Beyond tipping points: risks, equity and the ethics of intervention

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Abstract

Earth system tipping points pose existential threats to current and future generations, both human and non-human, with those least responsible for causing them facing the greatest risks. 'Positive' social tipping points (that we shorten to positive tipping points, or PTPs) are often deliberate interventions into social systems with the aim of rapidly mitigating the risks of Earth system tipping. However, the desire to intervene should neither increase risks nor perpetuate unjust or inequitable outcomes through the creation of sacrifice zones. In this paper, we argue that considerations of what needs to change, who is being asked to change and where and by whom the impacts of change will be felt, are fundamental and normative questions that require reflexivity and systemic understanding of decision-making across scales. All actors have a role to play in ensuring that justice, equity and ethics are carefully considered before any intervention. Enabling positive tipping points for radical transformations would thus benefit from more diverse perspectives, with a particular emphasis on the inclusion of marginalised voices in offering solutions. We conclude that taking a cautious approach to positive tipping interventions, including careful consideration of distributional and unintended consequences, and stepping back to explore all options, not just those appearing to offer a quick fix, could lead to more equitable and sustainable outcomes.

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Earth system tipping points pose existential threats requiring urgent action. However, this imperative should neither increase risks nor perpetuate injustices. We argue that considerations of what needs to change, who is asked to change and where the impacts will be felt and by

whom, are fundamental questions that need to be addressed in decision-making. Everyone has a role to play in ensuring that justice and equity are incorporated into actions towards a more sustainable future.

1. Introduction

The world is facing a series of era-defining, existential threats including climate change, biodiversity loss, increased inequality and poverty. In response to these critical challenges, there have been calls for transformative change (IPBES, 2019, 2024). Some of these transformations are proposed as advancing 'positive' tipping points, which we shorten to PTPs. PTPs are defined as changes to a system that become self-perpetuating beyond a threshold, and which lead to substantial, often abrupt impacts that can be predominantly beneficial to humans and the natural systems we rely on (McKay et al., 2022; Milkoreit et al., 2018). As we argue, 'positive' is a value judgement, and not all the changes associated with PTPs are universally welcome; difficult decisions and trade-offs need to be made as we weigh up the distribution of anticipated harms and benefits. Nevertheless, we argue that there is a collective duty to bring about "intentional transformation towards global sustainability" (Lenton et al., 2022: 2), and this is clearly a normative enterprise. The moral force in our usage of the 'positive' descriptor is based on the science of Earth system boundaries and the ethics of Earth system justice (Gupta et al., 2023a; Rockström et al., 2023).

Undertaking or operationalizing such transformations that attempt to orient complex systems onto more safe and just trajectories, however, is messy and complicated (Olsson and Moore, 2024). As history shows, there are dark sides of transformations, with unintended consequences, distributional impacts and the potential for vested interests to co-opt or reap the benefits of such processes (Blythe et al., 2018). Caution and care is thus necessary when considering the use of PTPs, including clarity about what transformations are intended, whom they benefit, and whom they may harm (Pereira et al., 2024).

Any moment of societal change will inevitably generate winners and losers (O'Brien and Leichenko, 2003), and this should also be taken into account in the identification and operationalisation of PTPs, where the aim is often to create both rapid and radical change. Indeed, the language of positive tipping needs to be exercised with caution since the very definition of a PTP is likely to be experienced by many actors as a polarising event and can have differential welfare impacts on different segments of the population (Ehret et al., 2022). For example, while some welcome a tipping point away from a fossil fuel-based economy towards one dominated by renewables (IEA, 2022; IRENA, 2022; Systemiq, 2023), others in fossil fuel and related industries may fear the loss of their livelihoods and those of various communities. Similarly, the expansion of cobalt and lithium mining for battery production, driven by the rapid increase in the production of electric vehicles, has led to pollution, habitat destruction and poor working conditions for some communities, even as it has helped to fuel a perceived 'positive' tipping point in developed nations (Hernandez and Newell, 2022).

An approach to tipping point governance that centres principles of equity and justice (Okereke and Dooley, 2010) will recognise that tipping points, whether conceived primarily as positive or

negative, will leave segments of the population behind without the engagement of complementary redistribution mechanisms that can help mitigate against the worst impacts of change (Rammelt et al., 2023). This paper is not proposing how to govern tipping points, but rather focuses on surfacing the equity and justice challenges that are often overlooked in discussions of both Earth system and social tipping points. When identifying or triggering a tipping point through an intervention, it is necessary to ask: What kind of trade-offs are necessary? Who are the winners and losers? And how can a comprehensive understanding of justice be included in a rigorous way when examining PTPs?

1.1. Climate Justice in light of Tipping Points

Recent UNFCCC climate summits have seen increasing calls from climate justice campaigners and representatives of the Global South, including small island developing states, for a global recognition of the uneven historical and ongoing responsibility for climate change, articulated in the concept of "common but differentiated responsibilities" and calls for 'loss and damage' and elsewhere for reparations (Constantino et al., 2023; Huq et al., 2013). These calls are supported by the work of climate historians, decolonial critics and authors who assert that we cannot hope to advance climate action if we do not address the systems of capitalism and colonialism that have created the current crisis and still shape responses to it (Bhambra and Newell, 2022; Ghosh, 2022; Sultana, 2022; Yusoff, 2018). The future-focus of much scientific, political and popular discourse around climate change can create a disconnect with the past, occluding the fact that climate change and its associated crises 'are deeply rooted in history' (Ghosh, 2022: 158). In this context, there is a danger that the language of tipping points can be used to reinforce a discourse that abstracts climate change from past inequities and local contexts. The notion of tipping points that are rooted in a biophysical framing, which assumes some 'threshold' and 'set of shocks' that tips a system over, ignores the grinding every-day realities of life that many of the poor and most vulnerable endure as an interconnected set of social, economic and environmental crises (Nixon, 2013). These vulnerabilities will only be compounded by the increased risks associated with unmitigated climate change, biophysical pressures, and tipping points (O'Brien and Leichenko, 2000).

