

1 **Beyond tipping points: risks, equity and the ethics of intervention**
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21 **Abstract**

22
23 Earth system tipping points pose existential threats to current and future generations, both
24 human and non-human, with those least responsible for causing them **facing the greatest risks**.
25 **'Positive'** social tipping points **(that we shorten to positive tipping points, or PTPs)** are often
26 deliberate interventions into human systems with the **aim of rapidly mitigating the risks of Earth**
27 **system tipping**. However, the desire to intervene should neither increase risks nor perpetuate
28 unjust or inequitable outcomes through the creation of sacrifice zones. In this paper, we argue
29 that considerations of what needs to change, who is being asked to change and where **and by**
30 **whom** the change or its impacts will be felt **are fundamental and normative** questions that
31 require **reflexivity** and systemic understanding **of** decision-making **across scales**. All actors have
32 a role to play in ensuring that justice, equity and ethics are carefully considered before any
33 intervention. Enabling positive tipping points for radical transformations **would thus** benefit from
34 more diverse perspectives, **with a particular emphasis on the inclusion of marginalised voices, in**
35 **offering solutions**. We conclude that taking a cautious approach to positive tipping interventions,
36 **including careful consideration of distributional and unintended consequences**, and stepping
37 back to explore all options, not just those appearing to offer a quick fix, could lead to more
38 equitable and sustainable outcomes.

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40 500 character blurb
41 Earth system tipping points pose existential threats requiring urgent action. However, this
42 imperative should neither increase risks nor perpetuate injustices. We argue that considerations
43 of what needs to change, who is asked to change and where the impacts will be felt and by
44 whom, are fundamental questions that need to be addressed in decision-making. Everyone has

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58 a role to play in ensuring that justice and equity are incorporated into actions towards a more
59 sustainable future.

61 1. Introduction

62 The world is facing a series of era-defining, existential threats including climate change,
63 biodiversity loss, increased inequality and poverty. In response to these critical challenges,
64 there have been calls for transformative change (IPBES, 2019). Some of these transformations
65 are proposed as advancing 'positive' social tipping points, which we shorten to positive tipping
66 points (PTPs). PTPs are defined as changes to a system that become self-perpetuating beyond
67 a threshold, and which lead to substantial, often abrupt impacts that are predominantly
68 beneficial to humans and the natural systems we rely on (McKay et al., 2022; Milkoreit et al.,
69 2018). As we argue, 'positive' is a value judgement, and not all the changes associated with
70 PTPs are universally welcome; difficult decisions and trade-offs need to be made as we weigh
71 up the distribution of anticipated harms and benefits. Nevertheless, we argue that there is a
72 collective duty to bring about "intentional transformation towards global sustainability" (Lenton et
73 al., 2022: 2), and this is clearly a normative enterprise. The moral 'force' in our usage of the
74 'positive' descriptor is based on the science of Earth system boundaries and the ethics of Earth
75 system justice (Gupta et al., 2023a; Rockström et al., 2023).

76 However, undertaking or operationalizing such transformations that attempt to orient complex
77 systems onto more safe and just trajectories, is messy and complicated (Olsson and Moore,
78 2024). As history shows, there are dark sides of transformations, with unintended
79 consequences, distributional impacts, and the potential for vested interests to co-opt or reap the
80 benefits of such processes (Blythe et al., 2018). Caution and care is thus necessary when
81 considering the use of PTPs, including clarity about what transformations are intended, whom
82 they benefit, and whom they may harm (Pereira et al., 2024).

83 Any moment of societal change will inevitably generate winners and losers (O'Brien and
84 Leichenko, 2003), and this should also be taken into account in the identification and
85 operationalisation of PTPs, where the aim is often to create both rapid and radical change.
86 Indeed, in this context, the language of positive tipping needs to be exercised with caution since
87 the very definition of a PTP, is likely to be experienced by many actors as a polarising event and
88 can have differential welfare impacts on different segments of the population (Ehret et al.,
89 2022). For example, while some welcome a tipping point away from a fossil fuel-based economy
90 towards one dominated by renewables, (IEA, 2022b; IRENA, 2022; Systemiq, 2023), others in,
91 fossil fuel and related industries may fear the loss of their livelihoods and communities.
92 Pollution, habitat destruction and poor working conditions in the expansion of cobalt and lithium
93 mining for battery production, for example, driven by the rapid increase in the production of
94 electric vehicles, may create problems for some communities and opportunities for others
95 (Hernandez and Newell, 2022).

96 An approach to tipping point governance that centres principles of equity and justice (Okereke
97 and Dooley, 2010) will recognise that tipping points, whether conceived primarily as positive or
98 negative, will leave segments of the population behind without the engagement of

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136 complementary redistribution mechanisms that can help mitigate against the worst impacts of
 137 change (Rammelt et al., 2023). This paper is not proposing how to govern tipping points, but
 138 rather focuses on the equity and justice challenges that are often overlooked in discussions of
 139 both Earth system and social tipping points. When identifying or triggering a tipping point
 140 through an intervention, it is necessary to ask: What kind of trade-offs are necessary and what
 141 sacrifice zones are being created? Who ends up occupying these sacrifice zones? Who is left
 142 behind? And how can a comprehensive understanding of justice be included in a rigorous way
 143 when examining PTPs? An example of sacrifice zones are extractive zones created by the
 144 advancement of coordinated forms of capitalism that see those territories and the communities
 145 inhabiting them as commodifiable (Gómez-Barris, 2017).

