabling decision-makers to proactively address system instability and mitigate potential impacts.

Box 1.3.2:
Research Insight: State of Governance
Missing the linkages with ESTPs in India'

Advancing early warning systems (EWS) for extreme events is an important governance priority in India. The main concerns are monsoon variability, extreme heat and rainfall, sea-level rise and storm surge, and glacial changes and sudden events (e.g. glacial lake outburst floods). Impact-based EWS for heavy rain, floods, heatwaves, thunderstorms and associated lightning strikes are priorities for joint efforts across government, Earth system science organisations, and the National Disaster Management Authority.

Improved forecasting and early warning of cyclones is seen as a particular success story, with substantial reductions in human mortality in the past two decades. Moreover, the growing severity of extremes as well as increasing compound events (e.g. heatwaves and droughts) is leading to widespread interest in multi-hazard EWS. In this context, multinational efforts in data sharing and technical cooperation are growing, e.g. Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES). However, in India, EWS have not yet been linked to ESTPs. The failure to recognise that some of these hazards are linked to tipping processes means that these systems may quickly prove inadequate, undermining the successes achieved to date. Crucially, it also risks generating a widespread false sense of security in existing EWS that could prove fatal. There is therefore an urgent need to integrate tipping processes and risks into EWS, and to revise impact forecasting and planning across the region in light of tipping.

However, anticipatory governance requires monitoring and early warning for both approaching ESTPs and their societal impacts (See Box 1.3.2), and it requires institutions and decision-making mechanisms at the science-policy interface that can respond to the observations made and early warning signals provided. In both aspects, major research, funding and institutional innovation gaps remain. First, there is a significant need to expand research regarding the social, economic, political and cultural impacts of ESTPs. Greater knowledge of impacts is needed at national, sectoral and local scales to inform **tipping point risk assessment processes** across multiple scales (see below) and enable planning, adaptation and preparedness.

Second, while scientific and technical capacities for Earth system monitoring are being fostered by some governments and institutions, they are not yet matched by institutional arrangements capable of translating early warnings into timely and context-specific responses. To address this gap, a set of new, specialised institutions might be needed to enable continuous learning, monitoring, risk assessment, foresight and rapid action/response to tipping dynamics (see Box 1.3.3).

Box 1.3.3: Bridging science and action for Earth system tipping points

A novel type of science-to-action institution could address the urgent need for effective, continuous and rapid science-policy interactions to support anticipatory governance for ESTPs. Tipping Element Monitoring and Rapid Response Facilities (TEMRFs) could be designed to strengthen the recognition, representation, and response to tipping dynamics in the Earth system. Their core purpose is to provide early warning and rapid response capacity for critical Earth systems that may cross non-linear thresholds with cascading consequences for societies and ecosystems. Unlike existing science-policy interfaces, which often operate at a distance from decision-making and focus on long-cycle assessments, TEMRFs would be regionally grounded – each one tied to one or more specific tipping elements – yet globally networked hubs that combine scientific monitoring, foresight, and direct engagement with policymakers and communities. A key feature is their commitment to multi-stakeholder and multi-scale governance, ensuring that Indigenous Peoples, civil society, and private sector actors participate alongside governments and scientists, thereby enhancing both legitimacy and actionability.

Functionally, TEMRFs would combine multiple units to operationalise a representation-recognition-response triad: an Observatory Unit to recognise early warning signals through real-time monitoring, an Impact Foresight Lab to map vulnerabilities and cascading effects, and a Rapid Response Group to support timely and coordinated policy development in response to Earth system changes. Organised as a distributed yet interoperable network, TEMRFs would rely on and contribute to global data availability, shared standards, and digital public infrastructure to ensure open access and coordination across scales.

Increasing participatory approaches to impact governance (Recommendation 5)

There has been increasing attention given to, and interest in the use of, participatory and deliberative approaches around key societal issues, including climate change (Escobar and Elstub, 2025). Citizens' assemblies and other forms of deliberative democracy offer a compelling approach for the challenges posed by ESTPs. They bring together diverse, demographically representative 'mini publics' of ordinary people in facilitated discussions on politically challenging topics. By engaging directly with dilemmas and trade-offs, they can generate consensual policies, mobilise citizens, foster solidarity, and act as a practical response to crises in institutional legitimacy. They can be deployed at any scale, including at the global scale (see Box 1.3.4), whether commissioned by institutions or independently.

Box 1.3.4: A permanent Global Citizens' Assembly: The potential of a civic infrastructure for deliberative governance of ESTPs

The Global Citizens' Assembly (GCA) brings deliberative democracy to the planetary scale. It aims to amplify people's role in global climate governance and to become embedded in the annual COP cycle. The GCA is composed of two interrelated deliberative components supported by a coalition of governments, NGOs, firms, and civil society actors, and a cultural engagement campaign.

Civic Assembly: a transnational mini public selected by global lottery, bringing a planetary perspective to issues that transcend national borders. Its key contributions in relation to ESTPs could include:

- Legitimising planetary decisions by providing global democratic legitimacy for responses to tipping points.
- Deliberating uncertainty by tackling long-term and complex risks that outpace typical political cycles.
- Elevating justice by enabling discussions of intergenerational, interspecies, and interregional justice.
- Synthesising knowledge by integrating Earth system science with ethical and cultural insights.

Community Assemblies: bottom-up, place-based deliberative spaces that translate abstract risks into lived experience and practical action. They could contribute to:

- Contextualising risks: local realities such as drought or biodiversity loss help make tipping points tangible.
- Surfacing diverse knowledge: Indigenous, traditional, and ecological knowledge enrich global understanding and point to better ways of measuring the outcomes to which policy aims.
- Mobilising stewardship: community assemblies foster locally led solutions in climate and ecological adaptation, resilience, and regeneration.
- Building trust: participation at the local level can help to build legitimacy and readiness for broader systemic change.

The interaction between the Civic and Community Assemblies has the potential to contribute to multi-scale, distributed and reflexive governance (Curato et al., 2025) for ESTPs. The GCA delivers emerging agendas from grounded, diverse perspectives and globally coordinated mandates that are rooted in lived realities.

According to OECD data, there were on average 47 deliberative participatory processes per year across a range of issues and countries over the period 2019-2023, compared to 32 per year over the previous (2014-2018) 5-year period (OECD 2023). While there has been a mixed picture in respect to the legitimacy of such processes and the uptake of their recommendations by policymakers (Lorenzoni et al. 2025), the growing prominence of participatory approaches indicates the feasibility and potential of engaging publics on critical issues including ESTPs.

Reforming impact governance mechanisms with a view to ESTPs (Recommendations 1, 2 and 3)

The task of reforming existing governance mechanisms can take many forms ranging from adjustments of existing policies (e.g. including ESTP scenarios and risks to adaptation planning processes) to changing policy frameworks (e.g. long-term development plans), adopting different decision-making logics (e.g. precautionary, mid-century planning), and institutional reforms (e.g. introducing different structures, entities or processes dedicated to addressing cascading dynamics).

The EU has taken initial steps in identifying relevant institutions and policy frameworks that are in need of review and reform in the light of tipping point risks (see Box 1.3.5). Similar efforts will be needed around the world, across multiple scales, including in international institutions, such as the UNFCCC's governance frameworks related to adaptation, loss and damage, and climate finance. Such review efforts need to consider which governance scale is the most appropriate for the allocation of responsibility for tipping risks, e.g. not to overburden local governments with managing large, regional-scale dynamics or abandon collective international responsibility for tipping risks by leaving responses to regional organisations or national governments.

Box 1.3.5: Research Insight: State of Governance ESTPs remain a blind spot in anticipatory governance in the EU

The crossing of ESTPs would cause severe, irreversible changes to the European climate, economy and society. Despite this growing threat, EU risk governance frameworks, including climate adaptation strategies and disaster risk reduction mechanisms, are largely based on gradually increasing risks and currently overlook tail risks (e.g. extreme weather events that fall outside historical trends) and ESTPs. Europe is already experiencing climatic tail risk events, such as unprecedented floods, droughts, and storms. Furthermore, socio-economic models underpinning EU policy assessments omit the nonlinear damages from extreme climate events and ESTPs, severely underestimating potential economic damages and socio-ecological impacts. While the EU has a package of prevention policies in place, the absence of anticipatory discussions to manage ESTP-driven crises remains a significant governance blind spot.

In 2024, a European Commission workshop (European Commission 2025; EU 2025a) considered this challenge and identified several initiatives and policy frameworks that offer key entry points to integrate ESTP risks into European governance, including in early warning systems, long-term resilience planning, and risk assessments to support decision-making of EU institutions. These entry points include national risk assessments as part of the Preparedness Union Strategy (EU 2025b), the European Climate Adaptation Strategy (EU 2021) and its forthcoming European Climate Adaptation Plan, and the second European Climate Risk Assessment (EUCRA), expected in 2028. As a way to unlock action and to bypass methodological uncertainties, a new impulse on narrative-based methods (e.g. science-based storylines) is starting to support risk assessment processes at European and national scales, complementing efforts to quantify future climate hazards. By embedding ESTP anticipatory action as 'no regret' initiatives within ongoing climate change preparedness measures, the EU has a unique opportunity to lead a global discussion on managing systemic, non-linear climate risks.

Climate change adaptation: A decade after the Paris Agreement's adoption, global climate adaptation governance remains characterised by profound asymmetries between the Global North and South, with 3.6 billion people currently considered highly vulnerable to climate change impacts (IPCC, 2023). Adaptation governance in developing countries faces severe constraints across multiple dimensions, especially financing (Carbon Brief, 2023). While Global North countries have generally developed more robust institutional frameworks for domestic adaptation, they also often fall short of what is needed to keep up with already observed climate impacts. In this context, the multi-scale **governance system for adaptation has yet to address tipping point risks**.

Vulnerability to ESTPs does not necessarily align with historical patterns of climate risk. Countries or communities often perceived as less vulnerable could suffer significant impacts and disproportionate burdens, while local authorities in many countries—currently tasked with major responsibilities for adaptation—lack the capacity to analyse or respond to such complex threats. For example, AMOC and SPG collapse would heavily affect Northern Europe in unexpected ways, and boreal forest loss would primarily impact highly developed countries such as Canada, the Russian Federation, and Finland. These shifts underscore the need for new risk and vulnerability assessments and mapping.

Effective anticipatory adaptation requires diverse and flexible strategies that can be scaled up, adjusted, or complemented with new approaches as conditions change. Rather than relying on static solutions that risk becoming costly or ineffective, adaptation portfolios must remain open-ended, combining multiple pathways to enhance resilience and provide space for learning and adjustment (Biesbroek et al., 2025).

One critical form of adaptation is mobility, yet access to this strategy is profoundly unequal (Parsons et al. 2024, Thalheimer et al. 2025). At the same time, **global migration governance** is becoming increasingly strained: traditional protection frameworks are being eroded, political resistance to migration grows (Appleby 2024; Wibisono 2024), and climate-related displacement remains largely unaddressed. These dynamics highlight deep tensions between human mobility, rights, and geopolitics (Micinski et al. 2023, Woodworth 2023, Ullah 2025)—trends that make introducing ESTP risks into governance especially challenging, but also ever more important to ensure just and effective responses.

Earth system tipping points will expose and accelerate situations where communities reach the limits of adaptation, intensifying debates about soft versus hard limits (Berkhout et al., 2024). While many climate impacts can be managed through adaptation measures, tipping points may generate changes so abrupt and widespread that adaptive responses become unfeasible, ineffective, or prohibitively costly. These 'adaptation tipping points' (Kwadijk et al. 2010; Juhola et al. 2022) result in residual loss and damage—harms that cannot be avoided, adapted to, or recovered from (McNamara and Jackson, 2018)—posing profound challenges for existing governance frameworks. Responding effectively will require **expanding Loss and Damage mechanisms** to account for the systemic, irreversible nature of tipping point impacts, including rethinking financial instruments, insurance models, and legal responsibilities, while ensuring affected communities receive support beyond what adaptation alone can deliver.

In sum, **key policy priorities** for fostering ESTP impact governance include:

- mainstreaming ESTP risks into adaptation and development planning,
- updating vulnerability assessments to reflect ESTP risks,
- strengthening international mobility governance, and
- expanding loss and damage mechanisms.

All the recommendations presented in GTPR 2023 remain important. Cross-cutting these recommendations is an urgent need to better understand and anticipate ESTP impacts. As such, the near-term focus in building ESTP impact governance should be on developing monitoring, early warning and response systems (see above), and integrating ESTP impacts into risk assessments at the local, national, regional and international levels (see below).

1.3.3 Integrating ESTP impacts into risk assessment

The need for multi-scale risk assessments: Anticipatory governance aimed at mitigating systemic risks from crossing ESTPs must commence with systemic risk assessments across national, regional, and global scales. These assessments are critical for understanding potential impacts, catalysing institutional and policy reforms, and aligning adaptation and disaster risk management strategies with the realities of tipping dynamics. A recent policy brief by the European Commission's Joint Research Centre (JRC) (Roman Cuesta et al., 2025) underscores this necessity, as does the scientists' letter to the Nordic Council of Ministers regarding the AMOC, which argued that a regional risk assessment process would be an important measure the Nordic governments should undertake. Such risk assessments should be participatory, engaging decision-makers across multiple policy domains as well as relevant experts and a wide range of stakeholders.

At the global scale, the IPCC provides a regular authoritative scientific assessment of climate change risks. It has included the risks of ESTPs in its assessment reports since 2001. AR7 expected in 2028 will include a chapter dedicated to tipping risks ('Abrupt changes, low-likelihood high impact events and critical thresholds, including tipping points, in the Earth system'). The World Climate Research Programme (WCRP) is currently undertaking a review of science to assess Earth system tipping risks, and we provide an assessment here in Section 2 of GTPR 2025.

National and regional developments: At the national level, several initiatives have recently emerged to start assessing risks that arise from ESTPs. For example, the Finnish Meteorological Institute and Atmosphere and Climate Competence Center launched a policy brief in 2024 focusing on AMOC risks in Finland (Merikanto et al., 2024). The German government mentioned ESTPs in its National Interdisciplinary Climate Risk Assessment (NIKE 2025). The Australian government is reviewing its Reef 2050 Long-Term Sustainability Plan (launched in 2015), including an assessment of the extent to which coral reefs have already tipped (Commonwealth of Australia 2021). In some cases, like the UK, these developments are driven by non-state actors: a report by the Institute of Public Policy Research has drawn attention to security risks arising from AMOC or SPG tipping (Laybourn et al., 2024).

Most of these analyses have been advanced in developed countries and with a focus on a single or pair of tipping processes with direct geographic relevance for the country. More initiatives of this kind are needed across the globe, especially in countries facing the consequences of proximate ESTPs, i.e. those we identify as at risk between 1.5°C and 2.0°C warming.

At the regional level, the first European Climate Risk Assessment (EUCRA) published in 2024 identifies 36 climate risks threatening Europe's energy and food security, ecosystems, infrastructure, water resources, financial stability, and public health. While tipping risks served as 'wild cards' in EUCRA's scenario narratives, the report did not consider ESTP-related risks systematically. Future EUCRAs and similar regional processes in other parts of the world (e.g. under the frameworks of the African Union, ASEAN, ACTO) could be developed or strengthened to consider tipping risks and to reflect context-specific vulnerabilities and enhance regional governance capacities. The EU's JPI Climate and JPI Ocean platforms recently initiated a risk assessment process of the AMOC.

Methodological challenges & data gaps: Integrating ESTPs into risk assessment processes, policy and planning faces several methodological challenges and information gaps. Common risk calculations based on probabilities are often not possible given high levels of uncertainty. Existing IPCC assessments and socio-economic models fail to capture the nonlinear, cascading nature of tipping points, leading to a drastic, systematic underestimation of the risk and economic costs from crossing ESTPs (Roman Cuesta et al., 2025). There is an urgent need for alternative approaches (e.g. a recent proposal in Norway (Norway, 2018) to consider consequences, probability, knowledge and strength of knowledge to assess climate risks instead of the standard formula multiplying probability with expected quantified impacts) and improved modelling frameworks that integrate biophysical and socio-economic dimensions. More generally, research on the social impacts of tipping processes is lacking, leaving large data gaps concerning social or economic indicators.

Given the nature of tipping processes, the high levels of uncertainty and the challenging time horizons that need to be considered, anticipatory and participatory futures and foresight methods (e.g., horizon scanning, scenario development) will play an important role in tipping risk assessments. Approaches such as simulations (e.g. AI-enhanced agent based modelling (Gao et al., 2024; Ghaffarzadegan et al., 2024), storylines and wild cards, already trialled in EUCRA (EEA, 2024), or what-if scenarios used in a UK report on ESTP security risks (Laybourn et al., 2024), could be used to assess ESTPs risks, including those that cannot be easily quantified (e.g. risks of civil unrest).

It will be important to co-produce tipping risk assessment processes with key stakeholders, who can bring their knowledge and risk response skills to the exercise. This includes Indigenous Peoples (e.g. in the Amazon rainforest or the Arctic) and local communities, who have valuable place-based knowledge and understanding that will enhance risk assessment and the identification of effective response options.

Box 1.3.6: ESTPs and financial risk management

Financial and insurance institutions and regulators are starting the urgent task of updating their risk frameworks to reflect the growing threat of ESTPs. These risks are politically pertinent for pension funds because of their relatively long time horizons and the fiduciary duty to beneficiaries. ESTPs are nonlinear, interconnected, and lack clear historical precedents, making them difficult to model using current financial and insurance risk tools, which often use econometric approaches based on prior experience (Lenton et al., 2019; Kousky, 2019; Trust et al., 2025).

Traditional financial and insurance risk management that is focused on incremental and historically grounded scenarios has proven inadequate in the face of systemic shocks, as was shown in both the 2007–08 financial crisis and the COVID-19 pandemic. In both cases, emergency interventions by governments and regulatory bodies were required to stabilise the system, underscoring the failure of ex-ante risk governance (Bolton et al., 2020). ESTPs pose a similar challenge but with even less capacity for reactive containment and recovery. Despite this, most stress testing and portfolio risk assessment methods undertaken by financial institutions continue to assume gradual climate trajectories. There are some recent efforts to take into account the possibility of extreme events in the short term (NGFS, 2025) but the assessment of tipping points risk is only just beginning. As a result, risk assessments generally overlook the potential for cascading system failures and cross-sectoral disruptions triggered by tipping events (Battiston et al., 2017). This leads to dangerous overconfidence in asset resilience and mispricing of long-term environmental and financial risks (FSB, 2025; Marsden et al., 2024; Trust et al., 2025; WEF, 2020). Even when the consequences of passing a tipping point will take time to play out, if such consequences are irreversible, financial actors will rapidly reprice assets accordingly. This bringing of future consequences into the present is an additional source of financial instability. The early manifestations of this emerging challenge can be seen with the withdrawal of insurance and the repricing of real estate in regions affected by increasingly frequent climate-related extreme events.

The degradation of ecosystems further compounds financial vulnerability and interacts with tipping dynamics. Natural systems provide essential buffers, such as flood protection and carbon sequestration, that mitigate the severity of climate impacts (Costanza et al., 1997; 2017). Yet these services are rarely valued in financial models (Dasgupta, 2021). Biodiversity, in this context, functions as "natural insurance", but its degradation remains largely invisible to current regulatory and market structures (NGSF, 2022; OECD, 2023; IPBES, 2024).

Financial stability is a critical concern in the face of Earth system destabilisation, and the lack of consideration of nonlinear dynamics in risk analysis is a critical barrier to effective governance. Urgent reforms are needed to embed tipping dynamics into financial, insurance, and related corporate governance frameworks. A precautionary approach to financial regulation that embeds ecosystem resilience and tipping dynamics into regulatory frameworks is essential (Kedward et al., 2023). This includes revising capital requirements, integrating nature-related risks into disclosure standards (UNEP, 2022), and steering financial flows away from activities that accelerate Earth system destabilisation (WEF, 2024). The financial and insurance systems and biosphere resilience are now deeply interdependent; governance that fails to reflect this will compromise both.

Note: The role of finance in triggering and preventing ESTPs is addressed in Chapter 1.2, and positive tipping points in the financial system are addressed in Chapter 3.2.

1.3.4 Justice and intergenerational governance

ESTPs raise profound and unprecedented justice challenges. Their impacts are not only global and potentially irreversible but also distributed unequally across time, space, societies, and communities. The governance of these impacts must therefore be rooted in a robust and explicit commitment to justice, both to ensure fairness in the face of disruption and to build legitimacy for decisions made under uncertainty. The concept of **Earth system justice** (Gupta et al., 2023) offers a guiding framework here. Within the conceptualisation of Earth system justice, interspecies justice is integrated with intragenerational and intergenerational justice, considering substantive and procedural elements.

Intragenerational equity: Who bears the burden today?

While climate tipping points are planetary in scale, their consequences will be highly uneven—both geographically and socially. Many tipping points will disproportionately affect those who live near vulnerable systems (e.g. Amazon basin communities, low-lying coastal states), those with already limited adaptive capacity due to poverty or marginalisation, and those directly dependent on ecosystems at risk of collapse (e.g. coral reef fisheries, rain-fed agriculture). Crucially, specific tipping points can not only amplify existing climate risks, but they also alter how risks, impacts, loss and damage are distributed across space and time. These dynamics can **make impacts significantly worse** for communities already vulnerable to climate change by increasing the magnitude, speed, and irreversibility of impacts. At the same time, ESTPs can generate **new types of vulnerability not previously recognised**—some in places that have historically been less exposed.