Moreover, a focus on preventing negative tipping points can distract attention from the deep structural imbalances of capital and the asymmetric power that both drive tipping and the precarity and increased vulnerability to the impacts of tipping events in poorer regions (Roberts and Parks, 2006). The urgency that accompanies the notion of tipping points can overshadow the slow process of rebuilding trust and relationships that have been broken through past harms, referred to by Kyle Whyte as "relational tipping points" (Whyte, 2020). For many Indigenous peoples and local communities who have faced the existential crisis of colonialism and who are now at the forefront of the climate crisis (Gilio-Whitaker, 2019), relational tipping points may have already been breached (Whyte, 2020, 2021). The process of rebuilding consent, trust, accountability, and reciprocity—qualities of relationships necessary to avoid further injustices—requires time and commitment (Whyte, 2020). Attempts to avoid tipping points through geoengineering, for example, could merely pass on costs and irreversible effects onto future generations (Biermann et al., 2022). Hence without due care, attempts to address

tipping points, while important, can also perpetuate spatial and temporal inequities and injustices (Sovacool et al., 2022).

In this paper, we discuss ethical considerations of equity and justice in relation to the complex interconnection of biophysical and social, 'positive' and 'negative' tipping points. The destabilizing of critical Earth systems is already contributing to adverse effects on human well-being and the global ecosystems on which it depends, and will continue to worsen (Rockström et al., 2023). Crossing Earth system tipping points will exacerbate current injustices and inequities (Rammelt et al., 2023), as well as increasing potential harms on future generations and limiting their response capacity by triggering potentially irreversible processes. It is thus necessary to approach PTPs with due caution and humility in our understanding of how complex social-ecological processes unfold - as such we refer to the need for an ethics of tipping points interventions that holds considerations of equity and justice as central tenets.

1.2. Discourse matters

Within the framework of tipping points, it is crucial to remember that all human and non-human actors (sometimes referred to as more-than-human actors) are, in Donna Haraway's words, 'situated.. in complicated histories' (Haraway, 2016), which inform complex and plural visions for the future. The IPCC AR6 report urges immediate action and deep emissions reductions in this decade whilst also calling for climate resilient development that prioritises risk reduction, equity and justice (IPCC, 2023). In seeking to build a majority of people in favour of stronger, faster action, it is vital that values-inclusive forms of discourse are identified to build a sense of collective responsibility and action (Wiedmann et al., 2020).

The challenges and tradeoffs inherent in achieving a safe and just operating space for life on Earth need to be understood (Gupta et al., 2023a). Dominant discourses that centre efficiency and technocratic solutions to meet internationally agreed temperature targets, must also reconcile with the need to address over-consumption and inequalities within and between nations (Constantino and Weber, 2021; Hickel and Kallis, 2019; Lamb et al., 2020; Steinberger et al., 2020; Wiedmann et al., 2020). A growing understanding of tipping points in the Anthropocene challenges 'the peaceful and reassuring project of sustainable development' (Bonneuil and Fressoz, 2016: 29). We have entered what Bruno Latour calls 'the new climatic regime' (Latour, 2018) in which the geophysical framework that we have always taken for granted, the ground on which our history, politics and economics have played out, has become destabilised. An ethical community of nations that respects the Earth's biophysical limits and minimum social foundations for human flourishing must recognise that the only viable solutions are ones that prioritise strong sustainability and sufficient access to resources for all (Haberl, 2015; Kallis et al., 2025; Raworth, 2017; Trebeck and Williams, 2019). This implies different responsibilities for different groups of people as we seek to navigate towards more just, equitable and sustainable futures.

1.3. What do we mean by equity and justice?

Gupta et al. (2023) propose an integrated "Earth system justice" framework to approach questions of climate justice and understand how to reduce risks associated with crossing tipping points while ensuring well-being for all and an equitable distribution of benefits, risks and related responsibilities. Earth system justice is conceptualised through multiple approaches and understandings of justice including, but not limited to, intragenerational, intergenerational and interspecies justice. Intragenerational justice refers to the relationships between humans in the present moment and includes justice between states and social groups. Intergenerational justice examines relationships across generations, such as the legacy of greenhouse gas emissions or ecosystem destruction by current and past generations on youth and future generations, and assumes that natural resources and environmental quality should be shared across generations (Tremmel, 2009). In this context, interspecies justice considers the rights of nature and other species. It draws on a right of nature discourse (Harden-Davies et al., 2020) that also counters the idea of human exceptionalism as a lens for thinking through development impacts (Srinivasan and Kasturirangan, 2016) and potential remedies like defining ecocide as a crime (Setiyono and Natalis, 2021). Drawing on these justice frameworks can help us to assess the uneven impacts of nearing Earth system tipping points, but also the differential responsibility for efforts to avoid tipping points and the potential distributional and procedural aspects of positive tipping dynamics.

Within the domains mentioned above, one can discriminate between different dimensions of justice: distributive (or equity across different populations), procedural (how decision or research processes are designed, who is involved), and reparative (e.g. recognition of wrongs, restoration where possible, and compensation for negative impacts and past injustices) (Byskov and Hyams, 2022). Such justice approaches also include recognition and epistemic justice, which consider the value of multiple knowledge systems, especially local, Indigenous, and unrecognised, misrecognized or marginalised groups (de Sousa Santos, 2008). Finally, 'intersectional' justice that includes multiple and overlapping social identities and categories underpinning inequality, underrepresentation, marginalisation, and the capacity to respond (i.e. gender, race, age, class, health) must be considered in the context of Earth system justice (Gupta et al., 2023b). These different forms of justice are not mutually exclusive: procedural justice may be used to arrive at restoration or compensatory payments, which can be assessed through the lens of distributive justice. Changes related to tipping points need to be analysed with reference to these different justice considerations to design anticipatory actions that avoid negative impacts.

2. Blind Spots of intervention

Policymakers often overlook the normative dimensions of climate policy and the possibility of unintended social consequences (Klinsky et al., 2017; Okereke and Dooley, 2010). All actors, however, in the process – from scientists to world leaders – must take efforts to avoid creating a situation in which today's solutions become tomorrow's harms. This is especially true when considering interventions designed to trigger exponential rates of positive social change, or quick 'fixes' such as geo-engineering (Sovacool, 2021), which could have substantial negative impacts that could be difficult to mitigate if they are not considered before a social tipping point

is reached. It is thus imperative that all actors take responsibility to acknowledge potential risks and centre questions of justice when considering PTPs as solutions to the ongoing climate and other social-ecological crises.