146 1.1. Climate Justice in light of Tipping Points

147
 148 Recent UNFCCC climate summits have seen increasing calls from climate justice campaigners
 149 and representatives of the Global South, including the small island developing states, for a
 150 global recognition of the uneven historical and ongoing responsibility for climate change,
 151 articulated in the concept of “common but differentiated responsibilities” and calls for ‘loss and
 152 damage’ and elsewhere for reparations (Constantino et al., 2023; Huq et al., 2013). These calls
 153 are supported by the work of climate historians, decolonial critics and authors who assert that
 154 we cannot hope to advance climate action if we do not address the systems of capitalism and
 155 colonialism that have created the current crisis and still shape responses to it (Bhambra and
 156 Newell, 2022; Ghosh, 2022; Sultana, 2022; Yusoff, 2018). The future-focus of much scientific,
 157 political and popular discourse around climate change can create a disconnect with the past,
 158 occluding the fact that climate change and its associated crises ‘are deeply rooted in history’
 159 (Ghosh 2022, 158). In this context, there is a danger that the language of tipping points can be
 160 used to reinforce a discourse that abstracts climate change from past inequities and local
 161 contexts. The notion of tipping points that are rooted in a biophysical framing, which assumes
 162 some ‘threshold’ and ‘set of shocks’ that tips a system over, ignores the grinding every-day
 163 realities of life that many of the poor and most vulnerable endure as an interconnected set of
 164 social, economic and environmental crises (Nixon, 2013). These vulnerabilities will only be
 165 compounded by the increased risks associated with unmitigated climate change, biophysical
 166 pressures, and tipping points (O’Brien and Leichenko, 2000).

167
 168 Moreover, a focus on preventing negative tipping points can distract attention from the deep
 169 structural imbalances of capital and the asymmetric power that both drive tipping and the
 170 precarity and increased vulnerability to the impacts of tipping events in poorer regions (Roberts
 171 and Parks, 2006). The urgency that accompanies the notion of tipping points can overshadow
 172 the slow process of rebuilding trust and relationships that have been broken through past
 173 harms, referred to by Kyle Whyte as “relational tipping points” (Whyte, 2020). For many
 174 Indigenous peoples and local communities who have faced the existential crisis of colonialism
 175 and who are now at the forefront of the climate crisis (Gilio-Whitaker, 2019), relational tipping
 176 points may have already been breached (Whyte, 2020, 2021). The process of rebuilding
 177 consent, trust, accountability, and reciprocity—qualities of relationships necessary to avoid
 178 further injustices—require time and commitment (Whyte, 2020). Attempts to avoid tipping points

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through geoengineering, for example, could merely pass on costs and irreversible effects onto future generations (Biermann et al., 2022), while contemporary drives to reach technological tipping points, such as the push towards electric vehicles, can produce new vulnerabilities for communities situated in areas that are rich in rare Earth minerals (Calvão et al., 2021). 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 considerations of ethics, equity and justice in relation to the complex interconnection of biophysical and social, 'positive' and 'negative' tipping points. The destabilising 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 biophysical and social 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 precaution 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 centres 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 'create 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 must shift towards ones that instead aim to reconcile the need to meet the internationally agreed temperature targets 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; Trebeck and Williams, 2019). For example, Raworth's (2017) 'doughnut economics' has as its goal the establishment of a safe and just operating space for

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Deleted: (Wiedmann et al., 2020) and which avoid alienating the actors needed to form this coalition. Even processes to decolonise understandings of time, including seeing it as linear, must be fostered so that we do not exacerbate problems as we act with urgency to find near-term solutions to the climate emergency like large-scale renewable energy infrastructures that can sometimes infringe on human and nature's rights (Whyte, 2021).

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humanity that includes staying above social 'floors' such that everyone has access to necessary goods and services while also staying below the planetary boundaries, beyond which the economy begins to outstrip the planet's natural resources (Gupta et al., 2023b; Raworth, 2017). This implies differential responsibilities on 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. (2023a,b) 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 justice and interspecies justice. Intragenerational justice refers to the relationships between humans right now 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 requires considering the rights of nature and other species. It draws on a rights 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 ecocide (Setiyono and Natalis, 2021). Drawing on these 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 distributional and procedural aspects of positive tipping dynamics.

Within the domains mentioned above, one can discriminate between different dimensions of justice, i.e., 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., 2023c). 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 can be analysed with reference to these myriad justice considerations to design forward looking actions that avoid negative impacts.

2. Blind Spots of intervention

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Deleted: ¶ Changes related to Earth and social system tipping can be analysed with reference to all these justice considerations to design forward looking actions that avoid negative impacts. Especially in cross-disciplinary discussions and exchanges between different actors, having shared understanding of the nuance and need for contextual framing of challenges will enable and speed up implementation. It is key to highlight that what is perceived as fair is subjective and highly context specific and may change over time (Caney, 2012). In the context of addressing negative biophysical tipping points by attempting to enable positive tipping, an ... [1]

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402 Policymakers often overlook the normative dimensions of climate policy and the possibility of
 403 unintended social consequences (Klinsky et al., 2017; Okereke and Dooley, 2010) . However, all
 404 actors in the process – from scientists to world leaders – must take efforts to avoid creating a
 405 situation in which today's solutions become tomorrow's harms. This is especially true when
 406 considering interventions designed to trigger exponential rates of positive social change, or
 407 quick 'fixes' such as geo-engineering (Sovacool, 2021), which could have substantial negative
 408 impacts that could be difficult to mitigate if they are not considered before a social tipping point
 409 is reached . It is thus imperative that all actors take responsibility to acknowledge potential risks
 410 and centre questions of justice, when considering PTPs as solutions to the ongoing climate and
 411 other social-ecological crises.