For instance, abrupt ice sheet collapse, permafrost thaw, or AMOC disruption, could have cascading effects on food security, infrastructure, and livelihoods in regions previously considered relatively insulated from the worst effects of climate disruption.

This evolving risk landscape demands a shift in governance thinking. Impact governance must not only prioritise and expand support for communities already at risk, but also anticipate and respond to emerging and new vulnerabilities, especially those that fall outside current adaptation frameworks. Planning and investment decisions must ensure an equitable distribution of adaptation resources and address irreversible harms in equitable ways. Mechanisms for loss and damage need to be significantly strengthened and expanded to reflect the long-term, systemic nature of tipping point impacts.

Emerging international frameworks—such as the Loss and Damage Fund and the Santiago Network—offer entry points for addressing these concerns. But to be truly effective, such frameworks must evolve to reflect the redistributive, unpredictable, and cascading nature of tipping point risks—across both the Global South and Global North.

Intergenerational responsibility: Who bears the burden tomorrow?

Perhaps the clearest justice issue raised by tipping points is **intergenerational**. Many tipping processes, such as ice sheets or ocean circulation, take place over extended time periods - decades to millennia, and their consequences will persist for centuries and millennia. Once passed, these thresholds commit future generations to living with radically altered Earth system conditions. Unlike other environmental risks, these changes cannot be reversed or "cleaned up" later - the impacts of the current generations' decisions will be permanent.

This deep **intertemporal asymmetry** creates a powerful moral imperative: today's decisions about ESTP prevention and adaptation will shape the basic life-support systems of tomorrow's societies. Governance must therefore be designed not only to protect current populations, but also to safeguard the rights and wellbeing of those yet to be born. This requires:

- Expanding the time horizons of policy and financial planning to consider temporal patterns of tipping (at least several decades).
- Strengthening legal and institutional mechanisms that represent future generations (e.g. ombudspeople, constitutional protections, or future councils).
- Embedding precautionary principles in high-stakes decision-making, especially when uncertainty intersects with irreversibility.

Legislation such as the Well-being of Future Generations (Wales) Act 2015 shows that this is possible. The Act places a duty on public bodies to carry out sustainable development. It requires public body decision-making to take account of the long term, to prevent generating and/or exacerbating problems, to take an integrated and collaborative approach, and to consider and involve people of all ages and diversity. However, such frameworks need to be drafted with ESTPs in mind, and be seen not merely as 'aspirational' (Stokes and Smyth, 2024) but as requiring urgent and accountable implementation.

Interspecies justice and ESTPs

Many non-human species are acutely vulnerable to tipping point impacts—especially those with limited ability to adapt to rapid environmental change, such as reptiles, amphibians, and most fish. Sudden habitat shifts may exceed the adaptive capacity of numerous ecosystems.

Human activity is a key driver of these tipping points, reinforcing our responsibility to act to protect non-human species. Ensuring interspecies justice requires a better understanding of the impacts of tipping processes on non-human species and ecosystems, and the actions that can protect ecological integrity. It requires governance that aligns development pathways with ecological and Earth system thresholds.

Some governments and institutions have taken initial steps to recognise the rights of nature—steps that need to expand globally to reflect the interconnected and cascading nature of tipping elements (see Chapter 1.4, subsection 1.4.7).

Procedural justice: Inclusion in decision-making

The domain of justice concerns the way decisions are made as well as their outcomes (Sen, 2009). Decisions about how to prepare for and respond to tipping point impacts will involve trade-offs across sectors, regions, populations and generations. Such decisions must therefore be made through processes that are transparent, participatory, and inclusive, and grounded in the values of respect, neutrality, trustworthiness and voice (Meyerson, Mackenzie and MacDermott, 2020, p.8). At the same time, they must be designed to facilitate urgent action and not become an undue obstacle (Ruhl & Salzman 2023). Yet many communities most at risk — including Indigenous Peoples, youth, women, older persons, and those with limited access to resources in both the Global North and the Global South — remain underrepresented in climate governance. In the context of tipping points, greater inclusion of such groups may improve decision-making processes and outcomes in the following ways:

- **Local and Indigenous knowledge** can complement scientific models, particularly those for tipping points with significant non-climate drivers (e.g., Amazon) and improve the legitimacy of adaptation decisions addressing localised impacts.
- **Youth representation** promotes consideration of future interests in present-day planning.
- **Multi-stakeholder forums** can help navigate complex trade-offs, build consensus, and reduce the risk of conflict.

Carefully building participatory governance processes into national and regional institutions is not only fair, but it also increases resilience by aligning policy with local realities, strengthens social trust, and promotes the perceived legitimacy of decision-making.

In summary, tipping points confront policymakers with hard questions about what kind of future we are preparing for, and for whom. The just governance of tipping point impacts concerns not only resilience, but also fairness between countries, communities, generations, and species.

1.3.5 Final remarks

As global warming approaches or exceeds 1.5°C, the risk of crossing ESTPs is a near-term possibility demanding immediate policy responses. Their impacts go beyond the scope of conventional climate policy and demand a new kind of impact governance—an approach that can anticipate and manage systemic change, protect the most vulnerable populations, and maintain social, political, and economic stability amid deep uncertainty.

Governance for tipping point impacts requires a fundamental shift in approach: from managing known risks to navigating the unknown; from improving existing systems to preparing for deep transformation; and from responding to short-term crises to building long-term resilience and advancing Earth system justice. A multi-phase governance framework is needed—beginning with early anticipation and preparedness, extending through rapid response as tipping thresholds are crossed, and continuing into the turbulent period of irreversible change that follows. This shift demands that we strengthen existing institutions, reform inadequate structures, and innovate new mechanisms that are fit for navigating tipping dynamics.

Most current governance mechanisms—whether in adaptation, disaster risk reduction, or economic planning—are not designed for the scale or speed of change that ESTPs entail. Institutional reforms and innovations are needed to enable real-time risk monitoring and coordinated policy responses. At the same time, governments must integrate tipping risks into national and regional assessments and use participatory foresight tools to inform planning in the face of uncertainty. While some regions have taken initial steps, global progress remains limited and uneven.

Justice must lie at the heart of impact governance. Tipping point impacts will fall unevenly across geographies, communities, and generations—exacerbating existing vulnerabilities while creating new ones in places previously considered secure. Governance must prioritise inclusion, fairness, and transparency to build legitimacy and maintain social cohesion in the face of upheaval. Ultimately, preparing for tipping points is not just about managing risks—it is about governing for a future that will be fundamentally different, and doing so in a way that is accountable, adaptive, and just for all.

1.4 A human rights framework for Earth system tipping point governance

Authors: Malcolm Rogge, Tomas Chaigneau, Lauren Gifford, Ben Hudson, Timothy M. Lenton, Aaron Marr Page, Manjana Milkoreit, Karen Morrow, Laura Pereira, Niko Soininen, Sebastian Villasante, Simon Willcock, Yulia Yamineva

Reviewers: Maja Groff, Louis Kotzé, David A. Armstrong McKay, Annalisa Savaresi, Jessica Seddon

Key Messages

- **Preventing Earth system tipping points and addressing their impacts are essential for the global protection of fundamental human rights.**
- **State and non-state actors must be adequately informed about the human rights implications of transgressing Earth system tipping points and governance responses to them based on the best available science.**
- **Tipping points science should be used to strengthen future litigation efforts related to human rights.**
- **We recommend convening a multi-stakeholder working group on human rights and Earth system tipping points, including the UN Office of the High Commissioner for Human Rights, scientific experts, Indigenous Peoples and civil society organisations.**

1.4.1 The vital role of human rights in ESTP governance

Human rights provide a potentially powerful and globally legitimate overarching normative framework to help guide ESTP governance. The core role that human rights play within the system of global climate norms was underscored by the recent advisory opinions of the International Court of Justice (ICJ, 2025) (Obligations of States in respect of Climate Change), the Inter-American Court of Human Rights (IACtHR, 2025) (Climate Emergency and Human Rights), and the International Tribunal for the Law of the Sea (ITLOS, 2024) (Climate Change and International Law), as well as the rapid proliferation of strategic litigation efforts around the world (see 3.2.2.3). The risks to human rights of crossing ESTPs have been cited as compelling evidence in recent landmark court judgments requiring state actors to act more decisively on reducing greenhouse gas (GHG) emissions. In examining these and other juridical developments, the chapter provides support for policymakers, scientists, legal experts, environmental defenders and other actors (see Chapter 1.5) who are driving systemic and transformative change in global legal and policy frameworks for addressing the climate crisis and ESTPs.

Human rights exist both as ethical concepts closely connected to the idea of justice (Sen, 2009) and as a mature regime of legally-binding norms and supporting institutions at the international, regional, and national levels. The 2023 Global Tipping Points report warned about the potentially “unequal and unjust consequences” of transgressing ESTPs (Key Messages, p. 8). Human rights frameworks are well-positioned to help understand and address these consequences, in conjunction with other normative tools. Critically, they help us understand both what is at stake and how to take action in the face of legitimate competing interests and priorities. Human rights frameworks are inclusive, especially with attention to the rights of future generations. They can be potent and persuasive communication tools for influencing public opinion, diversely situated policymakers and other strategic actors, including judges.

Like any other normative framework, human rights face legitimacy and practicality challenges, in particular as to enforceability and long-term societal impact in a time of growing inequality and persistent global injustice (Kotze, 2019; Moyn, 2019). There also exist patterns of political resistance to bringing human rights language into climate change negotiations (Wallbott and Schapper 2015), often making processes more contentious and difficult. Nonetheless, a diverse array of human rights norms, institutions, and practices have a proven record in guiding and constraining state and non-state actors in all regions of the world. As imperfect as they are, human rights will inevitably play a role in the motivation, conceptualisation and design of approaches to global ESTP governance, alongside other frameworks such as equity and justice (Pereira et al., 2024), the Earth system justice framework (Gupta et al., 2023), Earth stewardship (Chapin et al. 2022), and the lens of planetary resilience (Rockstrom et al., 2024).

The international human rights framework provides an overarching set of norms for addressing key governance challenges that are specific to ESTPs, including anticipatory governance, intertemporal decision-making, and systemic risk governance (on these challenges, see Milkoreit et al., 2024). In establishing principles and practices for tipping point governance, human rights laws and ‘soft law’ instruments provide baseline standards of conduct for states and non-state actors. Such instruments include, among others, the core UN-administered human rights instruments and enforcement mechanisms, the “UN right to a clean, healthy and sustainable environment” (General Assembly Resolution A/RES76/300), and the UN Guiding Principles on Business and Human Rights (UNGPs, 2011).

Non-state actors, such as businesses and non-governmental organisations, also play a key role in ESTPs governance (see Chapter 1.5), and they too require normative guidance and guardrails. A growing set of human rights norms apply directly and indirectly to these actors, including the UNGPs (UNGPs, 2011), the OECD Guidelines for Multinational Enterprises (OECD Guidelines, 2023), corporate sustainability governance frameworks (e.g. WBCSD, 2018), and national laws, such as the EU’s Corporate Sustainability Due Diligence Directive (CSDDD, 2024) and France’s 2017 Duty of Vigilance Law (Savourey & Brabant, 2021; Reinsberg & Steinert, 2024). Perhaps counter-intuitively, the human rights field can help formulate the ‘business case’ for taking urgent action on ESTPs. Transgressing ESTPs will lead to massive adverse impacts on the global economy (Institute and Faculty of Actuaries, 2025; Potsdam Institute for Climate Impact Research, 2025) and reducing the risk of such impacts is an important and legitimate concern for businesses. That being said, human rights, as ethical concepts, give priority to normative-ethical motivations over economic-instrumentalist motivations (Sen, 2009; Rogge, 2022). Thus, a human rights approach to ESTPs governance will give priority to the ethical motivation to prevent and mitigate harm to people and nature as ends in and of themselves.

1.4.2 Why ESTPs are a threat to human rights

Preventing ESTPs is essential for the global protection of human rights. Transgressing ESTPs will lead to dramatic and irreversible changes in regional and global climate and biophysical systems (see Section 2) with consequent severe adverse impacts on the human rights of hundreds of millions, even billions, of human beings, including future generations (IPCC AR6, 2023, Ritz, 2024). While these impacts can be described in many ways, they can be powerfully understood as violations of civil & political rights (ICCPR rights), economic, social and cultural rights (ESCR rights), environmental rights, Indigenous rights, and breaches of equity and justice (Wewerinke-Singh & Maxwell, 2025). The unjust impacts of climate change that already exist today could be exacerbated by the transgression of ESTPs, compounding harms to future generations (Rammelt et al., 2023; Pereira et al., 2023). ESTPs could also create new harms, changing the map of present climate-related vulnerability and impact distribution around the world. Such impacts threaten the foundational guarantee of human dignity expressed by the entire corpus of human rights law, as reflected in, among others, the Universal Declaration of Human Rights, the multi-state Charter of Fundamental Rights of the European Union, the national-level Constitution of the Republic of South Africa; the Constitution of the Republic of Ecuador, and the Basic Law for the Federal Republic of Germany (Ritz, 2024). As Ritz states, "[a]nthropogenic emissions largesse leading to the triggering of tipping points in the climate system most severely interferes with the right to life of millions across the planet..." (Ritz, 2024).

ESTPs give rise to two very different kinds of human rights risks: first, direct harms caused by abrupt and massive biophysical changes in the environment; second, indirect adverse human rights impacts from state and non-state responses to ESTPs risks. The direct biophysical ESTPs risks include, among others: widespread global shrinkage of crop growing areas; disruption of monsoons (e.g. West Africa); forest dieback in the Amazon Basin; degradation of savanna and drylands; die-off of coral reefs; die-off of mangrove forests; water eutrophication; and linked adverse impacts on global and regional food security, water availability, human health, housing and cultural identity (see Table 1.4.1).

Indirect human rights impacts include, among a wide range of adverse societal consequences, rising authoritarianism and crackdowns on civil liberties, the use of racist and discriminatory criteria in adaptation responses, further marginalisation of vulnerable populations, and the potentially adverse impacts of geoengineering (on the latter, see Lazard et al., 2025). The 2023 Tipping Points Report acknowledges that "[p]lanned relocation in close collaboration with affected communities will become increasingly necessary" (Key Messages, p. 23). If resettlement programs and other large scale adaptations are discriminatory, poorly designed, delayed through mismanagement, corruptly administered, imposed without meaningful stakeholder engagement (Buhmann et al., 2025), or carried out without the free, prior and informed consent of indigenous peoples (Hanna & Vanclay, 2013), there is a risk that ESTPs mitigation efforts themselves may violate human rights.

A summary of the threats to different categories of human rights of transgressing ESTPs, and how they can amplify the harms that may be caused by incremental climate change, is included in Table 1.4.1. ICCPR rights are at risk insofar as the impacts on human beings threaten peoples' freedom, dignity, and their very subsistence and survival. IESCR rights are at risk due to the adverse impacts on livelihoods and culture, labour conditions, and the viability of diverse existing human settlements. These rights are violated where there are disproportionate adverse impacts on marginalised groups within states and on the least developed countries. States are obligated to fulfil human rights for the most vulnerable groups (Pariotti, 2023), and this obligation implies that groups who are especially vulnerable to specific ESTPs risks must be protected (e.g. detrimental impacts on coral reefs and fishers; the adverse impacts on indigenous peoples of Amazon forest dieback). Non-discrimination, as a branch of both ICCPR and IESCR rights, requires that the rights of vulnerable communities should not be undermined in "green sacrifice zones" (see the 2023 Global Tipping Points Report, 4.2.4; Zografos & Robbins, 2020; Pereira et al., 2024).

Table 1.4.1: Human rights implications of climate change compared to Earth system tipping points

Human Right	Impact of general climate change	Additional/distinct impacts from earth system tipping points	Applicable human rights laws, statutes, and authoritative frameworks (not exhaustive)
Right to Life	Increased mortality from heatwaves, floods, wildfires, and disease spread.	Tipping points like AMOC collapse increase frequency/intensity of hurricanes; Greenland Ice Sheet melt more rapidly raises sea levels, threatening entire regions.	- UDHR Art. 3 - ICCPR Art. 6 - Sendai Framework for Disaster Risk Reduction
Right to Food	Crop failures due to drought, shifting seasons, pests, and storms, decline in fisheries.	Amazon dieback reduces rainfall in key agricultural zones (e.g. Brazil, Argentina); AMOC slowdown disrupts monsoon cycles, affecting agriculture in South Asia and Africa; coral reef collapse impacts fisheries.	- ICESCR Art. 11 - FAO Right to Food Guidelines - SDG 2
Right to Water	Glacial melt and drought reduce access to clean water; flooding contaminates supplies.	Permafrost thaw alters freshwater flows; AMOC and monsoon shifts drastically affect regional water cycles.	- ICESCR Arts. 11 & 12 - UNGA Resolution 64/292 - CEDAW Art. 14(2)(h)
Right to Health	Increased vector- and water-borne diseases; mental health crises; air pollution.	Environmental breakdown and associated uncertainty are detrimental to mental health; Permafrost thaw may release ancient pathogens.	- ICESCR Art. 12 - WHO Constitution - Paris Agreement - EU Charter of Fundamental Rights, Art. 35
Right to Housing	Coastal and inland displacement due to sea-level rise, fires, floods, and storms.	Greenland and West Antarctic Ice Sheet melt causes meters of sea-level rise; coral reef collapse removes natural coastal barriers; AMOC slowdown increases storm surges in certain regions.	- ICESCR Art. 11 - Paris Agreement Art. 8 (Loss and Damage) - OAS Convention Art. 21 - Kampala Convention (Africa)
Right to Development & Livelihoods	Economic stress from disrupted agriculture, fisheries, tourism, and infrastructure.	Coral reef dieback affects fishers and tourism; forest dieback undermines forest-based economies (e.g. Amazon & boreal regions); AMOC shifts impact global trade and GDP.	- ICESCR Art. 6 - ILO Convention 169 - SDG 8
Right to Culture	Loss of environmental heritage, practices, and traditional knowledge.	Coral reef loss undermines Indigenous and local cultural identity; forest degradation (e.g. boreal and Amazon) erases landscapes central to belief systems and oral traditions.	- UNDRIP Arts. 11, 25, 29 - ICESCR Art. 15 - AU Charter Arts. 17(2) and 22(1)
Right to Self-Determination	Marginalised communities face disproportionate harm with little say in climate governance.	Small Island states risk complete submersion (e.g. Tuvalu, Maldives), challenging sovereignty; forest-dependent Indigenous nations lose territorial integrity.	- UN Charter Art. 1(2) - UNDRIP Art. 3 - AU Charter Art. 20
Right to a Healthy Environment	Degradation of biodiversity, ecosystems, and air/water quality.	Transgressing tipping points will cause irreversible collapse of ecosystems (e.g. Amazon, coral reefs); permafrost thaw and albedo loss from ice sheets, thereby accelerating global degradation of ecosystems.	- UNGA Res. 76/300 (2022) - CBD (1992) - UNCLOS Arts. 192–194
Rights of Future Generations (Intergenerational Justice)	Current emissions threaten future generations' access to basic needs and livable climate.	Tipping elements risk locking in irreversible changes beyond human control, disproportionately harming those not yet born.	- Rio Declaration Principle 3 - UNFCCC Preamble - Our Common Future - UN Declaration on Future Generations - Maastricht Principles on the Human Rights of Future Generations

As the examples above show, ESTPs, if transgressed, will have direct impacts on millions and even billions of people, particularly the most vulnerable groups and populations, pushing them into poverty, deprivation, and conditions of forced migration.

1.4.3 The overarching human rights obligation to tackle the drivers of ESTPs

The primary positive human rights obligation of states related to ESTPs is the obligation to take science-based steps to prevent and mitigate the adverse effects of climate change and to adapt where necessary (ICJ, 2025, paras 72-87; 268, 273; KlimaSeniorinnen, 2024). Such steps require not only that states take responsibility for their own actions, including the actions of state-owned enterprises, but also that they effectively regulate the economic activity and business conduct of non-state actors (ICJ, 2025, para 428; IACtHR 2025, para 353). The ICJ has explicitly acknowledged "the obligation of States to regulate the activities of private actors as a matter of due diligence" (ICJ, 2025, para 428). Regulation must pertain to the negative obligation on states to not increase GHG emissions; and this negative obligation implies corollary responsibilities for businesses (McVey & Savaresi, 2025).

As the key driver of ESTPs is global temperature increase, the "heart of effective prevention strategies" lies in accelerated climate change mitigation (see Chapter 1.2). ESTPs can be divided into two groups: those that are nearly entirely climate-driven and are not sensitive to anything but mitigation as a prevention strategy (e.g. AMOC collapse), and those with both climate and non-climate-related drivers. Thus, the human rights obligation on states to prevent and mitigate ESTPs pertain to two different processes (see Chapter 1.2):

1. Prevention and mitigation of ESTPs predominantly driven by climate,
2. Prevention and mitigation of ESTPs driven by a combination of climate and non-climate drivers.

These two categories imply different but complementary human rights obligations on states (on the two different processes, see Table 1.2.1).