2.1. Risks and unintended consequences of interventions to mitigate climate change

Interventions aimed at mitigating climate change can have unintended consequences including poorly aligned interventions that can exacerbate existing vulnerabilities and risks. A good example of risks associated with the quest for PTPs is the transformation to a renewable energy economy. The growth in demand for renewable energy worldwide, including for batteries and solar panels, is increasing the demand for lithium, cobalt and other rare earth minerals (Dutta et al., 2016). While this creates economic benefits for mining communities and the renewable energy sector, it can also produce negative ecological, economic and social impacts in the near, medium and long-term (Hernandez and Newell, 2022; Manzetti and Mariasiu, 2015). A recent study finds that if today's demand for electric vehicles is projected to 2050, the lithium requirements for the US market alone would triple the amount of lithium currently produced for the global market (Rionfrancos et al., 2023). Lithium demand, however, could be reduced by 92% in 2050 relative to the most lithium-intensive scenarios by decreasing car dependency (e.g. through increasing public transit or biking), limiting the size of EV batteries, and creating a robust recycling system (Rionfrancos et al., 2023). Within this context, the industrial mining sector has been accused of supporting state violence and corruption, polluting ecosystems (Banza Lubaba Nkulu et al., 2018), and exacerbating poverty, while the informal mining sector is known for ignoring occupational safety and health standards and human rights concerns (Sovacool, 2019). Other prominent examples of unintended consequences in climate policy have been documented for: a) large-scale renewable and bioenergy projects, resulting in significant local opposition (Cavicchi, 2018; Torres Contreras, 2022); b) the displacement of Indigenous peoples, local communities (Zurba and Bullock, 2020) and coastal fishers (Beckensteiner et al., 2023); c) deforestation (Kraxner et al., 2013); d) biodiversity losses (Pedroli et al., 2013); e) competition for land and water resources (Haberl, 2015; Tarhule, 2017); f) and food insecurity (Hasegawa et al., 2018).

In an effort to mitigate some of these unintended consequences, significant policy research has focused on the concept of a 'just transition' (Newell and Mulvaney, 2013; Wang and Lo, 2021), spurred by the negative labour market impacts of decarbonization measures in coal-intensive regions of the Global North (Abraham, 2017). Unless sufficient government investment, regional regeneration, support and skills retraining are provided to those workers and communities facing the greatest risks from a transition away from fossil fuels, severe economic, social and cultural hardships are likely to follow. Furthermore, this could reduce trust in government and strengthen counter-narratives aimed at delaying climate action (Lamb et al., 2020; Patterson et al., 2018). Participatory and deliberative governance approaches that include potential losers, winners and other stakeholder groups in designing and implementing policy for sustainability transitions can help to lower the barriers to a just transition by building political will and legitimacy, and negotiating effective compromises for more equitable outcomes (Fesenfeld et al., 2022). More generally in the Global North, climate policy needs to be designed to subsidise

lower-income households for the higher costs that may accompany measures such as carbon pricing, emissions trading, new standards for energy-efficient buildings, smart energy systems, and the electrification of transport systems. Failure to do so could increase poverty, inequality, hunger and other health impacts, popular protests and political instability (Davies and Oreszczyn, 2012; Newell et al., 2021).

In the Global South, the transition to net-zero carbon emissions must happen alongside reductions in poverty and multidimensional vulnerabilities while also ensuring decent living standards for all. Many countries are confronted with a toxic mix of shrinking carbon budgets, growing inequalities, heightened climate-related risks, and limited capabilities for mitigation and adaptation due, in part, to increasing debt burdens (Steele and Patel, 2020). But the debate on historic responsibilities, development rights, and net-zero efforts is gaining renewed attention (Mishra, 2021). From this perspective, achieving just transitions requires addressing the double inequality of the climate crisis where developing countries bear a disproportionate share of the risks, while industrialised nations are primarily responsible for historical emissions (Gardiner, 2004). Therefore, developing countries are demanding fair procedures for distributing the costs and benefits of mitigation and adaptation, such as the Warsaw International Mechanism for Loss and Damage. Whilst concrete financing commitments from rich countries remained absent at COP28 in Dubai in 2023 (Jessop et al., 2023), the Baku Finance Goal at COP29 set a new global target to channel $1.3tn of climate finance to developing countries by 2035 and includes a new core finance goal of $300bn that triples the previous $100bn target.

Unintended consequences can also emerge from a failure to build broad coalitions based on value-inclusive narratives and norms (Constantino and Weber, 2021; Evans, 2017; Klein, 2015; Meadowcroft, 2011; Rowson and Corner, 2014; Sloterdijk, 2012). Procedural justice is key here, as small producers and/or vulnerable actors are often excluded from the political processes and negotiations that determine climate policy (Villasante et al., 2022). In centering justice and combining multiple, intersecting social movements under the climate justice umbrella, many campaigners and scholars believe that the strength of their combined movements can be amplified (Mikulewicz et al., 2023). However, there are also concerns that strong social justice framings can increase political polarisation rather than build broader coalitions (Patterson et al., 2018; Smith, 2022) and can sometimes trigger a widespread ‘backlash’ (Patterson, 2023). Examples include the response to the Australian carbon pricing scheme (Crowley, 2017) and the French fuel tax increase that gave rise to the Gilets Jaunes or Yellow Vests protest movement in 2018-2019 (Kinniburgh, 2019). Research has also shown that some actors recognise the need for greater urgency in climate policy, but are reluctant to champion it to avoid being labelled as ‘extremists’ (Willis, 2020). As a result, climate policymakers and other actors may prefer to focus on the more technocratic, less politically risky aspects of transition governance (Patterson et al., 2018).