413 2.1. Risks and unintended consequences of interventions to mitigate climate change

415 Interventions aimed at mitigating climate change can have unintended consequences including
 416 poorly aligned interventions that can exacerbate existing vulnerabilities and risks . A good
 417 example of risks associated with the quest for PTPs is the transformation to a renewable energy
 418 economy. The growth in demand for renewable energy worldwide, including for batteries and
 419 solar panels, is increasing the demand for lithium, cobalt and other rare earth minerals (Dutta et
 420 al., 2016) . While this creates economic benefits for mining communities, it can also produce
 421 negative ecological, economic and social impacts in the near, medium and long-term
 422 (Hernandez and Newell, 2022; Manzetti and Mariasiu, 2015) . A recent study finds that if today's
 423 demand for electric vehicles is projected to 2050, the lithium requirements for the US market
 424 alone would triple the amount of lithium currently produced for the global market (Rionfrancos et
 425 al., 2023) . However , lithium demand could be reduced by 92% in 2050 relative to the most
 426 lithium-intensive scenarios by decreasing car dependency (e.g. through increasing public transit
 427 or biking), limiting the size of EV batteries, and creating a robust recycling system (Rionfrancos
 428 et al., 2023) . Within this context, the industrial mining sector has been accused of supporting
 429 state violence and corruption, polluting ecosystems (Banza Lubaba Nkulu et al., 2018) , and
 430 exacerbating poverty, while the informal mining sector is known for ignoring occupational safety
 431 and health standards and human rights concerns (Sovacool, 2019) .

433 Other prominent examples of unintended consequences have been documented for: a) large-
 434 scale renewable and bioenergy projects, resulting in significant local opposition (Cavicchi, 2018;
 435 (Torres Contreras, 2022) ; b) the displacement of Indigenous peoples, local communities (Zurba
 436 and Bullock, 2020) and coastal fishers (Beckensteiner et al., 2023) ; c) deforestation (Kraxner et
 437 al., 2013) ; d) biodiversity losses (Pedroli et al., 2013) ; e) competition for land and water
 438 resources (Haberl, 2015; Tarhule, 2017) ; f) food insecurity (Hasegawa et al., 2018) ; and g) for
 439 decarbonisation of the built environment, particularly the housing stock, resulting in health
 440 impacts from poor indoor air quality, and fuel poverty (Davies and Oreszczyn, 2012) .

442 An example of climate policy leading to unintended outcomes with social justice implications is
 443 'carbon leakage' (Carbon leakage, 2023; Grubb et al., 2022) . Although often difficult to measure
 444 and distinguish from the more general offshoring of emissions due to globalisation of trade and
 445 deindustrialisation in richer countries, carbon leakage in response to climate policy measures is

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490 an example of a negative spill-over effect. Unilateral climate policies such as carbon pricing and
 491 emissions trading schemes (ETs), designed to encourage carbon-intensive sectors to invest in
 492 carbon-neutral production domestically, may lead firms to relocate to regions with equal access
 493 to the same markets, but with fewer or less stringent regulations (Prellezo et al., 2023).

494
 495 Relatedly, significant policy research has focused on the concept of a 'just transition' (Newell
 496 and Mulvaney, 2013; Wang and Lo, 2021), spurred by the negative labour market impacts of
 497 decarbonization measures in coal-intensive regions of the Global North (Abraham, 2017).
 498 Unless sufficient government investment, regional regeneration, support and skills retraining are
 499 provided to those workers and communities facing the greatest risks from a transition away from
 500 fossil fuels, severe economic, social and cultural hardships are likely to follow. Furthermore, this
 501 could reduce trust in government and strengthen counter-narratives aimed at delaying climate
 502 action (Lamb et al., 2020; Patterson et al., 2018). Participatory and deliberative governance
 503 approaches that include potential losers and other stakeholder groups in designing and
 504 implementing policy for sustainability transitions can help to lower the barriers to a transition by
 505 building political will and legitimacy, and negotiating effective compromises for more just
 506 outcomes (Fesenfeld et al., 2022). More generally, climate policy needs to be designed to
 507 subsidise lower-income households for the higher costs that may accompany measures such as
 508 carbon pricing, emissions trading, new standards for energy-efficient buildings, smart energy
 509 systems, and the electrification of transport systems. Failure to do so could increase poverty,
 510 inequality, hunger and other health impacts, popular protest and political instability (Davies and
 511 Oreszczyn, 2012; Newell et al., 2021).

512 In the Global South, the transition to net-zero carbon emissions must happen alongside
 513 reductions in poverty, and multidimensional vulnerabilities, and while ensuring decent living
 514 standards for all. These countries are confronted with a toxic mix of shrinking carbon budgets,
 515 growing inequalities, heightened climate-related risks, and limited capabilities for mitigation and
 516 adaptation due, in part, to increasing debt burdens (Steele and Patel, 2020). But the debate on
 517 historic responsibilities, development rights, and net-zero efforts is gaining renewed attention
 518 (Mishra, 2021). From the perspective of the Global South, achieving just transitions requires
 519 addressing the double inequality of the climate crisis where developing countries bear a
 520 disproportionate share of the risks, while industrialised nations are primarily responsible for
 521 historical emissions (Gardiner, 2004). Therefore, developing countries are demanding fair
 522 procedures for distributing the costs and benefits of mitigation and adaptation, such as the
 523 Warsaw International Mechanism for Loss and Damage. However, concrete financing
 524 commitments from rich countries remained absent at COP28 in Dubai in 2023 (Jessop et al.,
 525 2023).

526 Unpopular climate policies can sometimes trigger a widespread 'backlash' (Patterson, 2023).
 527 Examples of climate policy backlash include the response to the Australian carbon pricing
 528 scheme (Crowley, 2017) and the French fuel tax increase that gave rise to the Gilets Jaunes or
 529 Yellow Vests protest movement in 2018-2019 (Kinniburgh, 2019). Other well-researched forms
 530 of unintended impacts of policy measures include rebound effects (Chakravarty et al., 2013).