For ESTPs driven by a mix of climate and non-climate drivers, state obligations require targeted actions that, in some cases, have a regional focus. So, for example, in coral reef die-off, state obligations arguably include taking specific prevention actions, such as reducing water pollution/nutrient sediment, and reducing disruption caused by shipping and over-harvesting of reef fish. In the Amazon forest, state obligations arguably include reducing deforestation and degradation which will require regional and national policies that are tailored to meet the specific environmental threats that may arise from agricultural expansion, mining, oil drilling, and human settlement (see Table 1.2.1). Regional and international co-operation on land use management changes and resource allocations are needed to prevent Amazon tipping points and their consequent adverse impacts on human beings and nature (Box 1.2.2). The need for multi-scale, cross-border co-operation is supported by the ICJ's 2025 Advisory Opinion, which affirms that "[c]limate change is a common concern" and that states have a legal duty to co-operate with other states to prevent significant harm to the environment, including by avoiding transboundary pollution (ICJ, 2025, paras 301-307; 347-349).

While preventing harm from transgressing ESTPs is a priority human rights obligation in and of itself, the approaches taken by state and non-state actors to prevent specific ESTPs (e.g. to prevent coral reef and Amazon forest die off) must also be guided by human rights norms, particularly with regard to the potential unintended negative impacts of on affected populations. With the huge diversity and scale of action that is needed around the globe, it is inevitable that some ESTP governance interventions will have controversial or contested elements. In this regard, states are obliged to protect and respect the human rights of affected populations who may, now or long in the future, be critical of, or protest against, specific ESTPs governance interventions.

1.4.4 ESTP science: a trend towards greater judicial acknowledgement of nonlinear risks

The effective protection of human rights today and in the future requires state and non-state actors to be fully informed by the science of ESTPs. As recognised by the ICJ in its 2025 Advisory Opinion (ICJ, 2025), and expressed in Articles 4.1 and 14.1 of the Paris Agreement, states have an obligation to undertake rapid reductions of GHG emissions in accordance with best available science (Paris Agreement, 2015; Ritz, 2024). Integrating best available ESTPs science as summarised in this report has the potential to drive a paradigm shift for global legal advocacy efforts, policymaking, and for ESTPs-aware judicial determinations. Adducing scientific evidence that demonstrates how severe harms to human beings and ecosystems will occur if ESTPs are transgressed helps to boost the legal case for taking urgent action "to pursue a warming limit below likely tipping thresholds" (Ritz, 2024).

The adverse human rights impacts of transgressing ESTPs have been noted in a small, but important, number of recent climate change cases. A key domestic case is *State of the Netherlands v. Stichting Urgenda*, in which the Supreme Court of the Netherlands emphasised that any delay in climate action "creates a greater risk of an abrupt climate change occurring as the result of a tipping point being reached." (State of the Netherlands v. Stichting Urgenda, 2019, summary). In *Urgenda*, the court ruled that the right to life (article 2) and right to family life (article 8) of the European Convention on Human Rights (ECHR) require states to take adequate measures to address the "real and immediate risk to people's lives or welfare" posed by climate change, including abrupt changes that may be brought on by reaching tipping points (State of the Netherlands v. Stichting Urgenda, 2019, at 5.6.2; see Jodoin, et al., 2024). The link between ESTPs and human rights harm was also recognised in the German Federal Constitutional Court's groundbreaking *Neubauer* decision (Neubauer, et al. v. Germany, 2021), which required Germany to accelerate its GHG reduction targets (Sabin Center & Grantham Institute, 2025; Kotzé, 2021).

Regional human rights courts are important fora for ESTPs-informed legal advocacy. In the European Court of Human Rights' (ECtHR) Grand Chamber decision in *KlimaSeniorinnen*, the Court referenced the claimant's contention that, "…that there was a real risk of exceeding critical further thresholds known as 'tipping points', and that significant climate change mitigation measures had to be taken as a matter of extreme urgency to avoid the most catastrophic impacts, even if all impacts could no longer be avoided" (KlimaSeniorinnen, at para. 334; the court also refers to tipping points at para. 397). In its decision, the ECtHR draws a direct link between the risk of irreversible harm and state human rights obligations:

> "…taking into account the scientific evidence regarding the urgency of combating the adverse effects of climate change, the severity of its consequences, **including the grave risk of their reaching the point of irreversibility**, and the scientific, political and judicial recognition of a link between the adverse effects of climate change and the enjoyment of (various aspects of) human rights (see paragraph 436 above), the Court finds it justified to consider that climate protection should carry considerable weight in the weighing-up of any competing considerations."
>
> *[KlimaSeniorinnen, 2024, at para. 334, emphasis added]*

The ECtHR emphasised that states' human rights obligations to protect the climate system arise from "the urgency of the situation and the risk of irreversible harm," and expressed deep concern about the "prospect of aggravating consequences arising for future generations" (KlimaSeniorinnen, 2024, at para 420).

In *KlimaSeniorinnen*, the ECtHR emphasised the importance of keeping up to date on climate science for the purpose of protecting human rights. The Court noted that Swiss Federal law requires that government action on climate change and GHG emissions must be taken "in the light of current scientific knowledge and experience" and that the government "shall take into account the latest scientific knowledge" (KlimaSeniorinnen, 2024, at paras 122 and 127). The decision of the ECtHR is binding on Swiss authorities and sets an important precedent for the rest of Europe; it also has the potential to influence decisions in courts around the world (Savaresi, 2025).

As the reach of ESTP-aware jurisprudence expands, governments may be required to incorporate ESTPs science and impacts into their assessments and action plans. This line of argument is supported by the 2024 ITLOS Advisory Opinion on climate change obligations under the UN Convention on the Law of the Sea – the Tribunal referenced scientific evidence on climate tipping points to support its conclusion that the standard of the state due diligence obligation is a stringent one (ITLOS 2024, para 398).

As the cases above indicate, Courts are beginning to take note that the risk of crossing irreversible tipping points poses a threat to the human rights of billions of people, and that this threat increases the urgency of prevention action needed. In line with this trend, the IACtHR explicitly refers to tipping points in its 2025 Advisory Opinion, recognising that, "[t]he increase in the global average temperature also increases the probability of exceeding the **tipping points**" (IACtHR, 2025, at para 197, emphasis in original). The Court acknowledges the heightened risks of crossing tipping points at 1.5°C and above, and the potential for cascading effects: "[t]he feedback between these crucial points could increase the risk of triggering a global cascade in which other tipping points are exceeded, including the uncontrolled release of carbon from permafrost and the devastation of coral reefs" (para 197). Human rights claimants, their legal advocates, and policymakers in all parts of the world are now in a position to highlight the IACtHR's explicit acknowledgment of the dangerous human rights impacts of transgressing tipping points.

Looking ahead, ESTPs-informed climate litigation efforts have the potential to drive a paradigm shift in climate law. Drawing on ESTPs science, legal advocates can contribute to the formation of high-impact ESTPs-aware judicial decision-making. By building on prior successful cases, and by framing new claims within the nonlinear ESTPs paradigm, advocates can powerfully amplify the urgent need for stringent prevention obligations for states and non-state actors, as well as positive mandates (see Section 3.2).

1.4.5 Preventing regional tipping points: the urgent need to protect environmental defenders across the globe

Climate and environmental human rights defenders (also called "nature defenders" or "ocean defenders") play an integral role in worldwide efforts to raise awareness about the impacts of climate change and the risks of crossing tipping points. They also play a key role in encouraging state and non-state actors to take action to prevent and mitigate against ESTPs (United Nations UNECE End of Mission Statement, Forst, 2024; United Nations UNECE Statement, Forst, 2024; United Nations OHCHR Report, Morgera, 2024). The increasing threats to environmental defenders in both Global South and Global North (Front Line Defenders, 2024) makes their work more difficult and dangerous, and thus holds back progress on ESTPs prevention (see Section 1.2; United Nations UNECE End of Mission Statement, Forst, 2024). Environmental defenders face increasing marginalisation, intimidation, criminalisation, threats, violence, and murders, around the globe (UNECE Statement, Forst, 2024; Civic Freedoms and HRD Database). The failure to protect the human rights of environmental defenders must be urgently rectified by states, businesses, and civil society (Bennett et al., 2023). Protecting these defenders - who include Indigenous leaders, farmers, scientists and academics, paraecologists, lawyers, journalists, artists, entrepreneurs, and ordinary people - is more important than ever before (on how businesses can protect environmental defenders, see Freeman & Handagard, 2025).

Environmental defenders operate across scales – nationally, regionally, and internationally – and face different human rights risks in diverse contexts. One of the most prominent examples concerns the Amazon rainforest where, if tipping points are transgressed (causing Amazon forest dieback), the adverse human rights impacts on Indigenous and forest-dependent people will be severe, and may include the destruction of their culture and way of life. Such impacts will also have adverse human rights impacts on the millions of non-Indigenous people also living in the Amazon region, and these impacts will reverberate far beyond the Amazon itself. State repression and non-state threats and attacks on Indigenous human rights and environmental defenders in the Amazon region further undermine progress on prevention of ESTPs. In this respect, state and non-state repression of environmental and climate defenders constitutes an indirect non-climate driver of Amazon forest dieback (Box 1.2.3).

Deforestation and degradation in the Amazon region are exacerbated by illegal forestry, legal and illegal mining, oil development, and the marginalisation of Indigenous and rural populations (Siqueira-Gay & Sánchez, 2021; UNGA Report, Forst, 2017). Avoiding deforestation and increasing reforestation are critical to avoiding ESTPs (see Box 1.2.3); and yet, in some cases, the pursuit of these very goals has been linked to human rights abuses (UN OHCHR Report, Tzay, 2023; see 1.4.3, above). At scale, the aggregate effects of conflicts over land use management throughout the multi-state Amazon region have the potential to hold back ESTPs prevention efforts (Amazon Cooperation Treaty Organization, 2023). The achievement of net-zero forest loss on what remains of the Amazon and the restoration of 5 per cent of the biome (see Box 1.2.3) is unlikely to occur if the human rights of environmental defenders and Indigenous people are not respected and protected by state and non-state actors. To protect environmental defenders in the multi-state Amazon watershed, "coordinated cross-scale approaches" (see Box 1.2.3) are needed. To this end, legal advocates in the region are in a position to use ESTPs science while leveraging human rights obligations that have been acknowledged by the ICJ (ICJ, 2025) and the regional IACtHR, including the right to a healthy environment (IACtHR, paras 269-286) and indigenous environmental rights (Case of the Kichwa Indigenous People of Sarayaku v. Ecuador, 2012).

1.4.6 Taking action: Examples from the United Nations treaty bodies and the financial sector

United Nations treaty bodies

Now is the time for human rights advocates and policymakers working at the UN-level, including members of the UN treaty bodies, to shift from the predominantly linear paradigm of climate change to the nonlinear and dynamic paradigm of ESTPs. This shift can be made by creating UN-level and intergovernmental learning networks and platforms for collaborating with ESTPs physical and social scientists.

Drawing on this report and the 2023 Global Tipping Points Report, UN treaty bodies, and those who support their work, are in a position to frame their deliberations and statements on human rights and climate change within the ESTPs paradigm; and, in doing so, they are positioned to emphasise the severity, scale and urgency of climate-related threats to human rights. For instance, the Human Rights Committee's 2018 General Comment on Art. 6 of the International Covenant on Civil and Political Rights (ICCPR) can be updated to explicitly state the severe threat posed by ESTPs. The 2019 General Comment notes that, "[t]he obligation of states parties to respect and ensure the right to life extends to reasonably foreseeable threats and life-threatening situations that can result in loss of life" (United Nations Human Rights Committee, 2019, para. 7). In a similar vein, the UN Human Rights Committee is in a position to update its 2018 statement that climate change is one "of the most pressing and serious threats to the ability of present and future generations to enjoy the right to life" – appropriate updates will reflect the severity of harm, scale, and urgency associated with transgressing ESTPs. Other UN treaty bodies, such as the Committee on the Elimination of Discrimination against Women (CEDAW) are also in a position to shift to the ESTPs paradigm in their periodic reports, as these bodies have already found that states have an obligation under international human rights norms to mitigate climate change (see: Mayer, 2022; United Nations OHCHR, 2018, para 2; United Nations, OHCHR, 2023, para 3).

Integrating human rights risk from ESTPs into due diligence in the financial sector

Over the past decade, concerns about human rights risks to people and their relationship to business risk have gradually migrated into corporate governance and finance norms (Rogge, 2022; Litwin & Savourey, 2025). The global finance sector and its regulators play an important role in implementing the human rights framework for ESTPs governance. Financial firms, banks, and the businesses that they invest in should integrate ESTPs human rights risk analysis into all aspects of risk mapping (see Chapter 1.2.3.2). Such mapping should also consider the human rights risks of implementing carbon credits and mitigation technologies in response to ESTPs, including geoengineering (United Nations OHCHR Report, Morgera, 2024) (on geoengineering, see Chapter 1.2). At a minimum, financial sector and corporate ESTPs human rights risk analysis should align with the authoritative standards for human rights due diligence set out in the UNGPs (UNGPs, 2011) and the OECD Guidelines for Multinational Enterprises (OECD Guidelines, 2023).

Adequate financing is needed to help prevent the severe human rights impacts of transgressing tipping points. In line with the state and non-state human rights obligations considered above, intergovernmental and multilateral institutions (e.g. multilateral financial institutions, development banks) have an obligation to take action to prevent and mitigate ESTPs risks. At the same time, loans, insurance mechanisms, and other financial instruments extended to vulnerable countries for mitigation and adaptation in response to ESTPs risks should not worsen those countries' ability to develop and maintain appropriate social infrastructure. In other words, financial mechanisms that support ESTPs prevention and mitigation must also support human rights, thriving communities, and healthy environments for all people. ESTPs human rights risk analysis should be incorporated into the performance standards and grievance mechanisms of major financial institutions (e.g. IFC performance standards and Compliance Advisor Ombudsman process.

1.4.7 Leveraging the rights of nature for preventing and mitigating ESTPs

ESTPs pose a threat not only to human beings, but to nature itself. In the first Tipping Points Report 2023, it was recognised that there is "a need to consider not just humans but the rights of all species to exist on a healthy planet" (Section 4.6.1). The IACtHR's 2025 Advisory Opinion acknowledges the "increasing recognition of … the rights of Nature at the global level" (IACtHR, para 285). In lengthy groundbreaking decisions, Ecuadorian courts, including the Constitutional Court, have detailed clearly how human rights, the right to a healthy environment, and the rights of nature are interdependent and mutually reinforcing concepts (Los Cedros case, 2021; Llurimagua case, 2023). Incremental advances towards granting nature legal personhood and rights have occurred in many other jurisdictions (see Global Network on the Rights of Nature database). The emerging rights of nature jurisprudence has potential to inform policymaking in regards to ESTPs (for an example pertaining to coral reef ecosystems, see Earth Law Center, 2025). While global momentum builds around the rights of nature, states and non-state actors should not be guided solely by human rights norms; rather, they should also drive transformations that respect and enhance the rights of nature - not for instrumental human benefit, but for the intrinsic value of nature in and of itself (Avila Santamaría, 2024; Rodríguez-Garavito, 2024). Human rights and the rights of nature are interdependent and mutually reinforcing: the rights of nature and "interspecies justice" can only be realised if states uphold their duty to protect, respect, and fulfil human rights; and only if non-state actors, including businesses, respect human rights.

1.4.8 Conclusion: Towards an ESTPs-driven human rights and climate law

No human rights can be, or will be, fulfilled in a significantly compromised biosphere. The impacts of climate change are already throwing people into extreme distress, poverty, and ruin. If ESTPs are transgressed, conditions will worsen dramatically for already vulnerable communities and additional vulnerabilities will emerge. The best way to protect the threats to human rights of ESTPs is to prevent them from occurring in the first place. State and non-state intervention should prioritise delaying or permanently avoiding ESTPs and slowing the rate of their impacts (see Chapter 1.2). When prevention fails, just impact governance is needed to reduce exposure and vulnerability to ESTPs impacts (see Chapter 1.3). Drawing on the information contained in this report and the 2023 Global Tipping Points Report, advocates and jurists are in a position to drive an ESTPs-informed paradigm shift in human rights and climate law - this shift has the potential to accelerate ESTPs prevention and mitigation efforts by states and non-state actors. It must be acknowledged that there remain difficult legal doctrinal hurdles to overcome in the evolution of human rights and climate law (Ahmad, 2024) and in the development of ESTPs-informed jurisprudence. Nonetheless, significant progress has been made over the last decade (Leghari v. Federation of Pakistan, 2015; State of the Netherlands v. Urgenda Foundation, 2019; Neubauer, 2021; ITLOS, 2024; KlimaSeniorinnen, 2024; ICJ, 2025; IACtHR, 2025) and promising legal advocacy efforts continue apace around the world (Rodriguéz-Garavito, 2022; Aristova & Nichols, 2024, Tigre et al., 2025).

1.5 Actors, agency and strategies in Earth system tipping points governance

Authors: Ben Hudson, Manjana Milkoreit, Yulia Yamineva, Bernardo Flores, Margot Hurlbert, Karen Morrow, Leila Niamir, Malcolm Rogge, Stefanie Rynders, Jürgen Scheffran, Viktoria Spaiser, Joan David Tàbara, Sebastian Villasante, Simon Willcock

Reviewers: Michele M. Betsill, Maja Groff, Jessica Seddon

Key messages

- **Earth system tipping points (ESTPs) require engagement from not only national governments and international bodies, but also municipal, regional, corporate and community actors, each of whom have particular responsibilities, capacities and opportunities to influence outcomes.**
- **Diverse strategies are needed to address ESTPs—ranging from law and policymaking to advocacy, institutional reform and storytelling—drawing on the varied capacities, mandates and influence of actors operating across multiple scales and domains.**
- **In this early agenda-setting phase of ESTP governance, actors such as international organisations, science communicators and advocacy groups have a critical role to play in raising awareness, shaping narratives and mobilising political will.**
- **Addressing ESTPs requires building trust and fostering cooperation and coordination among state and non-state actors across multiple levels of governance.**

Earth system tipping points (ESTPs) have relevance for many governance actors across varying scales and they affect everyone – individuals, institutions, organisations and communities. This is because of the diversity of ESTP drivers and impacts, their geographical spread, and the potential for cascading effects. Moreover, the nature and scale of ESTPs are likely to overwhelm the capacity of any single governance actor.

Urgent action is needed to prevent crossing tipping points (see Chapter 1.2) and to prepare for their impacts (see Chapter 1.3). Multiple actors need to engage and take advantage of strategies that are available to them. For example, existing state institutions across scales, especially at the international level, need to adopt responsibilities for ESTP governance and define a corresponding agenda. This chapter maps the actor landscape and action options. Focusing on the current, early state of governance efforts related to ESTPs, the chapter explores the most immediate engagement needs in the short and medium term – learning and awareness raising, mobilising, agenda-setting, developing and initiating governance reforms and innovations, and coordinating across multiple stakeholders. It then discusses critical challenges key actors face.

1.5.1 ESTP governance functions

Governing ESTPs requires mobilising a diverse set of actors – this is because each performs particular functions related to the specific characteristics of ESTPs that cannot be easily substituted by others. Two features of the governance problem make this especially clear.

1. **Global systemic interdependence.** Tipping points such as AMOC collapse or Amazon dieback are planetary in scale, yet regionally and locally varied in their triggers and consequences. They cannot be governed piecemeal or by any single state. International organisations and intergovernmental forums therefore play a necessary role in providing planetary reach, convening actors and legitimising the issue. In the absence of dedicated treaties, early agenda-setting at the UN and similar bodies is essential to anchor ESTPs as a collective governance challenge. At the same time, ESTPs require governance across multiple scales, including the distinct regional (multi-country) scale of specific tipping systems. Taken together, these features underline the need for a multi-scale, multi-stakeholder, networked and participatory approach to governance.
2. **High uncertainty and scientific complexity.** ESTPs involve nonlinear dynamics, cascading effects, and thresholds that are difficult to identify with precision. In the absence of established norms or institutional frameworks, policymakers depend heavily on scientific communities and knowledge brokers to understand the biophysical processes of ESTPs, communicate risks, and establish credible and compelling reasons for why acting on tipping points matters. The role of the ESTP science community is not only to communicate uncertainty but also to support rapid learning and enable decision-makers to act on what is known. Scientific uncertainty is often used to justify inaction, yet, from a precautionary and anticipatory perspective, it is instead a strong reason to take measures that minimise threats to human wellbeing (see Report Introduction and Chaper 1.1).

Different actors assume varying degrees of importance throughout **different phases of the governance process.** Drawing on the established policy cycle framework (Howlett, 2009; Jann and Wegrich, 2007; Howlett et al., 2017), but operating within a larger, multi-scale system characterised by multiple institutional layers and cross-scale interactions, four main phases can be distinguished in ESTP governance:

3. **Agenda-setting:** This phase involves defining the problem, identifying governance objectives and scope, establishing foundational principles, facilitating learning processes, conducting risk assessment, and enabling interest formation among relevant stakeholders. Key activities include framing tipping point risks, building scientific consensus, demonstrating political salience for action and mobilisation, and adopting institutional mandates for the problem.
4. **Policy formulation:** This phase encompasses developing and designing ESTP governance responses, including norm entrepreneurship, reforms of existing policies and institutional mechanisms, selection of new policy instruments, and devising novel policies, initiatives, offices or organisations. It involves evaluating and contesting competing proposals through deliberative processes across multiple governance venues.
5. **Implementation:** This phase involves making concrete decisions about which measures to pursue, applying rules and ensuring enforcement, allocating resources, and coordinating action across different scales and sectors. This phase is particularly challenging for tipping points due to their cross-boundary nature and long-term horizons.
6. **Monitoring and adaptation:** This phase encompasses tracking the effectiveness of governance measures, assessing advancing scientific understanding of tipping point dynamics, evaluating institutional performance, and adapting governance approaches based on new evidence and changing conditions. It includes feedback mechanisms that inform subsequent policy cycles.