If decarbonisation is left mainly to market-based mechanisms that prioritise only profitability, the speed and up-scaling of technological change may threaten the human rights and well-being of some people while allowing other, more powerful, incumbent actors and structures to prevail (Newell et al., 2022). Unique opportunities to redesign entire systems and sectors along more efficient, ethical, sustainable, and equitable lines may be lost where speed and capital

accumulation is allowed to trump inclusivity and depth of process (Leach and Scoones, 2006). For example, U.S. solar photovoltaic deployment is forecast to grow non-linearly in the near-term, generating around 12% of all US power by 2027 (SEIA/Wood MacKenzie, 2023). While this is a positive development in terms of the speed of overall decarbonisation, the perpetuation of an energy system dominated by profit-maximising utility companies would be viewed as a missed opportunity for advocates of energy democracy and place-based, decentralized, cooperative and community-owned energy (Hoffman and High-Pippert, 2005; Stone et al., 2022). Likewise, 'plug and play' approaches that seek to electrify cars, but not boost the accessibility of public transport can serve to reinforce private automobility (Rionfrancos et al., 2023).

Additionally, there is a risk that growing concern regarding Earth system tipping dynamics could propel research into speculative interventions such as widespread carbon dioxide removal, geoengineering or solar radiation modification (a set of hypothetical solutions aimed at reducing incoming sunlight and thus lowering global mean temperatures) (National Academies of Sciences, Engineering, and Medicine, 2021). The most common solar geoengineering proposal involves injecting aerosols into the stratosphere to limit the influx of solar energy, but there are also more regional or local proposals involving different technologies. Proponents often argue for these hypothetical solutions on the grounds that we have made little progress in reducing carbon emissions and that solar geoengineering could be used to buy time or as a failsafe (Keith, 2013; Keith et al., 2017). However, solar geoengineering and other more speculative solutions often come with substantial uncertainty and risks, which are likely to vary across regions, and insufficient governance mechanisms to equitably and effectively manage such risks (Kravitz and MacMartin, 2020; McLaren, 2018; Schneider et al., 2020; Stephens et al., 2021). This has led groups of scholars to call for an "international non-use agreement" and for limits on related research as well (Biermann et al., 2022).

2.2. Winners and Losers: The (un)ethics of Sacrifice Zones

To include equity and justice in the discourse of tipping points, it is necessary to consider how resource extraction can drive tipping points through resource dispossession whilst also exacerbating the drivers leading to a transgression of planetary boundaries (Pereira et al., 2024). Resource extraction, be it for fossil fuels or minerals, creates sacrifice zones– places permanently impaired by environmental degradation and divestment- mainly in the Global South, but also in marginalised areas of the Global North, for example, the green energy developments in Sapmi territories in Scandinavia (Kårtveit, 2021), or lithium mining in Portugal (Canelas and Carvalho, 2023). These actions exacerbate the transgression of planetary boundaries (Sultana, 2023b), cutting across North and South, and are reflective of the uneven control of production, technology and the finance that drives extractivism between global ('polluter') elites and more marginalised social groups (Kenner, 2019).

Even well-intentioned interventions have the potential to put pressure on lands held by Indigenous and marginalised communities and reshape their ecologies into "green sacrifice zones" by reproducing a form of climate colonialism in the name of the energy transition (Lang, 2024; Zografos and Robbins, 2020). Climate colonialism involves ''the deepening or expanding

of domination of less powerful countries and peoples through initiatives that intensify foreign exploitation of poorer nations' resources or undermine the sovereignty of native and Indigenous communities in the course of responding to the climate crisis'' (Zografos and Robbins, 2020: 543). Sacrifice zones are extractive zones created by the advancement of coordinated forms of capitalism that see those territories and the communities inhabiting them as commodifiable (Gómez-Barris, 2017). Current examples include 'green grabs' for critical minerals, biofuels and water or the acquisition of land for forestry carbon offset projects (Fairhead et al., 2012; Scoones et al., 2015).

Rob Nixon describes what befalls marginalised communities over a long period of time as 'slow violence,' which has delayed effects and requires justice to take new forms to secure effective legal measures for prevention, restitution, and redress (Nixon, 2013). To include justice and equity in climate mitigation actions, Latin American countries, for example, have developed the first regional agreement *Acuerdo de Escazú* in 2018 (CEPAL, 2018). This agreement proposes three concrete objectives to include climate justice in environmental policies and transition actions: (1) access to environmental information, (ii) public participation in environmental decision-making processes, and (iii) access to justice in environmental matters. Such attempts to involve communities in discussions of climate justice are crucial for an approach to PTPs that aims to centre equity and justice outcomes. For the concept of PTPs to address local realities, Julie Sze argues for a "situated sustainability" where environmental justice research "sets the parameters for why and how vulnerability (environmental or other) is disproportionately distributed'' (Sze, 2018: 13). In other words, if the questions we ask aim at transformative change or PTPs, they cannot neglect how racial capitalism contributes to inequalities and environmental degradation (Newell, 2005; Sze, 2018).

2.3. Reinforcing current power dynamics and structures

While averting negative biophysical tipping points in the Earth system is a global challenge that will require a coordinated global effort, the research and policymaking surrounding positive tipping must also grapple with historical and contemporary inequalities in the production of environmental harms, and the differentiated and uneven capacity and responsibility to respond or to withstand such impacts. These concerns are enshrined in the UNFCCC principle of 'common but differentiated responsibilities and respective capabilities' and highlights the greater responsibility to act to reduce emissions and the likelihood of crossing critical thresholds by richer countries and polluter elites, whether through their own direct efforts or through the support of efforts in countries with fewer economic resources (O'Brien and Leichenko, 2000). Refocusing mitigation attention on high-emitting groups, countries and sectors foregrounds the need for interventions and policy measures that attempt to shift the current consumption patterns of the wealthy and the actions of large private corporations (Kenner, 2019; Newell, 2021; Rammelt et al., 2023; Wiedmann et al., 2020). It also highlights the urgency to act to shift the infrastructures of high-impact sectors such as food (reducing industrialised meat and dairy consumption) and energy production (switching to non-fossil fuel based energy), transport (reducing car use and air travel) and housing that, combined, comprise about 75% of total carbon footprints (Newell et al., 2021). Furthermore, this view highlights the need for substantial financial transfers from the Global North to the Global South to help build climate resilience, to

compensate for irreparable losses due to climate change, and to offset the costs of mitigation efforts (Jackson et al., 2023). Without such measures, efforts to address Earth System tipping points risk reinforcing unequal power dynamics and current inequities.