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611 Unintended consequences can also emerge from a failure to build broad coalitions based on
 612 value-inclusive narratives and norms (Constantino and Weber, 2021; Evans, 2017; Klein, 2015;
 613 Meadowcroft, 2011; Rowson and Corner, 2014; Sloterdijk, 2012). Procedural justice is also key
 614 as small producers and/or vulnerable actors are often excluded from the political processes and
 615 negotiations that determine climate policy (Villasante et al., 2022). In centering justice and
 616 combining multiple, intersecting social movements under the climate justice umbrella, many
 617 campaigners and scholars believe that the strength of their combined movements can be
 618 amplified (Mikulewicz et al., 2023). However, there are also concerns that strong social justice
 619 framings can increase political polarisation rather than build broader coalitions (Patterson et al.,
 620 2018; Smith, 2022). Research has also shown that some actors recognise the need for greater
 621 urgency in climate policy, but are reluctant to champion it to avoid being labelled as 'extremists'
 622 (Willis, 2020). As a result, climate policymakers and other actors may prefer to focus on the
 623 more technocratic, less politically risky aspects of transition governance (Patterson et al., 2018).
 624
 625 If decarbonisation is left mainly to market-based mechanisms that prioritise only profitability, the
 626 speed and up-scaling of technological change may threaten the human rights and well-being of
 627 some people while allowing other, more powerful, incumbent actors and structures to prevail
 628 (Newell et al., 2022). Unique opportunities to redesign entire systems and sectors along more
 629 efficient, ethical, sustainable, and equitable lines may be lost where speed and capital
 630 accumulation is allowed to trump inclusivity and depth of process (Leach and Scoones, 2006).
 631 For example, U.S. solar photovoltaic deployment is forecast to grow non-linearly in the near-
 632 term, generating around 12% of all US power by 2027 (SEIA/Wood MacKenzie, 2023). While
 633 this is a positive development in terms of the speed of overall decarbonisation, the perpetuation
 634 of an energy system dominated by profit-maximising utility companies would be viewed as a
 635 missed opportunity for advocates of energy democracy and place-based, cooperative and
 636 community-owned energy (Hoffman and High-Pippert, 2005; Stone et al., 2022). Likewise, 'plug
 637 and play' approaches that seek to electrify cars, but not boost the accessibility of public
 638 transport can serve to reinforce private automobility (Rionfrancos et al., 2023).
 639
 640 Additionally, there is a risk that a growing concern regarding Earth system tipping dynamics
 641 could propel research into speculative interventions such as widespread carbon dioxide
 642 removal geoengineering or solar radiation modification—a set of hypothetical solutions aimed at
 643 reducing incoming sunlight and thus lowering global mean temperatures (National Academies of
 644 Sciences, Engineering, and Medicine, 2021). The most common solar geoengineering proposal
 645 involves injecting aerosols into the stratosphere to limit the influx of solar energy, but there are
 646 also more regional or local proposals involving different technologies. Proponents often argue
 647 for these hypothetical solutions on the grounds that we have made little progress in reducing
 648 carbon emissions and that solar geoengineering could be used to buy time or as a failsafe
 649 (Keith, 2013; Keith et al., 2017). However, solar geoengineering and other more speculative
 650 solutions often come with substantial uncertainty and risks, which are likely to vary across
 651 regions, and insufficient governance mechanisms to equitably and effectively manage such
 652 risks (Kravitz and MacMartin, 2020; McLaren, 2018; Schneider et al., 2020; Stephens et al.,
 653 2021). This has led groups of scholars to call for an "international non-use agreement" and for
 654 limits on related research as well (Biermann et al., 2022).

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¶ In the field of climate communications, there are unintended consequences associated with

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Deleted: actions (Villasante et al., 2022). 'Climate justice' can then include colonial, gender and racial injustices and future generations (Jafry, 2018; Perkins, 2018), particularly in its more transformative form which seeks to address the drivers of climate injustice (Newell et al., 2021).

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Deleted: (Patterson et al., 2018; Smith, 2022). Political progressives tend to frame climate change risk in terms of 'individualising' values of equality, care and fairness, while political conservatives prefer to use 'binding' values based on loyalty, authority, and purity (Adger et al., 2017; Haidt, 2013; Graham et al., 2009). Conservatives are not necessarily against strong (... [12])

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2.2. Winners and Losers: Sacrifice Zones

720 To include equity and justice in the discourse of tipping points, it is necessary to consider how
721 resource extraction can drive tipping points through resource dispossession, whilst also
722 exacerbating the drivers leading to a transgression of planetary boundaries (Pereira et al.,
723 2024). Resource extraction, be it for fossil fuels or green energy sources, creates sacrifice
724 zones— places permanently impaired by environmental degradation and divestment— mainly in
725 the Global South, but also in marginalised areas of the Global North, for example, the green
726 energy developments in Sapmi territories in Scandinavia (Kårtveit, 2021), or lithium mining in
727 Portugal (Canelas and Carvalho, 2023). These actions exacerbate the transgression of
728 planetary boundaries (Sultana, 2023b), cutting across North and South, and are reflective of the
729 uneven control of production, technology and the finance which drives extractivism between
730 global ‘(polluter’) elites and more marginalised social groups (Kenner, 2019).