These phases represent complex, iterative and often overlapping processes that may proceed at different speeds across issue domains, sub-topics and governance venues. For instance, we might observe rapid responses to ongoing and observable phenomena, such as coral reef decline, through international initiatives and local management measures. Yet, there might be hesitancy and slower institutional reaction to less visible and more uncertain threats such as AMOC tipping. This is in part due to the absence of clearly designated responsible actors, as well as the longer-term, seemingly less tangible nature of the risks involved.

The four main phases of the governance process outlined above are conceptually independent of the three-phase governance framework we introduced in Chapter 1.1, Figure 1.1.1 (pre-tipping, reorganisation, stabilisation). Based on the assessment in this report (see Sections 2 and 3), the initial agenda-setting phase co-occurs with the pre-tipping phase for most tipping systems.

At the current phase of **agenda-setting for a new governance problem**, particular actor functions are needed: knowledge actors to clarify risks and enable learning, international organisations to establish legitimacy, governments to translate global concerns into political traction, and civil society and media to raise salience. Other actors—such as financial institutions, funders and transnational networks—will become increasingly central as governance moves into policy design and later implementation. Below we scope the larger landscape of relevant ESTP governance actors, with a particular focus on their roles in the current agenda-setting phase of governance and the following policy formulation phase.

1.5.2 The ESTP actor landscape

Table 1.5.1 maps the range of actors relevant to ESTPs, outlining their agency and the strategies they can employ across the agenda-setting and policy formulation phases of the ESTP governance process. It also identifies challenges when engaging with ESTPs. Table 1.5.1 is indicative, not exhaustive, of the range of governance tasks and functions needed, but what is clear is that **actors in all categories have reasons to engage with ESTPs, as well as distinct capabilities to do so.**

Table 1.5.1: ESTP actors, agency and challenges

Actor category	Distinctive value for ESTPs	Phase 1 (Agenda-setting): Key activities	Phase 2 (Policy formulation): Key activities	Challenges and constraints
1 **Science and knowledge actors** (e.g. IPCC, IPBES, Future Earth, Earth System Governance Project)	Provide authoritative knowledge on thresholds and cascades; develop early warning indicators; translate complex Earth system science into actionable concepts.	• Define and communicate tipping elements and risks. • Build consensus on ESTPs as relevant to governance. • Engage in high-level science–policy dialogues (e.g. IPCC).	• Deliver risk typologies, decision triggers, menus of no-regret options and adaptive pathways. • Develop scenarios and early warning signals. • Support scenario exercises and risk assessments.	Gaps and inefficiencies at the science-policy interface; resource limitations; effectively communicating high uncertainty.
2 **International and regional organisations & treaty bodies** (e.g. UNFCCC, CBD, UNEP, WMO, UNGA, OECD, ACTO, Arctic Council)	Provide global legitimacy; convene states; mandate work programmes; embed ESTPs into existing international regimes, processes and policies.	• Put ESTPs on the agenda. • Commission reports. • Organise agenda-setting dialogues and special sessions. • Adopt tipping specific mandates. • Coordinate varying stakeholders.	• Establish work programmes, shared glossaries and task forces (e.g. on the cryosphere, forests, AMOC). • Develop reporting templates and coordination platforms.	Siloed mandates; path dependencies in unwieldy processes with low ambition expectations; lack of enforcement power; geopolitical tensions; resource constraints.
3 **National governments** (custodians and emitters, e.g. Brazil, Arctic States)	Exercise regulatory control over land, ecosystems and emissions; set foreign policy; signal political salience; control access to critical data.	• Participate in high-level discussions. • Identify national interests. • Support science and data collection. • Enable data access with digital public infrastructure.	• Develop national tipping risk assessments. • Revise climate mitigation and adaptation policies. • Make contingency plans (e.g. on coral reef loss, AMOC tipping). • Lead club-style initiatives (e.g. carbon removal scaling).	Competing priorities; short-term electoral cycles; political economies tied to fossil fuels; uneven state capacity.
4 **Subnational and city governments** (e.g. C40, ICLEI, governor alliances)	Act as laboratories for rapid innovation; manage implementation levers in land use, infrastructure and climate adaptation.	• Pilot awareness campaigns. • Join transnational city/ province networks.	• Test early warning protocols. • Experiment with zoning rules and local monitoring schemes.	Limited fiscal and legal authority; multiple levels of bureaucracy can slow or hinder action.
5 **Courts and legal actors**	Agenda amplification; rule clarification; signalling legal risk to states and private sectors; accountability and enforcement; precautionary leverage.	• Climate litigation can force recognition of ESTPs as part of broader climate/ biodiversity cases. • Can establish mandates that help to accelerate action.	• Judgments and legal opinions shape how tipping points are framed in policy design; ensure new policies are legally defensible.	Typically reactive; largely constrained by the cases and questions brought before them.
6 **Civil society organisations** (NGOs, advocacy groups, social movements)	Translate science into demands; mobilise public opinion; act as watchdogs against policy capture; build justice frames linking ESTPs to equity and livelihoods.	• Campaign for recognition of tipping points as urgent risks. • Link ESTPs to broader climate justice debates.	• Stress-test draft policies for legitimacy and equity. • Propose accountability scorecards. • Build coalitions across issue areas (e.g. climate, biodiversity, human rights).	Resource and financial limitations and dependencies; limited access to formal decision-making processes; vulnerable to restriction by governments.
7 **Indigenous Peoples and local communities**	Can be stewards of ecosystems at risk (e.g. Amazon, Arctic, boreal); embody rights and legitimacy; hold place-based knowledge; vital for long-term monitoring.	• Raise visibility of rights and stewardship roles. • Testify on local observations of change. • Join advocacy coalitions.	• Co-design safeguards, FPIC mechanisms, benefit-sharing, and community monitoring systems written into policy drafts.	Historical marginalisation and lack of secure land rights; unequal power in governance forums; barriers to accessing high-quality information; limited resources to engage in transnational arenas.

Table 1.5.1: ESTP actors, agency and challenges

Actor category	Distinctive value for ESTPs	Phase 1 (Agenda-setting): Key activities	Phase 2 (Policy formulation): Key activities	Challenges and constraints
8 **Media** (including social media)	Amplify salience beyond expert circles; connect abstract risks to lived experience; frame issues in ways accessible to broad publics; watchdog narratives.	• **Report on emerging science and campaigns.** • **Cover potential tipping events.** • **Spotlight political inaction or leadership.**	• Translate draft policies into accessible narratives. • Watchdog implementation claims. • Counter misinformation/ disinformation.	Difficulty in translating complex science; loss of independence (private owners' editorial influence); misinformation, bias and politicisation; short news cycles; polarised media landscape.
9 **Financial system** (e.g. central banks, investors, national and MDBs)	Re-price systemic risks linked to ESTPs; shift capital rapidly away from tipping-hazard sectors; drive alignment of economic incentives.	• Conduct risk assessments. • Acknowledge tipping risks in financial discourse. • Join coalitions (e.g. Network for Greening the Financial System).	• **Develop prudential guidance, including tipping risk scenarios for supervision.** • **Apply exclusion lists.** • **Embed conditionality in MDB loans.** • **Design disclosure norms tied to tipping elements.** • **Divest from risk-increasing industries.**	Short-term profit imperatives and myopic interpretation of fiduciary duties; inertia; dependence on conventional risk models.
10 **Private sector / real economy firms**	Control and influence resource use, emissions, and innovation; implement supply chain controls at scale; operationalise verification.	• Build expertise. • Conduct tipping risk assessments, including supply chain risks.	• Adjust disclosure protocols to include tipping risks. • Draft sectoral protocols (e.g. deforestation-free verification), supplier audits, and data-sharing standards interoperable with public early warning systems.	Short-term profit motive and competitive pressures; business model drives tipping risks; ESG backlash.

Legend: **Turquoise font indicates critical actors in this governance phase.**

1.5.3 Taking action on tipping points

Here the focus is on the opportunities and abilities of actors to advance ESTP governance during the two most proximate phases of governance: agenda-setting and policy formulation.

Actors and strategies for agenda-setting

In the early phase of governance, the central challenge is to ensure that ESTPs are recognised as urgent, legitimate and politically tractable. This requires active engagement by a set of actors whose particular roles combine to generate scientific credibility, cultivate public salience, mobilise political will and catalyse action.

Science and knowledge actors provide the foundation. Scientists and science-policy engagement across multiple scales are indispensable for informing various actors, fostering learning about the problem and communicating why tipping processes matter. Knowledge brokers (Meyer, 2010; Boari and Riboldazz, 2014; Reinecke, 2015) and boundary organisations (Guston, 2001; Miller, 2001) play a vital bridging role, translating complex research into accessible insights, creating channels for information flows, and supporting meaning-making across disciplines and policy arenas. These actors together enable decision-makers to act under uncertainty and adapt as understanding evolves.

A recent rare example of science-policy engagement on tipping points is an open letter on AMOC that was submitted by a group of 43 climate scientists to the Nordic Council of Ministers in October 2024. The letter drew attention to "the serious risk of a major ocean circulation change in the Atlantic" (2024, p.1), with a request that the Nordic Council "initiate an assessment of this significant risk to the Nordic countries" and "take steps to minimise this risk as much as possible" (2024, p.2). While the effects of the letter are still unfolding (e.g. the Council is funding a workshop on AMOC impacts on the Nordic countries), Box 1.5.1 illuminates some of the challenges of such science-policy engagement.

Box 1.5.1: Research Insight: State of Governance
The AMOC scientific assessment dilemma in Denmark: Institutional legitimacy versus emerging science

National climate policymaking can face a critical dilemma when emerging scientific evidence differs from assessments from established institutions. This challenge became evident in Denmark's parliamentary response to a letter from 43 scientists warning of sudden AMOC collapse. The letter warns of sudden AMOC collapse risks and emphasises urgency, while the IPCC's latest assessment projects slow AMOC decline with limited likelihood (less than 10%) this century. These contrasting scenarios carry vastly different implications for Danish society and government responsibilities.

Climate policy relies on distinct scientific institutions with established legitimacy to inform decision-making. The IPCC provides authoritative assessments for international and national policy, while dedicated national bodies—such as Denmark's Meteorological Institute (DMI), legally designated as the country's climate science advisor—offer specialised national guidance.

Danish parliamentarians acknowledged the inherent slowness of IPCC processes compared to the fast-moving research on tipping points, expressing desire to base decisions on the best available science. However, they faced a legitimacy problem. Denmark's legal framework designates DMI, alongside IPCC assessments, as the only legitimate source of climate risk information for policymaking. The 43 signatories of the letter were operating outside established IPCC and national assessment processes. Accepting alternative scientific sources risks undermining the authority of legally designated institutions and potentially politicising science by allowing governments to selectively choose preferred scientific voices.

The government's solution—requesting the IPCC to provide an updated AMOC assessment in its next report—highlights a core challenge: maintaining institutional scientific legitimacy while potentially waiting until 2028 for crucial risk information that emerging science suggests may be urgently needed for national policy decisions.

International organisations and intergovernmental forums engage with ESTPs at the planetary scale because global recognition and coordination are required. By introducing ESTPs into agendas at the UNFCCC, CBD, UNGA and related bodies, international organisations supply legitimacy and anchor the issue as a collective challenge rather than a scientific debate. In this early phase, organisations such as the UNFCCC need to consider how ESTPs relate to their existing mandates, fit into agendas and work programmes, and how institutions and processes might need to be adjusted to account for tipping dynamics. For example, parties to the Paris Agreement need to revisit the global goal on adaptation (Art. 7) and the Global Stocktake process (Art. 14) to consider how to revise global adaptation governance to address the expected impacts of ESTPs (see Chapter 1.3). CBD negotiations need to consider the potential of tipping dynamics to create abrupt, large-scale losses of biodiversity (e.g. coral reefs, in the Amazon rainforest), and the corresponding need to revise targets and indicators to capture tipping dynamics.

National governments of major emitters and custodians of key tipping elements are critical engines of political will. Countries such as Brazil (Amazon), Arctic states (ice sheets and permafrost) and large emitters can make or break early momentum. Their buy-in signals that ESTPs are both globally significant and politically tractable. These governments also control much of the relevant data, land use policy and investment decisions, making their engagement central to shaping future governance options.

Civil society organisations, advocacy NGOs and media act as catalysts by communicating urgency, generating legitimacy and opening pathways for bottom-up collective action. In this phase, when no formal governance arrangements yet exist, their ability to raise awareness, link ESTPs to lived experience and justice concerns, and mobilise pressure on governments is crucial. Civil society organisations and individuals are already mobilising around ESTPs – these efforts can be strengthened and widened (see Box 1.5.2 below for an example). It is especially important that those who will be most affected by tipping, including Indigenous Peoples, are heard and their expertise valued, and that those likely to live in a tipped world, namely youth and future generations, are made aware and empowered to act, including via social media.

Box 1.5.2: Research Insight: State of Governance
Civil society actors raising awareness of tipping risks: Operaatio Arktis in Finland

Civil society organisations can play a significant role in raising awareness about tipping risks, as illustrated by the case of Operaatio Arktis, a youth organisation in Finland. Founded in 2022 by former Extinction Rebellion activists, Operaatio Arktis focuses on nonlinear and extreme climate risks. The organisation currently employs 12 people and is primarily funded by Finnish and international private foundations, including the Kone Foundation, Maj and Tor Nessling Foundation, LAD Climate Fund and The Navigation Fund.

Operaatio Arktis aims "to preserve the polar ice caps and prevent global tipping points". It pursues this mission by raising public awareness, advocating for political leadership to integrate tipping risk management into national strategies, and promoting research aimed at predicting, preventing and preparing for tipping impacts. Its main activities include participating in public debates, media appearances and organising events. The organisation has successfully engaged a broad range of stakeholders, including scientists, Sámi indigenous organisations, politicians and government officials.

Tipping risks are a relatively new focus for the organisation. Previously, it concentrated on advocating for increased research on climate interventions, including Solar Radiation Management (SRM), which, in their words, together with emission reductions and carbon sequestration, "may have the potential to secure a stable society and a thriving habitat for younger generations". It appears that what prompted the organisation to work on tipping risks is perceived proximity to their earlier focus on climate interventions.

Tipping points champions – opinion leaders or institutional representatives designated to lead on tipping points within their respective domains – can help to raise the profile of tipping. For example, an international tipping points champion can build momentum and catalyse actions in the global policy space. The UN Secretary-General is already drawing attention to tipping risks, and enjoys a unique platform to further inspire action and to integrate tipping into the global conversation. At the national level, policymakers can act as tipping points champions. For example, in the UK House of Lords, several Peers have taken a lead on questioning the UK government about the existential risks posed by AMOC collapse and whether this is being factored into economic planning. Tipping points champions can also exist within non-governmental organisations and collectives, and can vary from scientists and educators, to business leaders and celebrities. The example of pop band, A-ha, collaborating with environmental activists to propel uptake of electric vehicles in Norway (by both consumers and the government) shows that this can be a successful strategy.

In short, critical at this early agenda-setting phase of ESTP governance are those actors who:

- establish credible, validated and engaging scientific framings, and translate them to wider audiences (knowledge actors, science-policy processes);
- provide platforms for global recognition (intergovernmental organisations, including those at regional scales with specific capacities related to distinct tipping elements);
- create political traction (national governments of key regions, civil society mobilisers); and
- build momentum with effective reporting and narratives (media, champions).

Other actors are also important, yet their influence is likely to grow as the issue matures from agenda-setting to policy formulation and implementation. For now, the 'first movers' need to anchor tipping points in political imagination and institutional debates.

Actors and strategies for policy formulation

As ESTP governance moves from agenda-setting into the policy formulation phase, the focus shifts from recognition to design - from generating awareness and political traction to shaping concrete governance options. In this phase, the key task is to translate broad concern into workable governance architectures, incentive structures and safeguards. In this policy formulation and institutional design phase, various action proposals to address ESTP risks are debated, developed and evaluated. These proposals can include reforms of existing policies and institutions, new principles and approaches (e.g. systemic risk governance or anticipatory governance, Earth system logic), and novel policy instruments and institutions.

These activities require a somewhat different constellation of actors than in the agenda-setting phase. While science, international organisations and national governments remain central, new actors such as Indigenous Peoples and local communities take on a more prominent role. Together, they help translate recognition of tipping risks into workable policy pathways.

Science and knowledge actors remain central, but their role evolves. Rather than primarily raising awareness, scientists, knowledge actors and experts now support the co-design of policy options, providing decision-relevant insights and scenario analyses to test feasibility under uncertainty.

International organisations and intergovernmental forums continue to provide legitimacy and spaces to convene, while also now serving as incubators of emerging norms and instruments. Through forums such as the UNFCCC, CBD or the G20, they can frame principles for tipping point governance, disseminate good practice, coordinate cross-border approaches and establish platforms for negotiation.

National governments become more directly engaged in shaping options, especially major emitters and custodians of tipping elements. Their domestic policies—on land use, emissions, infrastructure or indigenous rights—will define what is politically feasible and form templates for international governance arrangements.

While targeted ESTP actions are required at the national and international levels, it is also necessary to consider governance that is scaled to individual tipping elements (Milkoreit et al., 2024, p.11). While governance capacities at this scale are currently weak, in some cases regional institutions with suitable mandates exist, including the Amazon Cooperation Treaty Organisation (ACTO), the Arctic Council (including the Arctic Monitoring and Assessment Program) and the Nordic Council of Ministers.

Indigenous Peoples and local communities are essential to the design phase, both for their situated knowledge of ecosystems and for ensuring that governance strategies recognise and respect rights, secure safeguards and build legitimacy. Including Indigenous Peoples and local communities as partners in co-design helps avoid technocratic solutions that overlook lived realities and justice concerns.

Subnational governments (e.g. cities, regions, provinces) play a growing role as testbeds for innovation. They can pioneer pilot policies, experiment with regulatory and planning instruments, network and demonstrate models that may later be scaled nationally or internationally.

Economic actors, particularly industry associations and sector bodies, play an important role in shaping policy design. They often bring resources, agility, and deep knowledge of supply chains and on-the-ground realities. By recognising the risks of tipping points to their operations, major players can mobilise their established lobbying power to shape policy responses.

Financial actors and sectoral standard-setters become particularly important in this phase. Multilateral development banks, institutional investors, commodity certification bodies and corporate standard-setters can create the incentives and disclosure frameworks that translate tipping point risks into concrete practices. Embedding tipping risks into financial norms and sectoral rules can make emerging governance structures economically credible.

Box 1.5.3: Transnational initiatives and policy development

Transnational initiatives complement intergovernmental processes by creating norms, standards and collaborative practices that influence both public and private decision-making. CDP (formerly the Carbon Disclosure Project) illustrates this potential. By mobilising investors, companies, cities and regions to disclose climate-related risks and impacts, CDP has built one of the world's largest environmental reporting systems. Its frameworks help translate complex climate science into metrics that guide policy and investment decisions, thereby lowering uncertainty and increasing accountability.

Alongside such cross-sectoral initiatives, tipping specific transnational initiatives are already emerging. The International Coral Reef Initiative (ICRI), for example, unites governments, NGOs and scientific organisations to safeguard coral reefs—one of the ecosystems most at risk of crossing tipping thresholds. ICRI coordinates monitoring and data-sharing systems, promotes early warning indicators of reef decline, and works to embed reef resilience into national and international policy frameworks. These activities illustrate how transnational initiatives can not only amplify global attention but also generate practical governance tools targeted at specific tipping elements.

Taken together, initiatives like CDP and ICRI show how transnational networks can help operationalise knowledge, align economic and political actors, and create early building blocks for governance where formal rules are not yet in place.

Judicial actors can play an authoritative role in interpreting existing laws in the light of ESTPs. Courts have shown their willingness to interpret laws in the light of climate change, even when provisions are not explicitly related to this issue. For example, the European Court of Human Rights (ECtHR) has confirmed that climate change impacts can result in violations of the European Convention on Human Rights (*Verein KlimaSeniorinnen Schweiz and Others v. Switzerland* (2024) Application No. 53600/20). While courts are generally limited to the cases that are brought before them, there is scope for them to be proactive in integrating ESTPs into law. For example, when asked to provide an Advisory Opinion on State obligations in response to the climate emergency, the Inter-American Court of Human Rights (IACtHR) explicitly mentioned tipping points in respect to the severity of climate change impacts (see Chapter 1.4 on Human Rights for further discussion). Individuals and collectives can expedite this process by bringing explicit tipping specific litigation before the courts (see Chapter 3.2).

With increased activity on ESTPs comes a need for greater coordination. The plurality of tipping point actors and activities, across varying actor types and scales, requires coordination that respects and enhances this plurality, rather than dilutes or undermines it. Yet, effective coordination in a polycentric landscape is a challenging task. Multiple centres of decision-making can relate to each other in both competitive and cooperative ways (McGinnis and Ostrom, 2012).