3. Illustrative case studies

3.1 Risks and Justice Implications in Marine Protected Areas

The ocean economy is expected to grow faster than the global economy in the coming decades, reaching $3 trillion by 2030 (OECD, 2016), with well-established (e.g. fisheries, aquaculture) and novel ocean sectors (e.g. seabed mining, ocean wave energy) multiplying their activity and footprint in recent years (Jouffray et al., 2020). Yet, opportunities, access and benefits from ocean interventions remain highly unequal. For instance, seafood production is highly concentrated in a few Global North large corporations (Österblom et al., 2015), while in most places of the Global South, local nutritional needs are jeopardised by the activity of distant fishing fleets, seafood trade, and the use of catches for fish oil/fish meal for animal feed (Hicks et al., 2019). The unprecedented race for food, spaces and materials, but also the effects of other drivers such as climate change and pollution, are exacerbating social inequities and threatening marine ecosystems' functioning and productivity. The race to occupy the oceans and exploit more resources and at greater depths, combined with the impacts of climate change, are leading to an increasing risk of reaching dangerous ocean tipping points (Jouffray et al., 2020; McKay et al., 2022). Thus, there is a pressing need for transformative actions that halt and reverse marine biodiversity loss rates, particularly in some Global South biodiversity hotspots (IPBES 2024).

The recent Kunming-Montreal Global Biodiversity Framework target 3 (30X30 target) seeks to protect 30% of the ocean by 2030 (CBD, 2022). Through the global Convention on Biological Diversity negotiations, conserving 30% of the ocean (and land) is seen as an important threshold for addressing biodiversity loss and maintaining ecosystem function (Baillie and Zhang, 2018; Dinerstein et al., 2019). However, if implemented badly, the 30x30 target risks perpetuating historical injustices, colonial legacies and power imbalances by imposing Western conservation models on communities in the Global South (Obura et al., 2023). It is essential to explore the intricate social aspects of the initiative (Sandbrook et al., 2023), offering a more nuanced and equitable discourse on PTPs in ocean governance and conservation and the role of Marine Protected Areas (MPAs) in achieving them.

Although the positive ecological impacts of MPAs are relatively well understood (i.e. large, old, well-enforced and 'no-take' MPAs would provide greater ecological benefits within the protected area (Sala and Giakoumi, 2018), less attention is paid to the negative socio-economic impacts that MPA establishment can have on dependent and marginalised communities (Bennett and Dearden, 2014; Rasheed, 2020). Research has shown that MPA establishment and management can exacerbate current equity issues by further marginalising already vulnerable coastal communities (Hill et al., 2016; Sowman and Sunde, 2018) and may exclude local and Indigenous participation, which in turn can also lead to reduced conservation and management

gains (Hill et al., 2016). A heightened focus on increasing MPAs may entail undesirable consequences for the well-being of vulnerable communities in a variety of ways, including forced removals and displacement of Indigenous peoples from traditional lands and waters, loss or restricted access rights, as well as negative impacts on food security, health, livelihoods, identity and culture (Bennett and Dearden, 2014; Hill et al., 2016; Oracion et al., 2005; Sowman and Sunde, 2018). Additionally, the current extent and distribution of MPAs do not adequately represent biodiversity. In the Phillippines, for example, only 2.8% of coral reefs are protected within no-take MPAs (Weeks et al., 2010); and in the 11.4% of EU waters covered by MPAs, 86% showed light, minimal, or no protection from the most harmful human activities, such as dredging, mining, or the most damaging fishing gears (Aminian-Biquet et al., 2024).

A strong global focus on increasing MPAs as a 'tipping point' towards conserving marine biodiversity, may fail to carefully and comprehensively address historical impacts and ongoing equity issues experienced by coastal communities. In addition, measuring conservation success based solely on a coverage metric can incentivize the establishment of large centrally-governed MPAs (often situated in former colonies) (O'Leary et al., 2018), at the expense of relatively small, but locally managed MPAs (Smallhorn-West et al., 2020). A looming time horizon for 30x30 may also discourage participatory and collaborative processes that may take longer to achieve, but are more efficient in the long term (O'Leary et al., 2018). Concerning global planning of MPAs expansion, maps are not apolitical. Global conservation planning exercises informed by biophysical variables and cumulative human impacts placed a significant proportion of priority areas within the Global South (e.g. Coral Triangle, Southwest Indian Ocean, Caribbean Sea) (Jenkins and Van Houtan, 2016; Selig et al., 2014; Zhao et al., 2020), occupying the entire Exclusive Economic Zones (EEZs) of some Global South countries (e.g. Indonesia). This reality can therefore be seen to perpetuate a form of green sacrifice zone where communities in biodiverse countries are denied access to their biodiversity whilst those in already degraded territories face no such impositions.

The 30x30 initiative and the revitalization and empowerment of local communities toward PTPs may be reconciled by balancing both biodiversity and well-being outcomes of local communities when enhancing existing MPAs and designing new ones, as well as seriously considering the wide range of "other effective area-based conservation measures", including those where small-scale actors, especially IPLCs, are empowered and included from the very beginning of decision-making processes to enhance procedural justice (Atlas et al., 2021). Importantly, the expansion of MPAs, across both large and small areas, should not be seen as a single strategy to balance marine biodiversity and socio-economic needs; it must be part of a broader and more diverse management and governance portfolio to govern our oceans in a sustainable and equitable manner (O'Leary et al., 2018).