731 Even well-intentioned interventions have the potential to put pressure on lands held by
732 Indigenous and marginalised communities and reshape their ecologies into “green sacrifice
733 zones” by reproducing a form of climate colonialism in the name of the energy transition (Lang,
734 2024; Zografos and Robbins, 2020). Climate colonialism involves “the deepening or expanding
735 of domination of less powerful countries and peoples through initiatives that intensify foreign
736 exploitation of poorer nations’ resources or undermine the sovereignty of native and Indigenous
737 communities in the course of responding to the climate crisis” (Zografos & Robbins, 2020: 543).
738 Green sacrifice zones then are “spaces or ecologies, places and populations that will be
739 severely affected by the sourcing, transportation, installation, and operation of solutions for
740 powering low-carbon transitions, as well as end-of-life treatment of related material waste”
741 (Zografos & Robbins, 2020: 543). Current examples include ‘green grabs’ for critical minerals,
742 biofuels and water or the acquisition of land for forestry carbon offset projects (Fairhead et al.,
743 2012; Scoones et al., 2015).

744 The violence that capitalism inflicts on places designated as sacrifice zones can be immediate,
745 but it can also be slow and imperceptible. Rob Nixon describes the “slow violence” that befalls
746 marginalised communities over a long period of time and which is almost imperceptible in the
747 marking out of zones for development (Nixon, 2013). This extractive view from corporations and
748 governments meets the resistance of “submerged perspectives”, that is, the ways in which the
749 local humans and nonhumans that inhabit those territories perceive life as entangled, where the
750 destruction of one part affects the rest of the entities and breaks the spiritual heritage in a region
751 (Gómez-Barris, 2017). Slow violence has delayed effects and requires justice to take new forms
752 to secure effective legal measures for prevention, restitution, and redress (Nixon, 2013). To
753 include justice and equity in climate mitigation actions, Latin American countries, for example,
754 have developed the first regional agreement Acuerdo de Escazú in 2018 (CEPAL, 2018). This
755 agreement proposes three concrete objectives to include climate justice in environmental
756 policies and transition actions: (1) access to environmental information, (ii) public participation in
757 environmental decision-making processes, and (iii) access to justice in environmental matters.
758 Such attempts to involve communities in discussions of climate justice are crucial for an
759 approach to PTPs that aims to centre equity and justice frameworks. For the concept of

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- Deleted: Some queer decolonial critique puts it, sacrifice zones are not random, but carefully chosen: “the colonial paradigm, worldview, and technologies [...] mark out regions of “high biodiversity” in order to reduce life to capitalist resource conversion” (Gómez-Barris, 2017).
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A theory of tipping points should not only recognise the way in which the military-industrial complex through powerful non-state actors, and even well-intentioned ... [16]
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sustainability and just sustainable futures to [address](#) local realities, environmental justice scholar Julie Sze argues that a “situated sustainability” is necessary ([Sze, 2018](#)). Situated sustainability should “set the parameters for why and how vulnerability (environmental or other) is disproportionately distributed, one of the key questions in environmental justice research” ([Sze, 2018: 13](#)). In other words, if the questions we ask aim at transformative change or positive tipping points, [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 echoed in the principle enshrined in the UNFCCC 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 highlights 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](#)) and 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 also 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, the 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](#)

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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 call for transformative actions that halt and reverse marine biodiversity loss rates (IPBES, 2019), particularly in some Global South biodiversity hotspots.

The recent Kunming-Montreal Global Biodiversity Framework target 3 seeks to protect 30% of the ocean by 2030 to halt biodiversity loss (30x30 target) (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, as previous levels of protection were insufficient (Baillie and Zhang, 2018; Dinerstein et al., 2019). With Target 3 set 'to ensure and enable that by 2030 at least 30% of terrestrial and inland water areas, and of marine and coastal areas, are effectively conserved and managed (CBD, 2022),' it could function as a potential driver of a PTP if appropriately implemented. However, 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). In effect, 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 area effectively protected (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). Past research has shown that the MPAs can exacerbate equity issues currently present in the Global South, by further marginalising already vulnerable coastal communities (Hill et al., 2016; Sowman and Sunde, 2018). MPAs establishment and management 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 social 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, current extent and distribution of MPAs, for example in the Philippines, do not adequately represent biodiversity, with only 2.8% of coral reef protected within no-take MPAs (Weeks et al., 2010) or, in the context of the 11.4% of EU waters that are covered by MPAs where 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).

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Deleted: (Bennett and Dearden, 2014; Hill et al., 2016). As an example, (Sowman and Sunde, 2018) explored the social dimensions of five MPAs in South Africa, finding that they led to the weakening of local governance rights and processes, loss of tenure rights and access to resources, loss of livelihoods, negative impacts on culture and way of life, and increased conflict in already marginalised coastal communities. Similarly, Oracion et al (2005) documented how in some MPAs in the Philippines, the tourism sector marginalised small-scale fisheries in terms of access and control, jeopardising the economic and socio-cultural viability of fishing-dependent communities.

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1151 A strong global focus on increasing MPAs as a 'tipping point' towards conserving marine
 1152 biodiversity, may fail to carefully and comprehensively address historical impacts and ongoing
 1153 equity issues experienced by coastal communities. In addition, measuring conservation success
 1154 based solely on a coverage metric can incentivize the establishment of large centrally-governed
 1155 MPAs (often situated in former colonies) (O'Leary et al., 2018), at the expense of relatively
 1156 small, but locally managed MPAs (Smallhorn-West et al., 2020). A looming time horizon for
 1157 30x30 may also discourage participatory and collaborative processes that may take longer to
 1158 achieve, but are more efficient in the long term (O'Leary et al., 2018). Concerning global
 1159 planning of MPAs expansion, maps are not apolitical. Global conservation planning exercises
 1160 informed by biophysical variables and cumulative human impacts placed a significant fraction of
 1161 priority areas within the Global South (e.g. Coral Triangle, Southwest Indian Ocean, Caribbean
 1162 Sea) (Jenkins and Van Houtan, 2016; Selig et al., 2014; Zhao et al., 2020), occupying the entire
 1163 Exclusive Economic Zones (EEZs) of some Global South countries (e.g. Indonesia) and thereby
 1164 perpetuating a form of green sacrifice zone. While providing important foundations, this
 1165 literature hardly discusses the ethical and governance considerations of such "conservation
 1166 planning exercises" and local socio-economics needs are either conceptualised as an extra map
 1167 layer that competes with wildlife or something to consider in future analyses.