Polycentricity can lead to fragmentation of governance, with both positive and negative impacts on its quality (Biermann et al., 2009), and a lack of coordination can lead to various inefficiencies, including competition for attention and resources among different actors. Cooperative strategies are therefore needed to coordinate various actors while respecting the agency that each has and the multiple perspectives they bring.

Taken together, these actors form the 'policy formulation coalition', tasked with moving ESTPs from abstract concern to implementable governance options, aligning incentives and embedding safeguards that can be adapted over time.

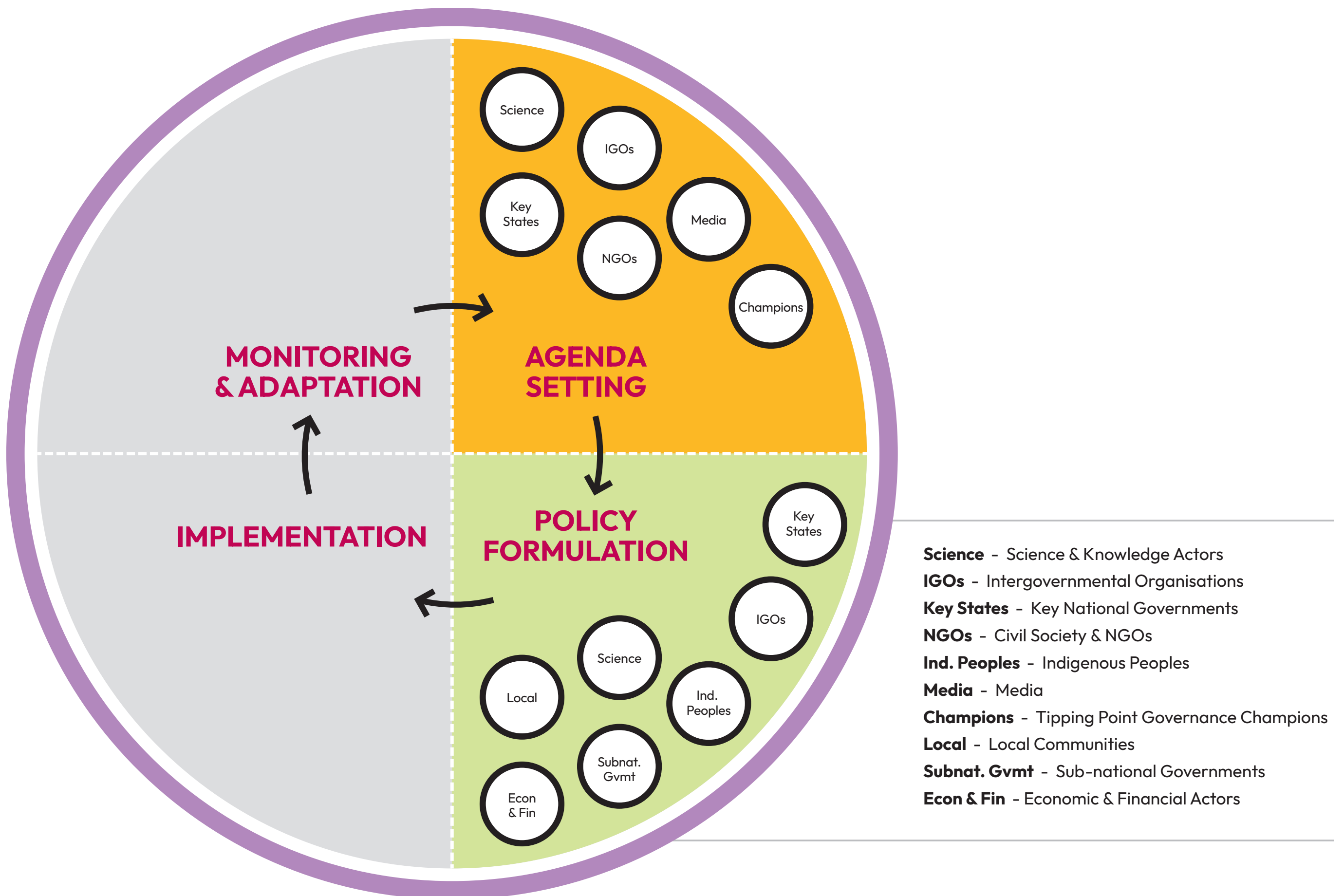


Figure 1.5.1: Key actors across phases of the ESTP governance process

1.5.4 Challenges in agenda-setting for tipping points

Setting the governance agenda for ESTPs faces a double bind: the science is both indispensable and challenging to communicate. Researchers and knowledge brokers must communicate deep uncertainty—such as nonlinear dynamics, thresholds and cascading risks—without losing urgency or credibility. If the risks are conveyed as too abstract, they can be dismissed as alarmist; if they are simplified too far, their gravity and systemic nature may be lost. Science–policy interfaces are only beginning to bridge this gap, and decision-makers remain hesitant to act on emerging evidence.

International organisations and national governments add another layer of challenge. Multilateral forums are already saturated with competing climate and development priorities, and geopolitical tensions strain collective action. At the same time, key national governments often weigh short-term economic and political pressures against longer-term systemic risks, slowing their willingness to put tipping points firmly on the agenda. The result is a governance vacuum, where ESTPs are recognised as urgent but not yet ‘owned’ politically.

Civil society and media can help fill this gap by raising salience, connecting tipping risks to justice concerns, and pressing governments to take notice. Yet here too there are obstacles: mobilising around uncertain or distant risks is inherently difficult, and public attention is fragmented by what are perceived as more immediate crises. Ensuring that those most affected—Indigenous Peoples, local communities and youth—are heard and valued is particularly important, however, their voices are not yet mainstreamed into global conversations.

These actor-specific hurdles are amplified by the current global political moment. Energy security concerns, economic instability and geopolitical rivalries constrain the bandwidth for new issues, while multilateral negotiations are already struggling to deliver on existing climate commitments. In this context, building momentum for ESTPs requires an ‘agenda-setting coalition’ that can overcome fragmentation, translate science into meaning and connect planetary risks to near-term decisions.

Cultivating trust among actors is also a challenge. There is existing mistrust in climate change governance, with trust strained by polarisation and shifts towards authoritarian leadership. Yet, trust is critically important for the success of collective climate efforts (Figueres, 2020) and for “shaping the network of policy agreement in a nascent subsystem” (Ingold et al., 2017, p.458). Building trust in ESTP governance requires distinct formats for trust-building, informal spaces for dialogue and, more broadly, the institutionalisation of social interaction (Schroeder et al., 2025). Trust can be built by shifting to collaborative forms of governance (Ansell and Gash, 2008, p.559). These are well-suited to ESTPs as they bring diverse actors together in collective forums with broad participation; collaboration “spurs a constructive use of scientific knowledge in processes of mutual learning and creative problem-solving” (Ansell et al., 2017, p.476). To stimulate collaboration, all actors need to believe their participation will have influence and produce results (Ansell et al., 2017, p.481). Given existing inequalities, effectively enabling all ESTP actors to collaborate will require a more equitable distribution of resources, as well as resource mobilisation and the strengthening of actors’ capabilities. However, this brings an additional benefit for dealing with ESTPs: when affected actors are empowered and have agency and enhanced capabilities, they are better able to respond to environmental challenges and to cope with systemic risks and cascading impacts.

1.5.5 Final remarks

The governance of ESTPs is still in its infancy, and the world is only beginning to grapple with the magnitude of the challenge. ESTPs have relevance for many different actors across varying scales – all these actors have reasons to act on ESTPs and strategies available to them. The nature and scale of ESTPs is likely to overwhelm the capacity of any single actor, meaning co-operation is essential, and effective coordination is needed to ensure coherence, to harness synergies, and to realise ESTP action that is greater than the sum of its parts.

In the **agenda-setting phase**, the central tasks are to raise awareness, build legitimacy and generate political traction. This requires a coalition of scientists and knowledge brokers to translate complexity into actionable insights, international organisations to provide platforms and legitimacy, national governments to signal political will, and civil society and media to mobilise urgency and justice concerns. Together, these actors form an agenda-setting coalition that determines whether tipping points gain sustained visibility in global policy.

As attention shifts to the **policy formulation phase**, the challenge becomes one of translation – moving from recognising risks to designing workable governance structures. Here, science remains crucial, yet its role evolves towards co-design and decision support. International organisations and national governments continue to anchor negotiations, but must now partner closely with Indigenous Peoples and local communities to ensure legitimacy and safeguards. Financial actors, investors and sectoral standard-setters are essential in aligning incentives, while subnational governments offer fertile ground for experimentation. This policy formulation coalition is key to turning concern into credible pathways for action.

Both phases face formidable challenges, from scientific uncertainty and political and economic short-termism to fragmented attention and geopolitical strain. Yet, the urgency of tipping risks means that delay is itself dangerous. Early momentum will depend on building alliances that can bridge science and politics, connect planetary-scale risks to local realities, and translate abstract warnings into actionable governance options that are both legitimate and tractable. In this way, actors across levels and sectors can start to craft the foundations of a governance architecture capable of anticipating and navigating tipping points.

References: 1.1

Armstrong McKay D, Staal A, Abrams JF, et al. (2022) Exceeding 1.5°C global warming could trigger multiple climate tipping points. Science 377(6611): eabn7950. https://doi.org/10.1126/science.abn7950

Armstrong McKay DI (2024) Two decades of climate tipping points research: Progress and outlook. Dialogues on Climate Change. SAGE Publications: 29768659241293272. https://doi.org/10.1177/29768659241293272

Bellomo K, Angeloni M, Corti S, et al. (2021) Future climate change shaped by inter-model differences in Atlantic meridional overturning circulation response. Nature Communications 12(1). Nature Publishing Group: 3659. https://doi.org/10.1038/s41467-021-24015-w

Ben-Yami M, Morr A, Bathiany S, et al. (2024) Uncertainties too large to predict tipping times of major Earth system components from historical data. Science Advances 10(31). American Association for the Advancement of Science: eadl4841. https://doi.org/ https://doi.org/10.1126/sciadv.adl4841

Bevacqua E, Schleussner C-F and Zscheischler J (2025) A year above 1.5°C signals that Earth is most probably within the 20-year period that will reach the Paris Agreement limit. Nature Climate Change. Nature Publishing Group: 1–4. https://doi.org/10.1038/s41558-025-02246-9

Biermann F (2014) The Anthropocene: A governance perspective. The Anthropocene Review 1(1): 57–61. https://doi.org/10.1177/2053019613516289

Biesbroek R, Haasnoot M, Mach KJ, et al. (2025) Adaptation planning in the context of a weakening and possibly collapsing Atlantic Meridional Overturning Circulation (AMOC). Regional Environmental Change 25(3): 93. https://doi.org/10.1007/s10113-025-02434-5

Hansen JE, Kharecha P, Sato M, et al. (2025) Global Warming Has Accelerated: Are the United Nations and the Public Well-Informed? Environment: Science and Policy for Sustainable Development 67(1). Routledge: 6–44. https://doi.org/10.1080/00139157.2025.2434494

IPBES (2024) Thematic Assessment Report on the Interlinkages among Biodiversity, Water, Food and Health of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (eds PA Harrison, PD McElwee and TL Van Huysen). Bonn, Germany: IPBES Secretariat. Available at: https://doi.org/10.5281/zenodo.13850054.

Jackson LS, Crook JA, Jarvis A, et al. (2015) Assessing the controllability of Arctic sea ice extent by sulfate aerosol geoengineering. Geophysical Research Letters 42(4): 1223–1231. https://doi.org/ https://doi.org/10.1002/2014GL062240

Kelly J, Kljun N, Cai Z, et al. (2024) Wildfire impacts on the carbon budget of a managed Nordic boreal forest. Agricultural and Forest Meteorology 351: 110016. https://doi.org/10.1016/j.agrformet.2024.110016

Kim RE (2022) Taming Gaia 2.0: Earth system law in the ruptured Anthropocene. The Anthropocene Review 9(3). SAGE Publications: 411–424. https://doi.org/10.1177/20530196211026721

Kotzé LJ and Kim RE (2019) Earth system law: The juridical dimensions of earth system governance. Earth System Governance 1: 100003. https://doi.org/10.1016/j.esg.2019.100003

Laybourn L, Evans J and Dyke J (2023) Derailment risk: A systems analysis that identifies risks which could derail the sustainability transition. Earth System Dynamics 14(6). Copernicus GmbH: 1171–1182. https://doi.org/10.5194/esd-14-1171-2023

McElwee PD, Harrison PA, van Huysen TL, et al. (2025) IPBES Nexus Assessment: Summary for Policymakers. 16 June. Zenodo. Available at: https://zenodo.org/records/15673657 (accessed 3 September 2025).

Migliavacca M, Grassi G, Bastos A, et al. (2025) Securing the forest carbon sink for the European Union's climate ambition. Nature 643(8074). Nature Publishing Group: 1203–1213. https://doi.org/ https://doi.org/10.1038/s41586-025-08967-3

Milkoreit M, Hodbod J, Baggio J, et al. (2018) Defining tipping points for social-ecological systems scholarship—an interdisciplinary literature review. Environmental Research Letters 13(3): 033005. https://doi.org/10.1088/1748-9326/aaaa75

Milkoreit M, Boyd E, Constantino SM, et al. (2024) Governance for Earth system tipping points – A research agenda. Earth System Governance 21: 100216. https://doi.org/10.1016/j.esg.2024.100216

Möller T, Högner AE, Schleussner C-F, et al. (2024) Achieving net zero greenhouse gas emissions critical to limit climate tipping risks. Nature Communications 15(1). Nature Publishing Group: 6192. https://doi.org/10.1038/s41467-024-49863-0

O'Brien K, Garibaldi LA, Agrawal A, et al. (2025) IPBES Transformative Change Assessment: Summary for Policymakers. June. Zenodo. Available at: https://zenodo.org/records/15645812 (accessed 3 September 2025).

Pan Y, Birdsey RA, Phillips OL, et al. (2024) The enduring world forest carbon sink. Nature 631(8021). Nature Publishing Group: 563–569. https://doi.org/10.1038/s41586-024-07602-x

Pattberg P and Zelli F (2016) Global environmental governance in the Anthropocene: An introduction. In: Environmental Politics and Governance in the Anthropocene. Routledge.

Ruhl JB and Ruhl HJ (2022) Pre-planning transformation to avoid collapse—Is it possible? Futures 144: 103058. https://doi.org/10.1016/j.futures.2022.103058

Tàbara JD, Frantzeskaki N, Hölscher K, et al. (2018) Positive tipping points in a rapidly warming world. Current Opinion in Environmental Sustainability 31. Sustainability governance and transformation 2018: 120–129. https://doi.org/10.1016/j.cosust.2018.01.012

Thienen P van, Maat H ter and Stofberg S (2025) Climate tipping points and their potential impact on drinking water supply planning and management in Europe. Cambridge Prisms: Water 3: e3. https://doi.org/10.1017/wat.2024.14

van Westen RM and Baatsen MLJ (2025) European Temperature Extremes Under Different AMOC Scenarios in the Community Earth System Model. Geophysical Research Letters 52(12): e2025GL114611. https://doi.org/10.1029/2025GL114611

Walker B, Crépin A-S, Nyström M, et al. (2023) Response diversity as a sustainability strategy. Nature Sustainability 6(6). 6. Nature Publishing Group: 621–629. https://doi.org/10.1038/s41893-022-01048-7

Winkelmann R, Donges JF, Smith EK, et al. (2022) Social tipping processes towards climate action: A conceptual framework. Ecological Economics 192: 107242. https://doi.org/10.1016/j.ecolecon.2021.107242

Wood RA, Crucifix M, Lenton TM, et al. (2023) A Climate Science Toolkit for High Impact-Low Likelihood Climate Risks. Earth's Future 11(4): e2022EF003369. https://doi.org/10.1029/2022EF003369

Wunderling N, Winkelmann R, Rockström J, et al. (2022) Global warming overshoots increase risks of climate tipping cascades in a network model. Nature Climate Change. Nature Publishing Group UK London: 1–8. https://doi.org/10.1038/s41558-022-01545-9

Wunderling N, von der Heydt AS, Aksenov Y, et al. (2024) Climate tipping point interactions and cascades: a review. Earth System Dynamics 15(1). Copernicus GmbH: 41–74. https://doi.org/10.5194/esd-15-41-2024

Zhang R, Sutton R, Danabasoglu G, et al. (2019) A Review of the Role of the Atlantic Meridional Overturning Circulation in Atlantic Multidecadal Variability and Associated Climate Impacts. Reviews of Geophysics 57(2): 316–375. https://doi.org/10.1029/2019RG000644

References: 1.2

Ameli, N., Chenet, H., Falkenberg, M., Kothari, S., Rickman, J. and Lamperti, F., 2025. Driving sustainability transitions through financial tipping points. Earth System Dynamics, 16(1), pp.333-345. https://doi.org/10.5194/esd-16-333-2025

Armstrong McKay, D.I., Staal, A., Abrams, J.F., Winkelmann, R., Sakschewski, B., Loriani, S., Fetzer, I., Cornell, S.E., Rockström, J. and Lenton, T.M., 2022. Exceeding 1.5 C global warming could trigger multiple climate tipping points. Science, 377(6611), p.eabn7950. https://doi.org/10.1126/science.abn7950

Asutosh, A., Tilmes, S., Bednarz, E.M. and Fadnavis, S., 2025. South Asian Summer Monsoon under stratospheric aerosol intervention. npj Climate and Atmospheric Science, 8(1), p.3. https://doi.org/10.1038/s41612-024-00875-z

Bednarz, E.M., Goddard, P.B., MacMartin, D.G., Visioni, D., Bailey, D. and Danabasoglu, G., 2025. Stratospheric aerosol injection could prevent future Atlantic Meridional Overturning Circulation decline, but injection location is key. Earth's Future, 13(8), p.e2025EF005919. https://doi.org/10.1029/2025EF005919

Beerling, D.J., Kantzas, E.P., Lomas, M.R., Wade, P., Eufrasio, R.M., Renforth, P., Sarkar, B., Andrews, M.G., James, R.H., Pearce, C.R., Mercure, J.F., Pollitt, H., Holden, P.B., Edwards, N.R., Khanna, M., Koh, L., Quegan, S., Pidgeon, N.F., Janssens, I.A., Hansen, J. & Banwart, S.A. 2020. Potential for large-scale CO2 removal via enhanced rock weathering with croplands. Nature, 583(7815), pp.242-248. https://doi.org/10.1038/s41586-020-2448-9

Bevacqua, E., Schleussner, C.F. and Zscheischler, J., 2025. A year above 1.5° C signals that Earth is most probably within the 20-year period that will reach the Paris Agreement limit. Nature Climate Change, 15(3), pp.262-265. https://doi.org/10.1038/s41558-025-02246-9

Beveridge, C.F., Espinoza, J.C., Athayde, S., Correa, S.B., Couto, T.B., Heilpern, S.A., Jenkins, C.N., Piland, N.C., Utsunomiya, R., Wongchuig, S. and Anderson, E.P., 2024. The Andes–Amazon–Atlantic pathway: A foundational hydroclimate system for social–ecological system sustainability. Proceedings of the National Academy of Sciences, 121(22), p.e2306229121. https://doi.org/10.1073/pnas.2306229121

Biermann, F., Oomen, J., Gupta, A., Ali, S.H., Conca, K., Hajer, M.A., Kashwan, P., Kotzé, L.J., Leach, M., Messner, D. and Okereke, C., 2022. Solar geoengineering: The case for an international non-use agreement. Wiley Interdisciplinary Reviews: Climate Change, 13(3), p.e754. https://doi.org/10.1002/wcc.754

Borràs-Pentinat, S., 2025. 'Rights of Nature', in M. Wewerinke-Singh and S. Mead (eds.) The Cambridge Handbook on Climate Litigation. Cambridge: Cambridge University Press (Cambridge Law Handbooks), pp. 275–298.

Bossio, D.A., Cook-Patton, S.C., Ellis, P.W., Fargione, J., Sanderman, J., Smith, P., Wood, S., Zomer, R.J., Von Unger, M., Emmer, I.M. and Griscom, B.W., 2020. The role of soil carbon in natural climate solutions. Nature Sustainability, 3(5), pp.391-398. https://doi.org/10.1038/s41893-020-0491-z

Boulton, C.A., Lenton, T.M. and Boers, N., 2022. Pronounced loss of Amazon rainforest resilience since the early 2000s. Nature Climate Change, 12(3), pp.271-278. https://doi.org/10.1038/s41558-022-01287-8

Carney, M, 2015. Breaking the tragedy of the horizon – climate change and financial stability, speech given at Lloyd's of London, 29 September 2015. Bank of England. Available at: https://www.bankofengland.co.uk/speech/2015/breaking-the-tragedy-of-the-horizon-climate-change-and-financial-stability (Accessed: 1 September 2025).