3.2 Positive financial tipping points: actors and mechanisms

The growing financialisation of the world's economy poses a significant threat to the fabric of society and the environment because of its reductionism of human and more than human life to financial metrics. At the core of this paradigm lies the dogma that prioritises wealth

accumulation, power, and unchecked economic growth, at the expense of common well-being and ecological sustainability (Fullerton, 2018). Several recent policy and private initiatives have been launched with the ambition to redirect financial flows towards activities that protect natural capital, influence ecosystems and generate equitable outcomes to people in a positive way (Ameli et al., 2023; Galaz et al., 2015, 2018), but many blind spots remain. Voluntary initiatives remain weak and many key financial actors have been abandoning even these arrangements. For example, major banks such as JPMorgan Chase Morgan Stanley, Citi, Bank of America, Wells Fargo, and Goldman Sachs have recently announced that they are leaving the Net Zero Banking Alliance (NZBA), a voluntary initiative launched in 2021 that has hundreds of member banks across dozens of countries. The limits of such initiatives to deliver meaningful change become clear once greater ambition is demanded and the actors back off, such as with GFANZ (Glasgow Financial Alliance for Net Zero) where many financial institutions were reluctant to countenance stricter requirements to divest from fossil fuels (Reclaim Finance, 2023). Likewise, their often-fleeting nature is underscored by the example of the Net-Zero Insurance Alliance that was discontinued as of April 2024. Very few banks and investors have portfolios, lending policies or goals aligned with sustainability goals. Carbon Tracker found that 98% of 134 companies, collectively responsible for up to 80% of emissions, did not provide sufficient evidence that they had considered the impact of climate matters when preparing their 2021 financial statements (Carbon Tracker, 2022). A different approach is required to accelerate what UNEP refers to as a 'quiet revolution' in finance (UNEP, 2015).

A positive tipping point to create a more sustainable financial system means simultaneously activating a range of often neglected levers and overlooked areas of finance such as taxation and debt. Proposals include taxation of the richest 1.5% of the world's population to lever funds to meet the 1.5 climate goal (Chancel et al., 2023) and debt for climate swaps (Green Climate Fund, 2024). Zucman (2016) suggests that there are several ways that would help limit tax evasion and avoidance in the global economy. For example, the creation of a global financial registry that tracks wealth regardless of where it is located, reforming the corporate tax system so that the global profits of multinational companies are distributed where the resources are extracted, and more strictly regulating banks that help evade taxes with lax regulations. Although the secrecy practices afforded by tax havens hinder a precise quantification, Fortune 500 companies are estimated to have US$2.3 trillion in offshore accounts and capital positions. (Shaxson, 2019). In comparison, financing needed to preserve global biodiversity is estimated at US$ 722-967 billion per year until 2030 (Deutz et al., 2020). In addition, the average global statutory corporate tax rate has gone from 40% in 1980 to 24% in 2020, with an actual tax rate much lower in many jurisdictions (Dempsey et al., 2022). This reduction in the tax rate for large companies has already been shown to lead to increased inequality in different countries around the world, with a higher risk in developing countries that are highly dependent on natural resource-based exports (Banerjee and Duflo, 2020). This becomes directly related to the debt that these countries then incur in response to insufficient tax bases to deliver the services that their people need.

Reconfiguring flows of finance towards climate mitigation, adaptation, loss and damage compensation, biodiversity conservation, addressing vulnerability etc. requires reimagining the

governance of public and private finance (Rammelt et al., 2023). This includes changing the mandates of multilateral development banks, reforming central banks and regulating private company law and disclosure policies as part of a more transformative approach to climate finance (Newell, 2024). Another way to unlock the funding needed to reverse nature loss by 2030 as well as the cost of reaching net zero carbon emissions by 2050 is to remove harmful subsidies that harm biodiversity, such as in agriculture, fisheries and fossil fuel production (Dasgupta, 2021). According to Koplow and Steenblik (2022), the world is spending at least $1.8 trillion a year, equivalent to 2% of global GDP on subsidies that are driving ecosystem destruction and species extinction (Dasgupta, 2021). To address this problem in global fisheries, Costello et al. (2016) recently showed that global governments could repurpose some or all of the roughly US$22 billion they annually allocate as harmful fisheries subsidies to directly support fishers' incomes without incentivizing overfishing. Likewise, there have been proposals to redirect a significant percentage of the USD $11 million a minute that governments currently spend on fossil fuel subsidies to a Global Transition Fund to support low carbon energy pathways in poorer regions of the world (Newell and Simms, 2020).

Positive tipping points in finance to achieve a net-zero carbon economy have been articulated by Ameli et al. (2023). Beyond these options, however, is a call to change the core cause of failure of the financial system (Deutz et al., 2020; Pinney et al., 2019; UNEP, 2023). Finance cannot be understood in a vacuum; it is embedded in the real economy, which in turn must be understood as embedded in and inseparable from the Earth system. Recent proposals to envision a more sustainable and just financial system (Deutz et al. 2020; UNEP, 2022) include ideas like regenerative 'capitalism,' which provides a new paradigm for finance where true wealth is not merely money in the bank as well as proponents of a post-growth economy (Kallis et al., 2025). Rather, it must be defined and managed in terms of the well-being of the whole, achieved through the inclusion of multiple types of wealth or capital, including social, cultural, living, and experiential (Fullerton, 2018).

4. Implications for practice

Above we have laid out a series of risks and potential injustices associated with the need to intervene quickly to address the increasing threat of climate change and related sustainability concerns. We argue that interventions, especially concerning narratives of PTPs, cannot be divorced from current injustices and inequities in the global Earth system and should be approached ethically. Below, we set out some key messages for different actors to internalise as we all seek to shift the planet onto a more sustainable and equitable trajectory.

4.1. Research

4.1.1. Employ inclusive and plural approaches

Biophysical and social system tipping points are interconnected, and do not exist in isolation (Sultana, 2023a). Avoiding an increase of harms requires a broad set of expertise, approaches and acknowledgment that we need multiple and plural approaches not only within academic disciplines, but also of diverse knowledge systems beyond academia (e.g. Indigenous and local

knowledge) and that these need to be taken seriously (Tàbara et al., 2022). Interactions between global change science with other knowledge systems are only slowly developing, and participatory approaches that involve stakeholders can still be very superficial and indeed do not go beyond mere consultation into more deeply embedded modes of knowledge co-production (Chambers et al., 2021; Osinski, 2021). By being more mindful about inclusiveness, researchers can increase justice in research through participatory co-design, action research and increased humility on the part of researchers as to the limits of their understanding (Huybrechts et al., 2017).