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1168
 1169 The 30x30 initiative and the revitalization and empowerment of local communities toward PTPs
 1170 may be reconciled by balancing both biodiversity and well-being outcomes of local communities
 1171 when enhancing existing MPAs and designing new ones and seriously considering the wide
 1172 range of "other effective area-based conservation measures", including those where small-scale
 1173 actors, especially IPLCs, are empowered and included from the very beginning of decision-
 1174 making processes to enhance procedural justice (Atlas et al., 2021). Importantly, the expansion
 1175 of MPAs, across both large and small areas, should not be seen as a single strategy to balance
 1176 marine biodiversity and socio-economic needs; it must be part of a broader and more diverse
 1177 management and governance portfolio to govern our oceans in a sustainable and equitable
 1178 manner (O'Leary et al., 2018).

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Deleted: , increasing the likelihood of equitable outcomes; (4) acknowledging customary, traditional and local practices of Indigenous peoples when protecting coastal areas; and (5) considering ongoing sustainable Indigenous management systems within the 30x30 target (e.g. Atlas et al., 2021).

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3.2 Positive financial tipping points: actors and mechanisms

1181
 1182 In today's world, the prevailing financial ideology wields an overwhelming influence on the
 1183 course of human lives and the health of the Earth system, posing a significant threat to the
 1184 fabric of society and the environment. At the core of this paradigm lies a series of unchallenged
 1185 "absolute truths" that prioritise wealth accumulation, power, and unchecked economic growth, at
 1186 the expense of communal well-being and ecological sustainability (Fullerton, 2018). Achieving a
 1187 sustainable future leaves no choice but to avoid a transgression of planetary boundaries and
 1188 tipping points in key Earth system processes (Lenton et al., 2019; Richardson et al., 2023).
 1189 Financial actors are key players in the global economy and affect sustainability biodiversity
 1190 around the world. Several recent policy and private initiatives have been launched with the
 1191 ambition to redirect financial flows towards activities that protect natural capital, influence
 1192 ecosystems and generate equitable outcomes to people in a positive way (Galaz et al., 2015).

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1210 Large financial actors have been shown to possess significant corporate control globally
1211 (Fichtner et al., 2017). Through their influence over economic activities that modify ecosystems
1212 associated with tipping elements, financial actors can also affect climate stability and
1213 biodiversity. A financial sector tipping point that reconfigures flows of finance towards climate
1214 mitigation, adaptation, loss and damage compensation, biodiversity conservation, addressing
1215 vulnerability etc. requires reimagining and reconfiguring governance of public and private
1216 finance (Rammelt et al., 2023). This includes changing the mandates of multilateral
1217 development banks, reforming central banks and regulating private company law and disclosure
1218 policies while also addressing issues such as debt and taxation as part of a more transformative
1219 approach to climate finance (Newell, 2024).

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1221 Higher costs of accessing finance in the Global South, for example, may mean that many
1222 countries are unable to invest sufficiently in providing access to basic services like electricity
1223 (Ameli et al., 2021), which underpin provision of healthcare and clean water, food security, and
1224 access to information and economic opportunity. The most vulnerable in these countries stand
1225 to gain significantly from the low-carbon transition, with cost reductions in renewable energy
1226 generation making solar PV the most viable way to provide electricity to the majority of those
1227 currently without access (nearly 600 million people in Sub-Saharan Africa alone) (IEA, 2022a).
1228 Low investment due to the difficulty of accessing finance creates a higher risk-perception of
1229 investment in these countries further increasing the cost of capital and leading to an 'investment
1230 trap' that can be further exacerbated by climate impacts (Ameli et al., 2021). Interventions that
1231 lower the cost of accessing capital, like credit guarantees and supporting growth of domestic
1232 capital markets, can help to break out of this cycle and open up flows of finance to address
1233 critical vulnerabilities and support adaptation.

1235 There is an increasing call to change the core cause of failure of the financial system (Deutz et
1236 al., 2020; Pinney et al., 2019; UNEP, 2023). At its core, the flawed design of finance rests on
1237 the assumption that we can separate finance from the Earth system, and reduce the complexity
1238 of our interconnected global economy into simplistic financial optimization calculations without
1239 any consideration of equity and justice. Finance cannot be understood in a vacuum. Holistically
1240 understood, finance is embedded in the real economy, which in turn must be understood as
1241 embedded in and inseparable from the Earth system. Recently, there have been proposals to
1242 envision a more sustainable and just financial system (Deutz et al. 2020; UNEP, 2022). For
1243 example, regenerative 'capitalism' provides a new paradigm for finance in which true wealth is
1244 not merely money in the bank. Rather, it must be defined and managed in terms of the well-
1245 being of the whole, achieved through the inclusion of multiple types of wealth or capital,
1246 including social, cultural, living, and experiential (Fullerton, 2018). To operationalize some of
1247 these changes, a framework for guiding sustainable and equitable investments, and a taxonomy
1248 of these investments is currently not universally defined. It is necessary to provide a
1249 classification system of activities that comply with the principles of such investments, thereby
1250 guiding capital investment decisions and development policy towards an improved sustainability
1251 (Sumaila et al., 2021). One example is the United Nations Principles for Responsible

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Investment² committing to responsible investment, which has been signed by 1400 signatories from all over the world since 2015, and with 59 trillion USD of assets under their management. In practice, this means that publicly listed companies globally need to abide by international principles, even if the countries they operate in might be insensitive to such standards (Galaz et al., 2015). Another example is the United Nations Environmental Programme (UNEP) Sustainable Blue Economy Finance Principles where UNEP works with financial institutions to incorporate environmental, social, and governance issues into business principles and financial market practices (UNEP, 2020) and the Principles for Responsible Banking developed with the United Nations Environment Programme Finance Initiative (UNEP FI) – a UN-private sector collaboration that includes membership of more than 240 finance institutions, aimed to guide banks to integrate sustainability across all its business areas and to align bank actions with sustainability needs (UNEP, 2019).