Chapron, G., Epstein, Y. and López-Bao, J.V., 2019. A rights revolution for nature. Science, 363(6434), pp.1392-1393. https://doi.org/10.1126/science.aav5601

Chenet, H., Kedward, K., Ryan-Collins, J. and van Lerven, F., 2022. Developing a precautionary approach to financial policy – from climate to biodiversity. INSPIRE Sustainable Central Banking Toolbox Policy Briefing Paper No. 2. SOAS Centre of Sustainable Finance and LSE Grantham Research Institute on Climate Change and the Environment. Published 27 April 2022. Available at: https://www.inspiregreenfinance.org/wp-content/uploads/2022/04/Chenet-et-al-April-2022-Developing-a-precautionary-approach-to-financial-policy-from-climate-to-biodiversity.pdf (Accessed: 1 September 2025).

Chenet, H., Ryan-Collins, J. and Van Lerven, F., 2021. Finance, climate-change and radical uncertainty: Towards a precautionary approach to financial policy. Ecological Economics, 183, p.106957. https://doi.org/10.1016/j.ecolecon.2021.106957

Chidichimo, M.P., Perez, R.C., Speich, S., Kersalé, M., Sprintall, J., Dong, S., Lamont, T., Sato, O.T., Chereskin, T.K., Hummels, R. and Schmid, C., 2023. Energetic overturning flows, dynamic interocean exchanges, and ocean warming observed in the South Atlantic. Communications Earth & Environment, 4(1), p.10. https://doi.org/10.1038/s43247-022-00644-x

Climate Governance Commission, 2023. Governing Our Planetary Emergency. Available at: https://www.stimson.org/wp-content/uploads/2023/11/Governing-Our-Planetary-Emergency-Report_WEB-1.pdf (Accessed: 1 September 2025).

Climate Policy Initiative (CPI), 2024. Global Landscape of Climate Finance 2024: Insights for COP29. London: Climate Policy Initiative. Available at: https://climatepolicyinitiative.org/publication/global-landscape-of-climate-finance-2024 (Accessed: 1 September 2025).

Convention on Biological Diversity (CBD), 2025. Decision adopted by the Conference of the Parties to the Convention on Biological Diversity on 27 February 2025 (CBD/COP/16/Dec.34). Montreal-Kunming, 27 February 2025. Available at: https://www.cbd.int/doc/decisions/cop-16/cop-16-dec-34-en.pdf (Accessed: 1 September 2025).

Cooper, G.S., Willcock, S. and Dearing, J.A., 2020. Regime shifts occur disproportionately faster in larger ecosystems. Nature Communications, 11(1), p.1175. https://doi.org/10.1038/s41467-020-15029-x

Corrigan, D. P. and Oksanen, M. (eds.),2021. Rights of Nature: A Re-examination. 1st edn. London: Routledge. https://doi.org/10.4324/9780367479589

Crona, B., Folke, C. and Galaz, V., 2021. The Anthropocene reality of financial risk. One Earth, 4(5), pp.618-628. https://doi.org/10.1016/j.oneear.2021.04.016

Directorate-General for Research and Innovation (European Commission) and Group of Chief Scientific Advisors (European Commission), 2024. Solar radiation modification. Publications Office of the European Union. https://doi.org/10.2777/391614 (Accessed: 1 September 2025).

Du Toit, L. and Kotzé, L.J., 2022. Reimagining international environmental law for the Anthropocene: An earth system law perspective. Earth System Governance, 11, p.100132. https://doi.org/10.1016/j.esg.2022.100132

Edling Müller, I. (2025) Justice for the whole forest: How legal recognition of interspecies justice could help avoid triggering forest-related Earth system tipping points. Master's thesis, Stockholm University, Faculty of Science, Stockholm Resilience Centre. Available at: https://su.diva-portal.org/smash/record.jsf?pid=diva2%3A1967625 (Accessed: 1 September 2025).

Eker, S., Lenton, T.M., Powell, T., Scheffran, J., Smith, S.R., Swamy, D. and Zimm, C., 2024. Cross-system interactions for positive tipping cascades. Earth System Dynamics, 15(3), pp.789-800. https://doi.org/10.5194/esd-15-789-2024

Fasullo, J.T., Tilmes, S., Richter, J.H., Kravitz, B., MacMartin, D.G., Mills, M.J. and Simpson, I.R., 2018. Persistent polar ocean warming in a strategically geoengineered climate. Nature Geoscience, 11(12), pp.910-914. https://doi.org/10.1038/s41561-018-0249-7

Felgenhauer, T., Bala, G., Borsuk, M., Brune, M., Camilloni, I., Wiener, J.B., Xu, J., 2022. Solar Radiation Modification: A Risk-Risk Analysis, Carnegie Climate Governance Initiative (C2G), March, New York, NY: www.c2g2.net

Financial Stability Board (FSB), 2025. Assessment of Climate-related Vulnerabilities: Analytical Framework and Toolkit. Published 16 January 2025. Available at: https://www.fsb.org/uploads/P160125.pdf (Accessed: 1 September 2025).

Flores, B.M., Montoya, E., Sakschewski, B., Nascimento, N., Staal, A., Betts, R.A., Levis, C., Lapola, D.M., Esquível-Muelbert, A., Jakovac, C. and Nobre, C.A., 2024. Critical transitions in the Amazon forest system. Nature, 626(7999), pp.555-564. https://doi.org/10.1038/s41586-023-06970-0

Fuss, S., Lamb, W.F., Callaghan, M.W., Hilaire, J., Creutzig, F., Amann, T., Beringer, T., de Oliveira Garcia, W., Hartmann, J., Khanna, T. and Luderer, G., 2018. Negative emissions—Part 2: Costs, potentials and side effects. Environmental research letters, 13(6), p.063002. https://doi.org/10.1088/1748-9326/aabf9f

Futerman, G., Adhikari, M., Duffey, A., Fan, Y., Gurevitch, J., Irvine, P. and Wieners, C., 2025. The interaction of solar radiation modification with Earth system tipping elements. Earth System Dynamics, 16(4), pp.939-978. https://doi.org/10.5194/esd-16-939-2025

Galaz, V., Crona, B., Dauriach, A., Scholtens, B. and Steffen, W., 2018. Finance and the Earth system–Exploring the links between financial actors and non-linear changes in the climate system. Global Environmental Change, 53, pp.296-302. https://doi.org/10.1016/j.gloenvcha.2018.09.008

García Ruales, J., 2024. Forest moralities, kindred knowledge and Sacha Runakuna: Kawsak Sacha as law. The International Journal of Human Rights, 28(10), pp.1662-1686. https://doi.org/10.1080/13642987.2024.2362837

Garmestani, A., Ruhl, J.B., Chaffin, B.C., Craig, R.K., van Rijswick, H.F., Angeler, D.G., Folke, C., Gunderson, L., Twidwell, D. and Allen, C.R., 2019. Untapped capacity for resilience in environmental law. Proceedings of the National Academy of Sciences, 116(40), pp.19899-19904. https://doi.org/10.1073/pnas.1906247116

Gonon, M., Svartzman, R. and Althouse, J., 2024. Bridging the Gap in Biodiversity Financing: A review of assessments of existing and needed financial flows for biodiversity, and some considerations regarding their limitations and potential ways forward. UCL Institute for Innovation and Public Purpose, Working Paper Series (IIPP WP 2024-14). Available at: https://www.ucl.ac.uk/bartlett/public-purpose/WP2024-14 (Accessed: 1 September 2025).

Gregory, J.M., Bouttes, N., Griffies, S.M., Haak, H., Hurlin, W.J., Jungclaus, J., Kelley, M., Lee, W.G., Marshall, J., Romanou, A. and Saenko, O.A., 2016. The Flux-Anomaly-Forced Model Intercomparison Project (FAFMIP) contribution to CMIP6: Investigation of sea-level and ocean climate change in response to CO 2 forcing. Geoscientific Model Development, 9(11), pp.3993-4017. https://doi.org/10.5194/gmd-9-3993-2016

Griscom, B.W., Adams, J., Ellis, P.W., Houghton, R.A., Lomax, G., Miteva, D.A., Schlesinger, W.H., Shoch, D., Siikamäki, J.V., Smith, P. and Woodbury, P., 2017. Natural climate solutions. Proceedings of the National Academy of Sciences, 114(44), pp.11645-11650. https://doi.org/10.1073/pnas.1710465114

Gupta, A., Biermann, F., Van Driel, E., Bernaz, N., Jayaram, D., Kim, R.E., Kotzé, L.J., Ruddigkeit, D., VanDeveer, S.D. and Wewerinke-Singh, M., 2024. Towards a non-use regime on solar geoengineering: Lessons from international law and governance. Transnational Environmental Law, 13(2), pp.368-399. https://doi.org/10.1017/S2047102524000050

Hadji-Lazaro, P., Salin, M., Svartzman, R., Espagne, E., Gauthey, J., Berger, J., Calas, J., Godin, A. and Vallier, A., 2024. Biodiversity loss and financial stability as a new frontier for central banks: An exploration for France. Ecological Economics, 223, p.108246. https://doi.org/10.1016/j.ecolecon.2024.108246

Hall, C., 2023. Diffusing the legal conceptions of the global south and decolonizing international law: crystallizing animal rights through inter-judicial dialogue. Frontiers in Animal Science, 4, p.1241318. https://doi.org/10.3389/fanim.2023.1241318

Hirasawa, H., Hingmire, D., Singh, H., Rasch, P.J. and Mitra, P., 2023. Effect of regional marine cloud brightening interventions on climate tipping elements. Geophysical Research Letters, 50(20), p.e2023GL104314. https://doi.org/10.1029/2023GL104314

Inter-American Court of Human Rights (IACHR), 2025. Advisory Opinion OC-32/25: The Climate Emergency and Human Rights. San José, Costa Rica: Inter-American Court of Human Rights. Available at: https://www.corteidh.or.cr/tablas/OC-32-2025/index-eng.html (Accessed: 1 September 2025).

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2022. Methodological assessment of the diverse values and valuation of nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Zenodo. https://doi.org/10.5281/zenodo.7687931

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2024. Thematic Assessment Report on the Underlying Causes of Biodiversity Loss and the Determinants of Transformative Change and Options for Achieving the 2050 Vision for Biodiversity of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (Transformative Change Assessment). O'Brien, K., Garibaldi, L., and Agrawal, A. (eds.). IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.11382215

International Court of Justice (ICJ), 2025. Advisory Opinion of 23 July 2025 — Obligations of States in Respect of Climate Change. Case No. 187, Doc. 187-20250723-ADV-01-00-EN. The Hague: International Court of Justice.

International Tribunal for the Law of the Sea (ITLOS), 2024. Request for an Advisory Opinion submitted by the Commission of Small Island States on Climate Change and International Law, Advisory Opinion (Case No. 31), 21 May 2024. Hamburg: ITLOS. Available at: https://www.itlos.org/fileadmin/itlos/documents/cases/31/Advisory_Opinion/C31_Adv_Op_21.05.2024_orig.pdf (Accessed: 1 September 2025).

Irvine, P., Emanuel, K., He, J., Horowitz, L.W., Vecchi, G. and Keith, D., 2019. Halving warming with idealized solar geoengineering moderates key climate hazards. Nature climate change, 9(4), pp.295-299. https://doi.org/10.1038/s41558-019-0398-8

Iyer, G., Ou, Y., Edmonds, J., Fawcett, A.A., Hultman, N., McFarland, J., Fuhrman, J., Waldhoff, S. and McJeon, H., 2022. Ratcheting of climate pledges needed to limit peak global warming. Nature Climate Change, 12(12), pp.1129-1135. https://doi.org/10.1038/s41558-022-01508-0

Kedward, K., Ryan-Collins, J. and Chenet, H., 2023. Biodiversity loss and climate change interactions: financial stability implications for central banks and financial supervisors. Climate Policy, 23(6), pp.763-781. https://doi.org/10.1080/14693062.2022.2107475

Kotzé, L.J. and Adelman, S., 2023. Environmental law and the unsustainability of sustainable development: a tale of disenchantment and of hope. Law and critique, 34(2), pp.227-248. https://doi.org/10.1007/s10978-022-09323-4

Kreibiehl, S., T. Yong Jung, S. Battiston, P. E. Carvajal, C. Clapp, D. Dasgupta, N. Dube, R. Jachnik, K. Morita, N. Samargandi, M. Williams, 2022: Investment and finance. In IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. https://doi.org/10.1017/9781009157926.017

Lenton, T. M., 2018. 'Can emergency geoengineering really prevent climate tipping points?', in Geoengineering Our Climate? Ethics, Politics, and Governance. London: Routledge. Available at: https://www.taylorfrancis.com/chapters/edit/10.4324/9780203485262-8/emergency-geoengineering-really-prevent-climate-tipping-points-timothy-lenton (Accessed: 1 September 2025).

Lenton, T. M., Armstrong McKay, D. I., Loriani, S., Abrams, J. F., Lade, S. J., Donges, J. F., Milkoreit, M., Powell, T., Smith, S. R., Zimm, C., Buxton, J. E., Bailey, E., Laybourn, L., Ghadiali, A., & Dyke, J. G. 2023. The global tipping points report 2023 (University of Exeter) https://global-tipping-points.org/

Lenton, T.M., 2011. Beyond 2 C: redefining dangerous climate change for physical systems. Wiley Interdisciplinary Reviews: Climate Change, 2(3), pp.451-461. https://doi.org/10.1002/wcc.107

Lobelle, D., Beaulieu, C., Livina, V., Sevellec, F. and Frajka�Williams, E., 2020. Detectability of an AMOC decline in current and projected climate changes. Geophysical Research Letters, 47(20), p.e2020GL089974. https://doi.org/10.1029/2020GL089974

Lohmann, J. and Ditlevsen, P.D., 2021. Risk of tipping the overturning circulation due to increasing rates of ice melt. Proceedings of the National Academy of Sciences, 118(9), p.e2017989118. https://doi.org/10.1073/pnas.2017989118

Loreau, M., Barbier, M., Filotas, E., Gravel, D., Isbell, F., Miller, S.J., Montoya, J.M., Wang, S., Aussenac, R., Germain, R. and Thompson, P.L., 2021. Biodiversity as insurance: from concept to measurement and application. Biological Reviews, 96(5), pp.2333-2354. https://doi.org/10.1111/brv.12756

Mace, M.J., Fyson, C.L., Schaeffer, M. and Hare, W.L., 2021. Large�scale carbon dioxide removal to meet the 1.5 C limit: key governance gaps, challenges and priority responses. Global Policy, 12, pp.67-81. https://doi.org/10.1111/1758-5899.12921

Marsden, L., Ryan-Collins, J., Abrams, J. and Lenton, T., 2024. Financial interactions with ecosystem tipping points: evidence from the Brazilian Amazon and Indonesian peatlands. UCL Institute for Innovation and Public Purpose, Working Paper Series (IIPP WP 2024-11). Available at: https://www.ucl.ac.uk/bartlett/public-purpose/publications/WP-2024-11 (Accessed: 1 September 2025).

Maxwell, L., Mead, S. and Van Berkel, D., 2022. Standards for adjudicating the next generation of Urgenda-style climate cases. Journal of Human Rights and the Environment, 13(1), pp.35-63. https://doi.org/10.4337/jhre.2022.01.02

Mercure, J.F., Lam, A., Buxton, J., Boulton, C. and Lenton, T., 2024. Evidence of a cascading positive tipping point towards electric vehicles. https://doi.org/10.21203/rs.3.rs-3979270/v1

Möller, T., Högner, A.E., Schleussner, C.F., Bien, S., Kitzmann, N.H., Lamboll, R.D., Rogelj, J., Donges, J.F., Rockström, J. and Wunderling, N., 2024. Achieving net zero greenhouse gas emissions critical to limit climate tipping risks. Nature Communications, 15(1), p.6192. https://doi.org/10.1038/s41467-024-49863-0

Morrow, K., 2025. 'Will a Human Right to a Clean, Healthy and Sustainable Environment Address the Wrongs of Environmental Degradation?', in Bakan, A. B. and Abu-Laban, Y. (eds.) Human Rights and the United Nations: Paradox and Promise. 1st edn. London: Routledge, chapter [online]. Available at: https://doi.org/10.4324/9781003404453-13 (Accessed: 1 September 2025).

National Academies of Sciences, Engineering, and Medicine, 2021. Reflecting Sunlight: Recommendations for Solar Geoengineering Research and Research Governance. Washington, DC: The National Academies Press. https://doi.org/10.17226/25762 (Accessed: 1 September 2025).

Network for Greening the Financial System (NGFS), 2024. Synthesis Report on the Greening of the Financial System: Insights for Financial Actors in Advanced and Emerging Economies. Published on the occasion of COP29, Baku, 14 November 2024. Available at: https://www.ngfs.net/system/files/import/ngfs/medias/documents/ngfs_synthesis_report_on_the_greening_of_the_financial_system.pdf (Accessed: 1 September 2025).

Nielsen, J., 2025. The big green button: stratospheric aerosol injection as a geopolitical dilemma during strategic competition between the United States and China, and implications for expanding aerosol injection near-term research. Oxford Open Climate Change, 5(1), p.kgaf009. https://doi.org/10.1093/oxfclm/kgaf009

Norwegian Government 2024 Prop. 1 S (2024–2025) – For budsjettåret 2025 under Klima- og miljødepartementet. Regjeringen.no. Available at: https://www.regjeringen.no/no/dokumenter/prop.-1-s-20242025/id3057446/?ch=3#kap6 (Accessed: 1 September 2025).

O'Donnell, E., Poelina, A., Pelizzon, A. and Clark, C., 2020. Stop burying the Lede: The essential role of indigenous law (s) in creating rights of nature. Transnational Environmental Law, 9(3), pp.403-427. https://doi.org/10.1017/S2047102520000242

O'Donnell, E.L. and Talbot-Jones, J., 2018. Creating legal rights for rivers. Ecology and Society, 23(1). https://doi.org/10.5751/ES-09854-230107

Pereira, J.C. and Terrenas, J., 2022. Towards a transformative governance of the Amazon. Global Policy, 13, pp.60-75. https://doi.org/10.1111/1758-5899.13163

Pflüger, D., Wieners, C.E., Van Kampenhout, L., Wijngaard, R.R. and Dijkstra, H.A., 2024. Flawed emergency intervention: Slow ocean response to abrupt stratospheric aerosol injection. Geophysical Research Letters, 51(5), p.e2023GL106132. https://doi.org/10.1029/2023GL106132

Poorter, L., Craven, D., Jakovac, C.C., Van Der Sande, M.T., Amissah, L., Bongers, F., Chazdon, R.L., Farrior, C.E., Kambach, S., Meave, J.A. and Muñoz, R., 2021. Multidimensional tropical forest recovery. Science, 374(6573), pp.1370-1376. https://doi.org/10.1126/science.abh3629

Realmonte, G., Drouet, L., Gambhir, A., Glynn, J., Hawkes, A., Köberle, A.C. and Tavoni, M., 2019. An inter-model assessment of the role of direct air capture in deep mitigation pathways. Nature communications, 10(1), p.3277. https://doi.org/10.1038/s41467-019-10842-5

Ritz, V., 2024. Climate tipping points: Tracing the limits of political discretion. Leiden Journal of International Law, pp.1-22. https://doi.org/10.1017/S0922156524000487

RiverOfLife, M., Poelina, A., Bagnall, D. and Lim, M., 2020. Recognizing the Martuwarra's first law right to life as a living ancestral being. Transnational Environmental Law, 9(3), pp.541-568. https://doi.org/10.1017/S2047102520000163

Rockström, J., Kotzé, L., Milutinović, S., Biermann, F., Brovkin, V., Donges, J., Ebbesson, J., French, D., Gupta, J., Kim, R. and Lenton, T., 2024. The planetary commons: A new paradigm for safeguarding Earth-regulating systems in the Anthropocene. Proceedings of the National Academy of Sciences, 121(5), p.e2301531121. https://doi.org/10.1073/pnas.2301531121

Schwinger, J., Asaadi, A., Goris, N. and Lee, H., 2022. Possibility for strong northern hemisphere high-latitude cooling under negative emissions. Nature Communications, 13(1), p.1095. https://doi.org/10.1038/s41467-022-28573-5

Science Panel for the Amazon (SPA), 2021. Amazon Assessment Report 2021. Available at: https://www.sp-amazon.org/publications/#ar2021 (Accessed: 1 September 2025).

Setzer, J. and Higham, C., 2025. Global Trends in Climate Change Litigation: 2025 Snapshot. London: Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science. Available at: https://www.lse.ac.uk/granthaminstitute/publication/global-trends-in-climate-change-litigation-2025-snapshot/ (Accessed: 1 September 2025).