4.1.2. Diversify expertise across multiple places

Science has an agenda-setting function that could benefit from accounting for the heterogeneity of the expertise that is needed to solve complex problems like tipping points. Place- and context-specific information and experience are often lacking as traditional research is concentrated in high-income countries. A more inclusive global research programme to reflect on the justice and risk aspects of the Earth system, and that understands the full breadth of impacts of positive and negative tipping points, needs to be undertaken. Funding institutions and universities therefore need to enable greater diversity in research and curriculum development - in terms of cultural, religious, ethnic, gender or background of the researcher, but also in the disciplines that are engaged. For example, considering humanities and social sciences in the intention, design, implementation and evaluation of interventions can help to avoid harms and associated costs, with potential to achieve both positive social and ecological impacts on people (Latulippe and Klenk, 2020).

By mandating the inclusion of diverse groups, perspectives, and knowledge systems in the quest for research into addressing global tipping points, this can enhance resilience and success for social tipping and will broaden the type and scope of research undertaken (Stirling, 2010). To harness relevant social tipping opportunities we need to learn about and understand diverse lived realities and interact with actors ‘outside of science’ (Bentley et al., 2014). Diversity and inclusivity of research teams–within and beyond academia– are needed to help find solutions to tipping points that do not exacerbate existing injustices and inequalities (Latulippe and Klenk, 2020; de Souza, 2021).

4.1.3. Address research gaps in how to govern non-linear dynamics

Existing governance institutions may be poorly adapted to the challenges associated with the governance of Earth system tipping points, which can have non-linear, cascading or systemic effects, and span long time horizons (Milkoreit et al., 2024; Pereira and Viola, 2018). Additional research is needed to identify adequate governance principles and institutional structures to manage Earth System tipping points, including ensuring equity and justice that are centred in efforts to prevent tipping points and efforts to respond to their impacts (Milkoreit et al., 2024). Researchers also need to further develop an understanding of tipping-point governance that includes lessons learnt from multi-scale, anticipatory governance (Boyd et al., 2015), grounded in systemic risk approaches (Centeno et al., 2015).

4.2. Business and finance

4.2.1. Transform financial systems

Finance and business are a part of social and ecological systems and not apart from them. Active steering and regulation are therefore required to divest, de-finance and divert financial resources away from the drivers of unsustainability towards sectors and regions where they are most required and where positive tipping points can be found (Newell, 2024). Transformation of financial systems must extend to providing mechanisms to transform sufficient financial assets back into biodiversity and climate assets held in secure commons instruments that can ensure equitable access to all, in particular in developing countries (IPBES, 2022). Governments and their relevant finance bodies need to strengthen the architecture of global financial governance that prioritises sustainability and social justice (UNEP, 2015). Reaching a financial sector tipping point implies changing the mandates of multilateral development banks, reforming central banks and regulating the need to change company law and disclosure policies. But as part of a global just transition and social compact, issues of debt relief and reform of taxation have to be on the negotiation table to ensure positive tipping points in the financial system that reduce rather than entrench poverty.

4.2.2. Introduce investment restrictions for non-compliant companies

Financial actors, such as international development banks, institutional and private investors, venture capital, credit rating agencies and international commercial banks, are increasingly interested in the financial risks of climate change and associated changes in ecosystems (Galaz et al., 2018). It is crucial that the capital investments made by these actors steer the sector toward improved sustainability and PTPs, as opposed to overexploitation of labour and resources (Hickel et al., 2021) by integrating sustainability and equity into traditional finance mechanisms (Jouffray et al., 2019), through ESG approaches or measures like the social cost of carbon (Prellezo et al., 2023). Cutting off investment for companies that are seen to be complicit in transgressing planetary boundaries, such as some oil majors and powerful cattle lobby groups in the Brazilian Amazon (Piotrowski, 2019), has the potential to reshape the business environment towards more ethical practices. Another area where investments could leverage positive tipping points, for instance, would be to finance a structural shift from car dependency as this could potentially ease pressure in the mining sector, reinforcing reduced social and environmental harms and a densification of metropolitan areas, which would experience myriad benefits from improved air quality to pedestrian safety (Rionfrancos et al., 2023).

4.2.3. Develop more supportive and inclusive investments

Redirecting public and private money to innovative tools and instruments can enable new entrants while reducing the degradation of biodiversity. With governments enabling this new and improved direction of finance mechanisms, businesses should then be able to both meet standards and operate in vulnerable areas that need finance to become more resilient. This includes moving money to key areas where it is needed (adaptation, biodiversity, social common goods) rather than just for profit (Crona et al., 2021). For example, the IIX Sustainability Bonds are debt securities that can be listed on a social stock exchange, and they explicitly address the inclusion of women in economic activities. There are also initiatives to

supplement gaps in the national currency systems such as Community Inclusion Currencies[2] that empower communities to create their own financial systems based on local goods and services (Ruddick, 2023). The Netherlands, for example, provides special green investment funds that are exempt from income taxation, thus allowing investors in green projects (e.g. green shipping, renewable energy development), to contract loans at reduced interest rates (usually ~2% below commercial rates). Another example is the Raven Indigenous Impact Fund[3], a new innovative financial product committed to Indigenous-led equity investments in mission-driven and innovative Indigenous enterprises to help build a renewed and sustainable Indigenous economy in Canada and the US. The Climate Bonds Initiative[4] has also several sector criteria (e.g. for marine energy and water utilities); while other relevant initiatives include the Blue Natural Capital Positive Impacts Framework[5] and the technical guideline for blue bonds. Mainstreaming these examples as best practice is critical for leveraging the financial system to enable PTPs.

4.3. Public sector

4.3.1. Design fiscal policies that are cognizant of extant configurations

Fiscal policy needs to be designed to subsidise lower-income households for the higher costs that may accompany climate policies such as carbon pricing, emissions trading, new standards for energy-efficient buildings, smart energy systems, and the electrification of transport. Failure to do so could set off a cascade of unintended consequences and increase poverty, inequality, hunger and other health impacts, popular protest and political instability. Hypothecation by policymakers, for example redirecting funds from fossil fuel subsidies to affordable public transport or from windfall taxes on oil companies for home insulation schemes, can build support among poorer groups for measures that might otherwise be opposed. Policy and governance actors attracted to tipping interventions need not only to design targeted, sector- and actor-specific approaches, but also to combine disciplines and sectors for a coordinated, complex systems thinking approach and capabilities. Including potential losers in the design process can also reduce opposition and ensure more equitable outcomes.