The recent vision for a global, multi-directional and interconnected public investment to design a new architecture of the finance system based on the application of a global and progressive tax system on wealth and on more democratic ways of deciding how best to spend public investments is one proposal for reform of the global financial structure (Global Public Investment Network, 2023). In addition, 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. Tax havens cost governments between US\$ 500-600 billion/year in lost taxation, including an estimated loss to non-OECD economies of US\$200 billion. Individual wealth sheltered in tax havens is an estimated US\$ 8-36 trillion, costing public accounts further (Shaxson, 2019).

For 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). At the national level, positioning sustainability as a tax principle, integrating this dimension into corporate social responsibility on financial markets and reducing the acceptability of tax avoidance can be powerful levers for generating the funds needed for sustainability agendas (Bird and Davis-Nozemack, 2018). Moreover, reducing tax avoidance, tackling illicit financial transfers, and reducing the debts of developing countries can produce in many cases more governmental income than what has been identified in the biodiversity finance gap (Dempsey et al., 2022).

² www.unpri.org/about-pri/the-six-principles

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The above distortions are not simply a market failure, they signal a broader institutional failure. Governments almost everywhere exacerbate the problem by paying people more to exploit nature than to protect it, and to prioritise unsustainable economic activities (Dasgupta, 2021). Therefore, 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; Sumaila et al., 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. In other words, public money is funding our own extinction (Dasgupta, 2021). To address this problem, 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. This funding could support business development capacities for fishers, be given to fishers as lump sum cash transfers, or be used to develop and institute management reforms all of which would support low-income fishers, particularly in the countries of the Global South. Likewise, there have been proposals to redirect a significant percentage of the USD \$11 million a minute 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).

4. Implications for practice

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

4.1. Researchers

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

4.1.2. Diversify expertise across multiple places.

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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. Diversity is a key principle of resilience and should also be a core framing when thinking through justice, so that diverse groups, perspectives, knowledge systems and research methods are not side-lined in the quest for addressing global tipping points. Place- and context-specific information and experience is 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 understanding the full breadth of impacts of positive and negative tipping points needs to be undertaken. Greater diversity in research is therefore needed - in terms of cultural, religious, ethnic, gender or background of the researcher, but also in the disciplines that are engaged. For example, considering social sciences in the intention, design, implementation and evaluation of interventions are also more likely to avoid harms and associated costs, with potential to achieve both positive social and ecological impacts on people (Latulippe and Klenk, 2020). Including diverse groups, perspectives, and knowledge systems in the quest for addressing global tipping points will 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 diverse living realities and interact with actors outside 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).

4.2. 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). This requires a greatly strengthened 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 table to ensure positive tipping points in the financial system that reduces rather than entrenches 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 capital investments steer the sector toward improved sustainability and PTPs, as opposed to overexploitation of labour and resources (Hickel et al., 2021) by

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4.1.3. Have more heterogeneity in research contributions.

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1448 [integrating sustainability and equity into traditional finance mechanisms \(Jouffray et al., 2019\).](#)
 1449 [through ESG approaches or measures like the social cost of carbon \(Prellezo et al., 2023\).](#)
 1450 Cutting off investment for companies that are seen to be complicit in transgressing planetary
 1451 boundaries, such as some oil majors and powerful cattle lobby groups in the Brazilian Amazon
 1452 [\(Piotrowski, 2019\)](#), has the potential to reshape the business environment towards more ethical
 1453 practices. Another area where investments could leverage positive tipping points, for instance,
 1454 would be [to finance a structural](#) shift from car dependency as this could potentially ease
 1455 pressure in the mining sector, reinforcing reduced social and environmental harms and a
 1456 densification of metropolitan areas, which would experience myriad benefits from improved air
 1457 quality to pedestrian safety [\(Rionfrancos et al., 2023\).](#)
 1458

1459 4.2.3. Develop more supportive and inclusive investments

1460 Redirecting public and private money to innovative tools and instruments can enable new
 1461 entrants while reducing the degradation of biodiversity. [With this improved and new direction of](#)
 1462 [finance mechanisms, businesses should then be able to both meet standards and operate in](#)
 1463 [vulnerable areas that need finance to become more resilient. This includes moving money to](#)
 1464 [key areas where it is needed \(adaptation, biodiversity, social common goods\) rather than just for](#)
 1465 [profit \(Crona et al., 2021\).](#) For example, the IIX Sustainability Bonds, are debt securities that can
 1466 be listed on a social stock exchange, and they explicitly address the inclusion of women in
 1467 economic activities. There are also initiatives to supplement gaps in the national currency
 1468 systems such as Community Inclusion Currencies⁴ that empower communities to create their
 1469 own financial systems based on local goods and services [\(Ruddick, 2023\).](#) [The Netherlands, for](#)
 1470 [example,](#) provides special green investment funds that are exempt from income [taxation](#), thus
 1471 allowing investors in green projects (e.g. green shipping, [renewable energy development](#)), to
 1472 contract loans at reduced interest rates (usually ~2% below commercial rates). Another
 1473 example is the Raven Indigenous Impact Fund⁵, a new innovative financial product committed to
 1474 Indigenous-led equity investments in mission-driven and innovative indigenous enterprises to
 1475 help build a renewed and sustainable Indigenous economy in Canada and the US. The Climate
 1476 Bonds Initiative⁶ has also a number of sector criteria (e.g. for marine energy and water utilities);
 1477 while other relevant initiatives include the Blue Natural Capital Positive Impacts Framework⁷ and
 1478 the technical guideline for blue bonds. Mainstreaming these examples as best practice is critical
 1479 for leveraging the financial system to enable PTPs.
 1480

1481 4.3. Decision and Policy-makers

1482 4.3.1. Design fiscal policies that are [cognizant](#) of extant configurations.