Smith, S. M., Geden, O., Gidden, M. J., Lamb, W. F., Nemet, G. F., Minx, J. C., Buck, H., Burke, J., Cox, E., Edwards, M. R., Fuss, S., Johnstone, I., Müller-Hansen, F., Pongratz, J., Probst, B. S., Roe, S., Schenuit, F., Schulte, I. and Vaughan, N. E. (eds.), 2024. The State of Carbon Dioxide Removal 2024 – 2nd Edition. https://doi.org/10.17605/OSF.IO/F85QJ

Sun, X., Wang, P., Ferris, T., Lin, H., Dreyfus, G., Gu, B.-H., Zaelke, D., and Wang, Y., 2022. Fast action on short-lived climate pollutants and nature-based solutions to help countries meet carbon neutrality goals. Advances in Climate Change Research, 13(4), pp.564-577. https://doi.org/10.1016/j.accre.2022.06.003

T n sescu, M., 2020. Rights of nature, legal personality, and indigenous philosophies. Transnational environmental law, 9(3), pp.429-453. https://doi.org/10.1017/S2047102520000217

Tilmes, S., MacMartin, D.G., Lenaerts, J., Van Kampenhout, L., Muntjewerf, L., Xia, L., Harrison, C.S., Krumhardt, K.M., Mills, M.J., Kravitz, B. and Robock, A., 2020. Reaching 1.5 and 2.0 C global surface temperature targets using stratospheric aerosol geoengineering. Earth System Dynamics, 11(3), pp.579-601. https://doi.org/10.5194/esd-11-579-2020

Trust, S., Saye, L., Bettis, O., Bedenham, G., Hampshire, O., Lenton, T. M., and Abrams, J. F., 2025. Planetary Solvency – finding our balance with nature [Working Paper]. Publication date: 16 January 2025. Available at: https://actuaries.org.uk/media/wqeftma1/planetary-solvency-finding-our-balance-with-nature.pdf (Accessed: 1 September 2025)

United Nations Environment Programme (UNEP) and Climate and Clean Air Coalition (CCAC) (2021) Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions. Nairobi: United Nations Environment Programme. Available at: https://www.ccacoalition.org/resources/global-methane-assessment-full-report (Accessed: 1 September 2025).

United Nations Environment Programme (UNEP), 2023. One Atmosphere: An Independent Expert Review on Solar Radiation Modification Research and Deployment. Nairobi: United Nations Environment Programme. Published 28 February 2023. Available at: https://www.unep.org/resources/report/Solar-Radiation-Modification-research-deployment (Accessed: 1 September 2025).

United Nations Environment Programme (UNEP), 2024. Emissions Gap Report 2024: No more hot air ... please! https://doi.org/10.59117/20.500.11822/46404

United Nations Framework Convention on Climate Change (UNFCCC) 2024. Periodic Review. UNFCCC. Available at: https://unfccc.int/topics/science/workstreams/periodic-review#Continuation-of-the-periodic-review (Accessed: 1 September 2025).

Van Westen, R.M., Kliphuis, M. and Dijkstra, H.A., 2024. Physics-based early warning signal shows that AMOC is on tipping course. Science advances, 10(6), p.eadk1189. https://doi.org/10.1126/sciadv.adk1189

Walker, W.S., Gorelik, S.R., Baccini, A., Aragon-Osejo, J.L., Josse, C., Meyer, C., Macedo, M.N., Augusto, C., Rios, S., Katan, T. and de Souza, A.A., 2020. The role of forest conversion, degradation, and disturbance in the carbon dynamics of Amazon indigenous territories and protected areas. Proceedings of the National Academy of Sciences, 117(6), pp.3015-3025. https://doi.org/10.1073/pnas.1913321117

Willcock, S., Cooper, G.S., Addy, J. and Dearing, J.A., 2023. Earlier collapse of Anthropocene ecosystems driven by multiple faster and noisier drivers. Nature Sustainability, 6(11), pp.1331-1342. https://doi.org/10.1038/s41893-023-01157-x

Willis, R., Curato, N. and Smith, G., 2022. Deliberative democracy and the climate crisis. Wiley Interdisciplinary Reviews: Climate Change, 13(2), p.e759. https://doi.org/10.1002/wcc.759

World Commission on the Ethics of Scientific Knowledge and Technology (COMEST), 2023. Report of the World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) on the ethics of climate engineering. Paris: UNESCO. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000386677 (Accessed: 1 September 2025).

Wunderling, N., Winkelmann, R., Rockström, J., Loriani, S., Armstrong McKay, D.I., Ritchie, P.D., Sakschewski, B. and Donges, J.F., 2023. Global warming overshoots increase risks of climate tipping cascades in a network model. Nature Climate Change, 13(1), pp.75-82. https://doi.org/10.1038/s41558-022-01545-9

Xie, M., Moore, J.C., Zhao, L., Wolovick, M. and Muri, H., 2022. Impacts of three types of solar geoengineering on the Atlantic Meridional Overturning Circulation. Atmospheric Chemistry and Physics, 22(7), pp.4581-4597. https://doi.org/10.5194/acp-22-4581-2022

Yamineva, Y., Kulovesi, K. and Recio, E. eds., 2024. Reducing Emissions of Short-Lived Climate Pollutants: Perspectives on Law and Governance. Brill/Nijhoff. ISBN: 978-90-04-68408-9

Zemp, D.C., Schleussner, C.F., Barbosa, H.M., Hirota, M., Montade, V., Sampaio, G., Staal, A., Wang-Erlandsson, L. and Rammig, A., 2017. Self-amplified Amazon forest loss due to vegetation-atmosphere feedbacks. Nature communications, 8(1), p.14681. https://doi.org/10.1038/ncomms14681

References: 1.3

Appleby JK (2025) The United States, Europe, and the Global Compacts: Honoring the Right to Remain and the Right to Migrate. Journal on Migration and Human Security 13(1). SAGE Publications Inc: 151–167. https://doi.org/10.1177/23315024241306416

Battiston S, Mandel A, Monasterolo I, et al. (2017) A climate stress-test of the financial system. Nature Climate Change 7(4). Nature Publishing Group: 283–288. https://doi.org/10.1038/nclimate3255

Berkhout F, Dow K and Thomas A (2024) Delayed, abrupt and unjust: An institutionalist perspective on limits to climate change adaptation. Climate Risk Management 44: 100611. https://doi.org/10.1016/j.crm.2024.100611

Biesbroek R, Haasnoot M, Mach KJ, et al. (2025) Adaptation planning in the context of a weakening and possibly collapsing Atlantic Meridional Overturning Circulation (AMOC). Regional Environmental Change 25(3): 93. https://doi.org/10.1007/s10113-025-02434-5

Bolton P, Morgan D, Pereira da Silva LA, et al. (2020) The Green Swan: Central banking and financial stability in the age of climate change. Bank for International Settlements. Available at: https://www.bis.org/publ/othp31.pdf.

Carbon Brief (2023) Three major gaps in climate-adaptation finance for developing countries. In: Carbon Brief. Available at: https://www.carbonbrief.org/guest-post-three-major-gaps-in-climate-adaptation-finance-for-developing-countries/ (accessed 4 September 2025).

Costanza R, d'Arge R, de Groot R, et al. (1997) The value of the world's ecosystem services and natural capital. Nature 387(6630). Nature Publishing Group: 253–260. https://doi.org/ https://doi.org/10.1038/387253a0

Costanza R, de Groot R, Braat L, et al. (2017) Twenty years of ecosystem services: How far have we come and how far do we still need to go? Ecosystem Services 28: 1–16. https://doi.org/10.1016/j.ecoser.2017.09.008

Curato N, Dryzek JS, Levai D, et al. (2025) Where next for global climate deliberation: From proof of concept to a role in transformation. Earth System Governance 25: 100280. https://doi.org/10.1016/j.esg.2025.100280

Dakos V, Boulton CA, Buxton JE, et al. (2024) Tipping point detection and early warnings in climate, ecological, and human systems. Earth System Dynamics 15(4). Copernicus GmbH: 1117–1135. https://doi.org/10.5194/esd-15-1117-2024

Dasgupta P (2021) The Economics of Biodiversity: The Dasgupta Review. 20 August. UK. Available at: https://www.gov.uk/government/publications/final-report-the-economics-of-biodiversity-the-dasgupta-review (accessed 4 September 2025).

Desmet K, Kopp RE, Kulp SA, et al. (2021) Evaluating the Economic Cost of Coastal Flooding. American Economic Journal: Macroeconomics 13(2): 444–486. https://doi.org/10.1257/mac.20180366

Dryzek JS (2016) Institutions for the Anthropocene: Governance in a Changing Earth System. British Journal of Political Science 46(4): 937–956. https://doi.org/v10.1017/S0007123414000453

EEA (2024) European Climate Risk Assessment. 10 March. European Environment Agency. Available at: https://www.eea.europa.eu/en/analysis/publications/european-climate-risk-assessment (accessed 4 September 2025).

Escobar O and Elstub S (2025) Climate Assemblies: New Civic Institutions for a Climate-changed World. Berlin: De Gruyter. https://doi.org/10.1515/9783111328393

EU (2021) Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN (accessed 4 September 2025).

FSB (2025) Assessment of Climate-related Vulnerabilities: Analytical framework and toolkit. 16 January. Available at: https://www.fsb.org/2025/01/assessment-of-climate-related-vulnerabilities-analytical-framework-and-toolkit/ (accessed 6 September 2025).

Galaz V, Sterblom HÖ, Bodin Ö, et al. (2016) Global networks and global change-induced tipping points. International Environmental Agreements 16: 189–221. https://doi.org/ 10.1007/s10784-014-9253-6

Galmarini S, Roman Cuesta RM, Dentener F, et al. (2025) Raising Awareness of Earth System Tipping Points: Implications for EU Governance : Workshop Report. Publications Office of the European Union. Available at: https://data.europa.eu/doi/10.2760/9047293 (accessed 4 September 2025).

Gao C, Lan X, Li N, et al. (2024) Large language models empowered agent-based modeling and simulation: a survey and perspectives. Humanities and Social Sciences Communications 11(1). Palgrave: 1259. https://doi.org/ 10.1057/s41599-024-03611-3

Ghaffarzadegan N, Majumdar A, Williams R, et al. (2024) Generative agent-based modeling: an introduction and tutorial. System Dynamics Review 40(1): e1761. https://doi.org/ 10.1002/sdr.1761

Gupta J, Liverman D, Prodani K, et al. (2023) Earth system justice needed to identify and live within Earth system boundaries. Nature Sustainability. Nature Publishing Group: 1–9. https://doi.org/10.1038/s41893-023-01064-1

Hilson C and Arnall A (2025) Sea level rise, claims-making and managed retreat in Fairbourne, North Wales. Climate Policy 25(6). Taylor & Francis: 852–865. https://doi.org/10.1080/14693062.2024.2420739

IPBES (2024) Thematic Assessment Report on the Interlinkages among Biodiversity, Water, Food and Health of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (eds PA Harrison, PD McElwee, and TL Van Huysen). Bonn, Germany: IPBES Secretariat. Available at: https://doi.org/10.5281/zenodo.13850054.

IPCC (2023) Climate Change 2023: Synthesis Report. In: Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (Eds.)]. Geneva, Switzerland: Intergovernmental Panel on Climate Change, pp. 35–115. Available at: 10.59327/IPCC/AR6-9789291691647.

Juhola S, Filatova T, Hochrainer-Stigler S, et al. (2022) Social tipping points and adaptation limits in the context of systemic risk: Concepts, models and governance. Frontiers in Climate 4. https://doi.org/10.3389/fclim.2022.1009234

Kedward K, Ryan-Collins J and Chenet H (2023) Biodiversity loss and climate change interactions: financial stability implications for central banks and financial supervisors. Climate Policy 23(6). Taylor & Francis: 763–781. https://doi.org/10.1080/14693062.2022.2107475

Kousky C (2019) Threats to Insurability. In: Kunreuther H, Meyer RJ, and Michel-Kerjan EO (eds) The Future of Risk Management. University of Pennsylvania Press, pp. 251–266. Available at: https://www.jstor.org/stable/j.ctv16t6ggg.17 (accessed 6 September 2025). https://doi.org/978-0-8122-2508-2

Kwadijk JCJ, Haasnoot M, Mulder JPM, et al. (2010) Using adaptation tipping points to prepare for climate change and sea level rise: a case study in the Netherlands. WIREs Climate Change 1(5): 729–740. https://doi.org/10.1002/wcc.64

Laybourn L, Abrams J, Benton D, et al. (2024) The security blind spot: Cascading climate impacts and tipping points threaten national security. Institute for Public Policy Research, IPPR. Available at: http://www.ippr.org/articles/security-blind-spot.

Lenton TM, Rockström J, Gaffney O, et al. (2019) Climate tipping points — too risky to bet against. Nature 575(7784). 7784. Nature Publishing Group: 592–595. . https://doi.org/10.1038/d41586-019-03595-0

Lorenzoni I, Jordan AJ, Sullivan-Thomsett C, et al. (2025) A review of National Citizens' Climate Assemblies: learning from deliberative events. Climate Policy 0(0). Taylor & Francis: 1–17. https://doi.org/10.1080/14693062.2024.2449416

Marsden L, Ryan-Collinss J, Abrams J, et al. (2024) Ecosystem tipping points: Understanding the risks to the economy and the financial system | Bartlett Faculty of the Built Environment. 25 April. UK: UCL Institute for Innovation and Public Purpose. Available at: https://www.ucl.ac.uk/bartlett/publications/2024/apr/ecosystem-tipping-points-understanding-risks-economy-and-financial-system (accessed 4 September 2025).

McNamara KE and Jackson G (2019) Loss and damage: A review of the literature and directions for future research. WIREs Climate Change 10(2): e564. https://doi.org/10.1002/wcc.564

Merikanto J, Makonen R, Thölix L, et al. (2024) The Significance of Climate Tipping Points for Finland: Latest Information on the Possible Shutdown of the Atlantic Meridional Overturning Circulation (AMOC) and Preventive Climate Actions. Atmosphere and Climate Competence Center (ACCC). Available at: https://www.acccflagship.fi/wp-content/uploads/Tipping_points_Policy_Brief_english.pdf.

Meyerson D, Mackenzie C and MacDermott T (eds) (2020) Procedural Justice and Relational Theory: Empirical, Philosophical, and Legal Perspectives. London: Routledge. https://doi.org/10.4324/9780429317248

Micinski NR and Lefebvre C (2024) The Geopolitics in the Global Compacts: Sovereignty, Emerging Norms, and Hypocrisy in Global Migration Governance. Geopolitics 29(1). Routledge: 1–12. https://doi.org/10.1080/14650045.2023.2265321

Milkoreit M, Boyd E, Constantino SM, et al. (2024) Governance for Earth system tipping points – A research agenda. Earth System Governance 21: 100216. https://doi.org/10.1016/j.esg.2024.100216

NGSF (2022) Central banking and supervision in the biosphere: an agenda for action on biodiversity loss, financial risk and system stability. Available at: https://www.ngfs.net/en/publications-and-statistics/publications/central-banking-and-supervision-biosphere-agenda-action-biodiversity-loss-financial-risk-and-system (accessed 6 September 2025).

NGSF (2025) NGFS Short-term Climate Scenarios for central banks and supervisors. Available at: https://www.ngfs.net/en/publications-and-statistics/publications/ngfs-short-term-climate-scenarios-central-banks-and-supervisors (accessed 4 September 2025).

Norway M of F (2018) NOU 2018: 17 - Climate risk and the Norwegian economy. NOU, 12 December. regjeringen.no. Available at: https://www.regjeringen.no/en/dokumenter/nou-2018-17/id2622043/ (accessed 4 September 2025).

OECD (2023) Assessing biodiversity-related financial risks. OECD Environment Policy Papers No. 36, 26 April. Paris: OECD. Available at: https://www.oecd.org/en/publications/assessing-biodiversity-related-financial-risks_d52137a5-en.html (accessed 6 September 2025).

OECD (2025) OECD deliberative Democracy Database. Available at: https://www.peoplepowered.org/resources-content/oecd-deliberative-democracy-database (accessed 6 September 2025).

Parsons ES, Jowell A, Veidis E, et al. (2024) Climate change and inequality. Pediatric Research. Nature Publishing Group: 1–8. https://doi.org/10.1038/s41390-024-03153-z

Pescaroli G, Dryhurst S and Karagiannis GM (2025) Bridging gaps in research and practice for early warning systems: new datasets for public response. Frontiers in Communication 10. Frontiers: 1451800. https://doi.org/10.3389/fcomm.2025.1451800

Roman Cuesta R, Dentener F, Galmarini S, et al. (2025) Earth System Tipping Points are a threat to Europe. Ispra (Italy): European Commission.

Ruhl JB and Salzman J (2023) The Greens' Dilemma: Building Tomorrow's Climate Infrastructure Today. Emory Law Journal 73(1): 1. https://scholarlycommons.law.emory.edu/elj/vol73/iss1/1

Schweizer PJ and Juhola S (2024) Navigating systemic risks: governance of and for systemic risks. Global Sustainability 7(e38). https://doi.org/10.1017/sus.2024.30

Sen A (2009) The Idea of Justice. Harvard University Press. https://doi.org/10.4159/9780674054578

Stokes E and Smyth C (2024) Hope-Bearing Legislation? The Well-being of Future Generations (Wales) Act 2015. Transnational Environmental Law 13(3): 569–587. https://doi.org/10.1017/S2047102524000219

Thalheimer L, Cottier F, Kruczkiewicz A, et al. (2025) Prioritizing involuntary immobility in climate policy and disaster planning. Nature Communications 16(1). Nature Publishing Group: 2581. https://doi.org/10.1038/s41467-025-57679-9

Trust S, Saye L, Bettis O, et al. (2025) Planetary Solvency – finding our balance with nature; Global risk management for human prosperity. Institute and Faculty of Actuaries, University of Exeter.

Ullah AKMA (2025) Migration as International Relations. Global Networks 25(3): e70016. https://doi.org/10.1111/glob.70016

UNEP (2022) Prioritising nature-related disclosures: considerations for high-risk sectors. Available at: https://www.unepfi.org/publications/prioritising-nature-related-disclosures-considerations-for-high-risk-sectors/ (accessed 6 September 2025).

WEF (2020) Nature Risk Rising: Why the Crisis Engulfing Nature Matters for Business and the Economy. World Economic Forum. Available at: https://www.weforum.org/publications/nature-risk-rising-why-the-crisis-engulfing-nature-matters-for-business-and-the-economy/ (accessed 4 September 2025).

WEF (2024) Global Risks Report 2024. World Economic Forum. Available at: https://www.weforum.org/publications/global-risks-report-2024/ (accessed 6 September 2025).

Wunderling N, von der Heydt AS, Aksenov Y, et al. (2024) Climate tipping point interactions and cascades: a review. Earth System Dynamics 15(1). Copernicus GmbH: 41–74. https://doi.org/10.5194/esd-15-41-2024

Young O (2021) Grand Challenges of Planetary Governance: Global Order in Turbulent Times. Edward Elgar Publishing. https://doi.org/10.4337/9781802200720v

Wibisono RB (2024) Migration, Security, and Human Rights: The Struggle for Refugee Protection. The Sunan Ampel Review of Political and Social Sciences 4(1): 61–82. https://doi.org/10.15642/sarpass.2024.4.1.61-82

Woodworth F (2024) Exclusion of Climate Migrants from the Global Compact on Refugees. Geopolitics 29(1). Routledge: 118–147. https://doi.org/10.1080/14650045.2023.2225242

References: 1.4

Ahmad, H. M. (2024) A Crosswinds of Corporate Accountability: Corporate Climate Liability in the Canadian Legal Abyss. Osgoode Digital Commons, All Papers. 393. Available at: https://digitalcommons.osgoode.yorku.ca/all_papers/393/

Amazon Cooperation Treaty Organization (ACTO) (2023) Declaration of Belém. Available at: https://otca.org/en/wp-content/uploads/2023/10/Declaration-of-Belem.pdf

Aristova, E., & Nichols, L. (2024) Climate change on the board: navigating directors' duties. Journal of Corporate Law Studies, 24(2), 479–514. https://doi.org/10.1080/14735970.2024.2414466

Avila Santamaria, R. (2024) The Systemic Theory of Law in the Jurisprudence of Nature in Ecuador: From the Machine to the Web of Life, in More Than Human Rights, César Garavito-Rodríguez (ed), NYU. Available at: https://mothrights.org/wp-content/themes/moth/assets/images/book/pdfs/More-Than-Human-Rights_Book.pdf

Basic Law for the Federal Republic of Germany. https://www.gesetze-im-internet.de/englisch_gg/englisch_gg.html

Bennett, N.J., López de la Lama, R., Le Billon, P., Ertör, I. and Morgera, E. (2023) Ocean defenders and human rights. Frontiers in Marine Science, 9, p.1089049.https://doi.org/10.3389/fmars.2022.1089049

Buhmann, K., Fonseca, A., Andrews, N., Amatulli, G. (2025) The Routledge Handbook on Meaningful Stakeholder Engagement, 494 p. Routledge.