4.3.2. Foster anticipatory governance to account for unanticipated consequences

While “positive” tipping interventions are appealing for policymakers by promising to initiate rapid, significant and potentially irreversible change towards a desired state, careful deliberation and participatory processes should be used to reach an agreement on what the desired change is, what the associated trade-offs are, and which populations it is likely to benefit or harm. Given the high levels of uncertainty associated with tipping point dynamics in complex systems, and the multiplicity of possible post-tipping states, decision-makers must give careful consideration before initiating a deliberate “positive” tipping intervention, focussing on anticipatory governance that seeks to imagine the potential futures that could arise and act accordingly (Olsson and Moore, 2024; Vervoort and Gupta, 2018). Policy actors should carefully monitor interventions for

[2] https://grassrootseconomics.org/
[3] https://ravencapitalpartners.ca/investments/impact-funds
[4] www.climatebonds.net
[5] https://bluenaturalcapital.org

transformation to avoid unintended negative consequences and to address distributional harms that might ensue (Olsson and Moore, 2024; Tàbara, 2024). The risk of unintended consequences that might ensue after a tipping process has been initiated may require new governance mechanisms or a stronger commitment to adaptive management practices and capacities, including a specific focus on monitoring the change process so that corrective measures can be introduced. Accountability structures for 'tipping gone wrong' should be included in legal frameworks in order to hold actors accountable for the impacts of their actions.

4.4. Media and communications

4.4.1. Be aware of the politics of language and power dynamics in science

Communicators, in particular the media, are key actors who interpret the world and are also capable of constructing new social realities and inspiring action (Kegan and Lahey, 2001). They must be alert to the ideologies, values and systems of power that affect which messages are communicated and how they are encoded. For example, how a tipping point is identified (Juhola et al., 2022), what specific language is used to define and communicate it (Milkoreit et al., 2018), and when it may be used inappropriately in discussing solutions (Milkoreit, 2023). Journalists in particular should be cautious in how they use the language of 'positive' and 'negative' tipping points, which can imply a universality of effect that can be insensitive to the diverse experiences (and responsibilities) of different communities illustrated above.

4.4.2. Recognize contested framings of key messages in the scientific landscape

In an equity and justice context, media and communicators must be alert to the competing ideologies and value systems that affect how a message is 'decoded' or interpreted by different communities (Holmes, 2020). The meaning of a message is not necessarily determined by the messenger or the message, but 'a complex interplay of how this meaning is framed though ideological values and beliefs' (Hall, 1980: 7). Thus, it is important to view communication not as a neutral process of information transmission, but as a complex, non-linear system that is entangled with competing knowledge and powers. Studies have shown that increased knowledge does not automatically lead to enlightened action (Norgaard, 2011) and, indeed, that more factual information may serve to further entrench dismissive perceptions of climate change (Bain et al., 2012). There is, therefore, a need for communicators (particularly those trying to prompt behaviour change) to go beyond the linear 'information deficit' models of communication, moving instead towards 'non-linear' models of communication that prioritise open, reflective dialogue between different stakeholders. For example, case studies of communication strategies involving Indigenous people and local communities on the frontline of climate change have found that messages rooted in empirical research and using simple language are insufficient and that researchers should investigate different stakeholders' understandings of what good climate change communication is, and through this determine the needs of different audiences from their unique cultural standpoints (Barau and Tanko, 2018; Gotangco and Leon, 2017). With this in mind, it is important that communication strategies are co-produced with the communities they are seeking to engage (Moser, 2016).

4.4.3. Embrace creative co-production practices

Different initiatives have been arising from the Arizona State University Imagination and Climate Futures Initiative, the University of Exeter-led 'Climate Stories' and 'We Still Have a Chance' projects, the Rapid Transition Alliance's curation of 'evidence-based hope' and the 'Seeds of Good Anthropocenes' project. These have shown that the arts and humanities offer models for empowering communities to create their own narratives and contextualise climate change in relation to their own systems of value, which is an important step towards the design and implementation of just and equitable transitions (Milkoreit et al., 2016; Roberts et al., 2023; Woodley et al., 2022). The effectiveness of literature, film, theatre and art in promoting ethical responses to climate change is increasingly being recognised in empirical studies (Houser, 2014; James, 2015; von Mossner, 2017). As David Holmes states, 'the arts have an ability to communicate the vulnerability and sensitivity of climate issues that other channels may lack' (Holmes, 2020: 10). Therefore, in the context of tipping points, researchers and practitioners should aim to engage a wide range of creative approaches in co-production processes. This would offer an open-ended, non-instrumental approach to communication, which could be key to achieving more ethical solutions in this complex field.

5. Conclusion

Biophysical tipping points pose existential threats to current and future generations, both human and non-human, with those currently underserved being the most vulnerable. It is therefore imperative to act. We also know PTPs are possible, but that any intervention must take care not to perpetuate past and current injustices and inequities. Considerations of what needs to transform, who is being asked to change and where the change or its impacts will be felt and by whom, require a deep level of reflexivity and systemic understanding. There are multiple potential points of intervention and strategies that can be adopted within a complex ecosystem of transformation to help address the power inequalities, social exclusions and governance gaps that are currently driving us towards Earth system tipping points. All actors have a role to play in ensuring that justice, equity and ethics are centred in these interventions, with a particular emphasis on the inclusion of those most affected by disruptive environmental change and the least responsible for causing it. Finally, enabling PTPs towards radical transformations will benefit from more diverse perspectives to open up the solution space, leveraging a shift in worldviews and paradigms rather than just reconfiguring materials and feedback sensu (Meadows, 1999). Trying to fix a system using the same tools that created it is not the way to address our planetary poly-crisis. Taking a step back to explore all options, not just those that seem to offer a quick fix or 'low-hanging' fruit, could offer a more substantial route into thinking through which positive tipping points could create a more equitable as well as a more sustainable future.

Author contribution

LP conceptualised the paper and prepared the initial draft together with SRS, LG, PN, BS and SV. TA, AC, SC, TS, AG, CV, TP and CZ edited and reviewed the draft.

Competing interests

The authors declare that they have no conflict of interest.

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