1483 Fiscal policy needs to be designed to subsidise lower-income households for the higher costs
 1484 that may accompany climate policies such as carbon pricing, emissions trading, new standards
 1485 for energy-efficient buildings, smart energy systems, and the electrification of transport. Failure
 1486 to do so could set off a cascade of unintended consequences and increase poverty, inequality,
 1487

⁴ <https://grassrootseconomics.org/>

⁵ <https://ravencapitalpartners.ca/investments/impact-funds>

⁶ www.climatebonds.net

⁷ <https://bluenaturalcapital.org>

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 Financial actors, such as international development banks, institutional and private investors, 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 capital investments steer the sector toward improved sustainability, as opposed to unsustainable working conditions and overexploitation of 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. For example, Prellezo et al (2023) highlight the need to build climate resilience, social sustainability, and equity in global fisheries to achieve targets to limit global warming established by the Paris Agreement. By internalising the social cost of carbon, the authors found that if CO2 trading prices reach the 2050 social cost of carbon, around 75% of the landings worldwide would be more valuable as carbon than as foodstuff in the market. ¶

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1529 hunger and other health impacts, popular protest and political instability. Hypothecation, for
1530 example redirecting funds from fossil fuel subsidies to affordable public transport or from
1531 windfall taxes on oil companies for home insulation schemes, can build support among poorer
1532 groups for measures that might otherwise be opposed. Policy and governance actors attracted
1533 to tipping interventions need not only to design targeted, sector- and actor-specific approaches,
1534 but also to combine disciplines and sectors for a coordinated, complex systems thinking
1535 approach and capabilities. Including potential losers in the design process can also reduce
1536 opposition and ensure more equitable outcomes.

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1538 **4.3.2. Foster anticipatory governance to account for unanticipated consequences**
1539 While “positive” tipping interventions are appealing for policymakers by promising to initiate
1540 rapid, significant and potentially irreversible change towards a desired state, careful deliberation
1541 and participatory processes should be used to reach an agreement on what the desired change
1542 is, what the associated trade-offs are, and which populations it is likely to benefit or harm. Given
1543 the high levels of uncertainty associated with tipping point dynamics in complex systems, and
1544 the multiplicity of possible post-tipping states, careful consideration must be given before
1545 initiating a deliberate “positive” tipping intervention, with a focus on anticipatory governance that
1546 seeks to imagine the potential futures that could arise and act accordingly (Olsson and Moore,
1547 2024; Vervoort and Gupta, 2018). Interventions for transformation should be carefully monitored
1548 to avoid unintended negative consequences and to address distributional harms that might
1549 ensue (Olsson and Moore, 2024; Tabara, 2024). The risk of unintended consequences that
1550 might ensue after a tipping process has been initiated may require new governance
1551 mechanisms or a stronger commitment to adaptive management practices and capacities,
1552 including a specific focus on monitoring the change process so that corrective measures can be
1553 introduced. Accountability structures for ‘tipping gone wrong’ should be included in legal
1554 frameworks in order to hold actors accountable for the impacts of their actions.

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1556 **4.3.3. Build appropriate institutions to govern non-linear dynamics**
1557 Existing governance institutions may be poorly fit to the challenges associated with the
1558 governance Earth system tipping points, which are non-linear, can have cascading or systemic
1559 effects, and span long time horizons (Milkoreit et al., 2024; Pereira and Viola, 2018). Additional
1560 research is needed to identify adequate governance principles and institutional structures to
1561 manage Earth System tipping points, including ensuring equity and justice are centred in efforts
1562 to prevent tipping points and efforts to respond to their impacts (Milkoreit et al., 2024). Tipping-
1563 point governance should include lessons learnt from multi-scale, anticipatory governance (Boyd
1564 et al., 2015), grounded in systemic risk approaches (Centeno et al., 2015).

1565 **4.4. Media and communications**

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1568 **4.4.1. Be aware of the politics of language and power dynamics in science**
1569 Communicators are a key actor who interpret the world and they are capable of constructing
1570 new social realities and inspire action (Kegan and Lahey, 2001). They must be alert to the
1571 ideologies, values and systems of power that affect which messages are communicated and
1572 how they are encoded. For example, how a tipping point is identified (Juhola et al., 2022), what

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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). This is particularly relevant in relation to the language of 'positive' and 'negative' tipping points, which can imply a universality of effect that is insensitive to the diverse experiences (and responsibilities) of different communities illustrated above.

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

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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 through ideological values and beliefs' (Hall, 1980). 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 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).

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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). Therefore, in the context of tipping points, engaging a wide range of stakeholders in creative co-production would offer an open-ended, non-instrumental approach to communication that could be key to achieving ethical solutions in this complex field.

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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 positive tipping points 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 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 crises. Taking a cautious 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 what positive tipping points could create a more equitable as well as sustainable future.

Author contribution

LP conceptualised the paper and prepared the initial draft together with SRS, LG, PN, BS and SV. TA, AC, SC, 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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