Chapin, F.S., Weber, E.U., Bennett, E.M. et al. (2022) Earth stewardship: Shaping a sustainable future through interacting policy and norm shifts. Ambio 51, 1907–1920. https://doi.org/10.1007/s13280-022-01721-3

Civil Freedoms & HRD Database, Business and Human Rights Resource Centre. Available at: https://www.business-humanrights.org/en/from-us/human-rights-defenders-database/

Constitution of the Republic of Ecuador. Available at: https://www.defensa.gob.ec/wp-content/uploads/downloads/2021/02/Constitucion-de-la-Republica-del-Ecuador_act_ene-2021.pdf

Constitution of the Republic of South Africa. Available at: https://www.justice.gov.za/constitution/SAConstitution-web-eng.pdf

Earth Law Center (2025) A Voice for Coral Reef Ecosystems Through the Rights of Nature and Ecocentric Law. Available at: https://static1.squarespace.com/static/55914fd1e4b01fb0b851a814/t/6849925769231f024a8edcdb/1749652058340/Rights+of+Coral+Reefs+Toolkit_ELC.pdf

European Parliament, the Council and the Commission (2000) Charter of Fundamental Rights of the European Union. Official Journal of the European Communities 18.12.2000, C 364/1. Available at: https://www.europarl.europa.eu/charter/pdf/text_en.pdf

European Commission (2024) Directive on corporate sustainability due diligence (Directive 2024/1760) Available at: https://commission.europa.eu/business-economy-euro/doing-business-eu/sustainability-due-diligence-responsible-business/corporate-sustainability-due-diligence_en

Freeman, B. and Handagard, R. (2025) Business Frameworks and Actions to Support Human Rights Defenders. International Human Rights Service and Business & Human Rights Resource Centre. Available at: https://ishr.ch/latest-updates/business-frameworks-and-actions-to-support-defenders-a-retrospective-of-10-years-of-progress-and-challenges/

Front Line Defenders, Global Analysis 2024/25, 2025. Available at: https://www.ohchr.org/en/documents/thematic-reports/ahrc5646-scene-setting-report-report-special-rapporteur-promotion-and

Global Alliance for the Rights of Nature, Rights of Nature Map, 2024. Available at: https://www.garn.org/rights-of-nature-map/

Gupta, J., Liverman, D., Prodani, K., Aldunce, P., Bai, X., Broadgate, W., Ciobanu, D., Gifford, L., Gordon, C., Hurlbert, M. and Inoue, C.Y. (2023) Earth system justice needed to identify and live within Earth system boundaries. Nature Sustainability, 6(6), 630-638. https://doi.org/10.1038/s41893-023-01064-1

Hanna, P., & Vanclay, F. (2013) Human rights, Indigenous peoples and the concept of Free, Prior and Informed Consent. Impact Assessment and Project Appraisal 31(2), 146–157. https://doi.org/10.1080/14615517.2013.780373

Institute and Faculty of Actuaries (2025) Current climate policies risk catastrophic societal and economic impacts. Available at: https://actuaries.org.uk/media-release/current-climate-policies-risk-catastrophic-societal-and-economic-impacts/ (Accessed: 7 September 2025).

Inter-American Court of Human Rights (IACHR), 2012. Case of the Kichwa Indigenous People of Sarayaku v. Ecuador. Available at: https://corteidh.or.cr/docs/casos/articulos/seriec_245_ing.pdf

Inter-American Court of Human Rights (IACHR) (2025) Advisory Opinion OC-32/25: The Climate Emergency and Human Rights. San José, Costa Rica: Inter-American Court of Human Rights. Available at: https://www.corteidh.or.cr/tablas/OC-32-2025/index-eng.html (Accessed: 1 September 2025).

Intergovernmental Panel on Climate Change (IPCC) (2023) Sixth Assessment Report. Available at: https://www.ipcc.ch/assessment-report/ar6/

International Court of Justice (ICJ) (2025) Obligations of States in Respect of Climate Change (Request for Advisory Opinion). Available at: https://www.icj-cij.org/case/187

International Law Association Committee on Legal Principles Relating to Climate Change (2014) Declaration of Legal Principles Relating to Climate Change, Resolution 2/2014. Available at: https://www.ila-hq.org/en_GB/documents/conference-resolution-no-2-english-washington-2014

International Tribunal for the Law of the Sea (ITLOS) (2024) Request for an Advisory Opinion Submitted by the Commission of Small Island States on Climate Change and International Law. Available at: https://itlos.org/fileadmin/itlos/documents/cases/31/Advisory_Opinion/C31_Adv_Op_21.05.2024_orig.pdf

Jodoin, S., Savaresi, A. and Wewerinke-Singh, M. (2021) Rights-based approaches to climate decision-making. Current Opinion in Environmental Sustainability, 52, pp.45-53. https://doi.org/10.1016/j.cosust.2021.06.004

Kotzé, L.J. (2019) The Anthropocene, earth system vulnerability and socio-ecological injustice in an age of human rights. Journal of Human Rights and the Environment, 10(1), pp.62-85. https://doi.org/10.4337/jhre.2019.01.04

Kotzé LJ. (2021) Neubauer et al. versus Germany: Planetary Climate Litigation for the Anthropocene? German Law Journal. 22(8):1423-1444. https://doi.org/10.1017/glj.2021.87

Lazard, O., Bissett, M., Dyke, J. (2025) Geoengineering: Assessing Risks in the Era of Planetary Security. Available at: https://carnegie-production-assets.s3.amazonaws.com/static/files/Lazard,%20Bissett,%20Dyke_Geoengineering%20Planetary%20Risks.pdf (Accessed: 7 September 2025).

Leghari v. Federation of Pakistan, W.P. No. 25501/201, 2015. Available at: https://climatecasechart.com/non-us-case/ashgar-leghari-v-federation-of-pakistan/

Litwin, D. and Savourey, E. (2025) Human Rights in EU Sustainable Finance, Journal of Financial Regulation, Volume 11, Issue 1, Pages 41–72, https://doi.org/10.1093/jfr/fjaf001

Llurimagua Case, Corte Provincial de Justicia de Imbabura, No. 10332-2021-00937, 2023. Available at: https://www.derechosdelanaturaleza.org.ec/wp-content/uploads/2021/05/SENTENCIA-SEGUNDA-INSTANCIA-LLURIMAGUA-1.pdf

Los Cedros Case, Constitutional Court of Ecuador, No. 1149-19-JP/20, 2021. Available at: https://celdf.org/wp-content/uploads/2015/08/Los-Cedros-Decision-ENGLISH-Final.pdf

Mayer B. (2022) The judicial assessment of states' action on climate change mitigation. Leiden Journal of International Law. 35(4):801-824. https://doi.org/10.1017/S092215652200036X

McVey, M. and Savaresi, A (2025) The ICJ Advisory Opinion on Climate Change: A Business and Human Rights Perspective. Opinio Juris 04.08.25. Available at: https://opiniojuris.org/2025/08/04/the-icj-advisory-opinion-on-climate-change-a-business-and-human-rights-perspective/

Milkoreit, M., Boyd, E., Constantino, S.M., Hausner, V.H., Hessen, D.O., Kääb, A., McLaren, D., Nadeau, C., O'Brien, K., Parmentier, F.J. and Rotbarth, R. (2024) Governance for Earth system tipping points–A research agenda. Earth System Governance, 21, p.100216. https://doi.org/10.1016/j.esg.2024.100216

Moyn, S. (2019) Not Enough, 296p. Harvard University Press.

Neubauer, et al. v. Germany, 2021. Available at: https://climatecasechart.com/non-us-case/neubauer-et-al-v-germany/

OECD Guidelines for Multinational Enterprises, 2023. Available at: https://www.oecd.org/en/publications/oecd-guidelines-for-multinational-enterprises-on-responsible-business-conduct_81f92357-en.html

Office of the Compliance Advisor Ombudsman, Available at: https://www.cao-ombudsman.org/

Pariotti, E. (2023) Vulnerability and Human Rights: Which Compatibility?. International Journal for the Semiotic Law 36, 1401–1413 https://doi.org/10.1007/s11196-023-09977-y

Paris Agreement, 2015. Available at: https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf

Pereira, L.M., Gianelli, I., Achieng, T., Amon, D., Archibald, S., Arif, S., Castro, A., Chimbadzwa, T.P., Coetzer, K., Field, T.L. and Selomane, O. (2024) Equity and justice should underpin the discourse on tipping points. Earth System Dynamics, 15(2), pp.341-366. https://doi.org/10.5194/esd-15-341-2024

Pereira, L. M., Smith, S. R., Gifford, L., Newell, P., Smith, B., Villasante, S., Achieng, T., Castro, A., Constantino, S. M., Ghadiali, A., Vogel, C., and Zimm, C. (2023) Risks, Ethics and Justice in the governance of positive tipping points, EGUsphere. https://doi.org/10.5194/egusphere-2023-1454

Potsdam Institute for Climate Impact Research (2024) 38 trillion dollars in damages each year: World economy already committed to income reduction of 19 % due to climate change. Available online at https://www.pik-potsdam.de/en/news/latest-news/38-trillion-dollars-in-damages-each-year-world-economy-already-committed-to-income-reduction-of-19-due-to-climate-change (Accessed: 1 September 2025)

Rammelt, C.F., Gupta, J., Liverman, J., Ciobanu, D., Abrams, J., Bai, X., Gifford, L., Gordon, C., Hurlbert, M., Inoue, C., Jacobson, L., Lade, S., Lenton, T., Armstrong McKay, D., Nakicenovic, N., Okereke, C., Otto, I., Pereira, L., Prodani, K., Rockström, J., Stewart-Koster, B., Verburg, P., & Zimm, C. (2022) Impacts of meeting minimum access on critical earth systems amidst the Great Inequality. Nature Sustainability 6, 212–221. https://doi.org/10.1038/s41893-022-00995-5

Reinsberg, B., and Steinert, C. V. (2025) The French duty of vigilance law: reconciling human rights and firm profitability. Review of International Political Economy, 1–33. https://doi.org/10.1080/09692290.2025.2519189

Ritz, V. (2024) Climate tipping points: Tracing the limits of political discretion. Leiden Journal of International Law, pp.1-22. https://doi.org/10.1017/S0922156524000487

Rockström, J., Kotzé, L., Milutinović, S., Biermann, F., Brovkin, V., Donges, J., Ebbesson, J., French, D., Gupta, J., Kim, R. and Lenton, T. (2024) The planetary commons: A new paradigm for safeguarding Earth-regulating systems in the Anthropocene. Proceedings of the National Academy of Sciences, 121(5), p.e2301531121. https://doi.org/10.1073/pnas.2301531121

Rodríguez-Garavito, C. (2022) Litigating the Climate Emergency: How Human Rights, Courts, and Legal Mobilization Can Bolster Climate Action, Cambridge University Press. https://doi.org/10.1017/9781009106214

Rodríguez-Garavito, C. (2024) More-Than-Human Rights: Law, Science, and Storytelling beyond Anthropocentrism in More Than Human Rights, César Garavito-Rodríguez (ed), NYU. Available at: https://mothrights.org/wp-content/themes/moth/assets/images/book/pdfs/More-Than-Human-Rights_Book.pdf

Rogge, M. (2022) Risk, Uncertainty and the Future of Corporate Human Rights Due Diligence. Corporate Responsibility Initiative Working Paper Series 2022.81, Mossavar-Rahmani Center for Business & Government. Available at: https://dash.harvard.edu/server/api/core/bitstreams/a1d0df07-9973-483b-9c20-42c253643703/content

Savaresi, A. (2025) Verein KlimaSeniorinnen Schweiz and Others v Switzerland: Making climate change litigation history. Review of European, Comparative & International Environmental Law, 34(1), pp.279-287. https://doi.org/10.1111/reel.12612

Savourey, E and Brabant, S. (2021) The French Law on the Duty of Vigilance: Theoretical and Practical Challenges Since its Adoption. Business and Human Rights Journal. 2021;6(1):141-152. https://doi.org/10.1017/bhj.2020.30

Sen, A. (2009) The Idea of Justice. Harvard University Press https://doi.org/10.2307/j.ctvjnrv7n

Setzer, J. and Higham, C. (2025) Global Trends in Climate Change Litigation: 2025 Snapshot. London: Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science. https://doi.org/10.21953/LSE.LH46LE9Y8SGI

Siqueira-Gay, J., Sánchez, L.E. (2021) The outbreak of illegal gold mining in the Brazilian Amazon boosts deforestation. Reg Environ Change 21, 28. https://doi.org/10.1007/s10113-021-01761-7

State of the Netherlands v. Stichting Urgenda, 2019. Available at: https://uitspraken.rechtspraak.nl/details?id=ECLI:NL:HR:2019:2007

Tigre, M.A., Murcott, M.J. and Samuel, S.A., (eds) (2025) Climate Litigation and Vulnerabilities: Global South Perspectives, Routledge. https://doi.org/10.4324/9781003470632

United Nations Economic Commission for Europe (2024) Statement regarding the four-year prison sentence imposed on Mr. Daniel Shaw for his involvement in peaceful environmental protest in the United Kingdom, United Nations Economic Commission for Europe, Michel Forst, ACSR/C/2024/26. Available at: https://unece.org/sites/default/files/2024-07/ACSR_C_2024_26_UK_SR_EnvDefenders_public_statement_18.07.2024.pdf

United Nations Economic Commission for Europe (2024) Visit to London, United Kingdom of Great Britain and Northern Ireland, 10-12 January 2024 End of Mission Statement, Michel Forst. Available at: https://unece.org/sites/default/files/2024-01/Aarhus_SR_Env_Defenders_statement_following_visit_to_UK_10-12_Jan_2024.pdf

United Nations Framework Convention on Climate Change (UNFCCC) (2024) Periodic Review. UNFCCC. Available at: https://unfccc.int/topics/science/workstreams/periodic-review#Continuation-of-the-periodic-review (Accessed: 1 September 2025).

United Nations General Assembly (UNGA) (2017) Report of the Special Rapporteur on the situation of human rights defenders, Michel Forst, A/72/170. Available at: https://docs.un.org/en/A/72/170

United Nations General Assembly (UNGA) (2022) The human right to a clean, healthy and sustainable environment. A/RES/76/300. Available at: https://docs.un.org/en/A/RES/76/300

United Nations Guiding Principles on Business and Human Rights (2011) HR/PUB/11/04 Available at: https://www.ohchr.org/sites/default/files/documents/publications/guidingprinciplesbusinesshr_en.pdf

United Nations Human Rights Committee, 2019. General comment No. 36, CCPR/C/GC/36. Available at: https://docs.un.org/en/CCPR/C/GC/36

United Nations Office of the High Commissioner for Human Rights (OHCHR) (2018) General recommendation No. 37 on gender-related dimensions of disaster risk reduction in a changing climate, CEDAW/C/GC/37. Available at: https://www.ohchr.org/en/documents/general-comments-and-recommendations/general-recommendation-no37-2018-gender-related

United Nations Office of the High Commissioner for Human Rights (OHCHR) (2023) General comment No. 26 on children's rights and the environment with a special focus on climate change, CRC/C/GC/26. Available at: https://www.ohchr.org/en/documents/general-comments-and-recommendations/crccgc26-general-comment-no-26-2023-childrens-rights

United Nations Office of the High Commissioner for Human Rights (OHCHR) (2024) Green Financing - a just transition to protect the rights of Indigenous Peoples - Report of the Special Rapporteur on the human rights of Indigenous Peoples, José Francisco Calí Tzay, A/HRC/54/31. Available at: https://www.ohchr.org/en/documents/thematic-reports/ahrc5431-green-financing-just-transition-protect-rights-indigenous

United Nations Office of the High Commissioner for Human Rights (OHCHR) (2024) Scene-setting report - Report of the Special Rapporteur on the promotion and protection of human rights in the context of climate change, Elisa Morgera, A/HRC/56/46. Available at: https://www.ohchr.org/en/documents/thematic-reports/ahrc5646-scene-setting-report-report-special-rapporteur-promotion-and

United Nations Universal Declaration of Human Rights (1948). Available at: https://www.un.org/sites/un2.un.org/files/2021/03/udhr.pdf

Verein KlimaSeniorinnen Schweiz and Others v. Switzerland (GC). Available at: https://hudoc.echr.coe.int/eng#{%22itemid%22:[%22002-14304%22]}

Wallbott, L. and Schapper, A. (2017) Negotiating by own standards? The use and validity of human rights norms in UN climate negotiations. International Environmental Agreements: Politics, Law and Economics, 17(2), pp.209-228.

Wewerinke-Singh M, Maxwell L. Human Rights. In: Wewerinke-Singh M, Mead S, eds. (2025) The Cambridge Handbook on Climate Litigation. Cambridge Law Handbooks. Cambridge University Press 171-199. https://doi.org/10.1017/9781009409155.010

World Business Council on Sustainable Development (2018) Enterprise Risk Management: Applying enterprise risk management to environmental, social and governance-related risks. Available at: https://docs.wbcsd.org/2018/10/COSO_WBCSD_ESGERM_Guidance.pdf

Zografos, C., Robbins, P. (2020) Green Sacrifice Zones, or Why a Green New Deal Cannot Ignore the Cost Shifts of Just Transitions. One Earth 3(5): 543-546. https://doi.org/10.1016/j.oneear.2020.10.012

References: 1.5

Aðalgeirsdóttir, G.T., Bindoff, N., Björnsson, H., et al. (2024) Open Letter by Climate Scientists to the Nordic Council of Ministers. Available at: https://en.vedur.is/media/ads_in_header/AMOC-letter_Final.pdf (Accessed: 2 September 2025).

Ansell, C. and Gash, A. (2008) 'Collaborative Governance in Theory and Practice', Journal of Public Administration Research and Theory, 18(4), pp. 543-571. https://doi.org/10.1093/jopart/mum032

Ansell, C., Sørensen, E. and Torfing, J. (2017) 'Improving Policy Implementation Through Collaborative Policymaking', Policy & Politics, 45(3), pp. 467-486. https://doi.org/10.1332/030557317X14972799760260

BBC (2022) How pop band A-ha inspired Norway's electric car revolution. Available at: https://www.bbc.com/news/uk-scotland-63375504 (Accessed: 6 September 2025).

Biermann, F., Pattberg, P., van Asselt, H. and Zelli, F. (2009) 'The Fragmentation of Global Governance Architectures: A Framework for Analysis', Global Environmental Politics, 9(4), pp. 14-40. https://doi.org/10.1162/glep.2009.9.4.14

Boari, C. and Riboldazzi, F. (2014) 'How Knowledge Brokers Emerge and Evolve: The Role of Actors' Behaviour', Research Policy, 43(4), pp. 683-695. https://doi.org/10.1016/j.respol.2014.01.007

Figueres, C. (2022) Solving Climate Change Requires A New Social Contract. Available at: https://time.com/6140430/climate-change-trust/ (Accessed: 6 September 2025).

Guston, D.H. (2001) 'Boundary Organizations in Environmental Policy and Science: An Introduction', Science, Technology & Human Values, 26(4), pp. 399-408. https://doi.org/10.1177/016224390102600401

Howlett, M. (2009) 'Process Sequencing Policy Dynamics: Beyond Homeostasis and Path Dependency', Journal of Public Policy, 29(3), pp. 241-262. https://doi.org/10.1017/S0143814X09990158

Howlett, M., McConnell, A. and Perl, A. (2017) 'Moving Policy Theory Forward: Connecting Multiple Stream and Advocacy Coalition Frameworks to Policy Cycle Models of Analysis', Australian Journal of Public Administration, 76(1), pp. 65-79. https://doi.org/10.1111/1467-8500.12191

Ingold, K., Fischer, M. and Cairney, P. (2017) 'Drivers for Policy Agreement in Nascent Subsystems: An Application of the Advocacy Coalition Framework to Fracking Policy in Switzerland and the UK'. Policy Studies Journal, 45(3), pp. 442-463. https://doi.org/10.1111/psj.12173

Jann, W. and Wegrich, K. (2007) 'Theories of the Policy Cycle'. In: Fischer, F., Miller, G.J. and Sidney, M.S. (eds) Handbook of Public Policy Analysis: Theory, Politics, and Methods. Routledge, pp. 43-62. https://doi.org/10.4324/9781315093192

McGinnis, M.D. and Ostrom, E. (2012) 'Reflections on Vincent Ostrom, Public Administration, and Polycentricity', Public Administration Review, 72(1), pp. 15-25. https://doi.org/10.1111/j.1540-6210.2011.02488.x

Meyer, M. (2010) 'The Rise of the Knowledge Broker', Science Communication, 32(1), pp. 118-127. https://doi.org/10.1177/1075547009359797

Milkoreit, M., Boyd, E., Constantino, S.M., et al. (2024) 'Governance for Earth system tipping points – A research agenda', Earth System Governance, 21(100216), pp. 1-15. https://doi.org/10.1016/j.esg.2024.100216

Miller, C. (2001) 'Hybrid Management: Boundary Organizations, Science Policy, and Environmental Governance in the Climate Regime', Science, Technology & Human Values, 26(4), pp. 478-500. https://doi.org/10.1177/016224390102600405

Operaatio Arktis (2025) Mission. Available at: https://www.operaatioarktis.fi/ (Accessed: 8 September 2025).

Reinecke, S. (2015) 'Knowledge brokerage designs and practices in four European climate services: A role model for biodiversity policies?', Environmental Science & Policy, 54, pp. 513-521. https://doi.org/10.1016/j.envsci.2015.08.007

Schroeder, H., Beyers, F., Schäpke, N.A., et al. (2025) 'The Role of Trust in the International Climate Negotiations', Environmental Policy and Governance, 35(2), pp. 328-343. https://doi.org/10.1002/eet.2144

UK Parliament House of Lords (2024) Climate Agenda. Available at: https://hansard.parliament.uk/Lords/2024-10-24/debates/DA117E0F-1B4A-4166-A971-ACF2B4EAB310/ClimateAgenda?highlight=amoc#contribution-217E7E75-4252-4B9F-A1F2-0958A3DA7E8D (Accessed: 2 September 2025).

UK Parliament House of Lords (2024) Climate Change: Atlantic Ocean. Available at: https://questions-statements.parliament.uk/written-questions/detail/2024-09-02/hl634 (Accessed: 2 September 2025).

UN (2024) Secretary-General's special address on climate action "A Moment of Truth". Available at: https://www.un.org/sg/en/content/secretary-general/speeches/2024-06-05 (Accessed: 6 September 2025).

Verein KlimaSeniorinnen Schweiz and Others v. Switzerland, Application No. 53600/20, 9 April 2024 (ECtHR Grand Chamber).