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Positive tipping points in a rapidly warming world

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The challenge of meeting the UNFCCC CoP21 goal of keeping global warming 'well below 2 °C and to pursue efforts towards 1.5 °C' ('the 2–1.5 °C target') calls for research efforts to better understand the opportunities and constraints for fundamental transformations in global systems dynamics which currently drive the unsustainable and inequitable use of the Earth's resources. To this end, this research reviews and introduces the notion of *positive tipping points* as emergent properties of systems–including both human capacities and structural conditions — which would allow the fast deployment of evolutionary-like transformative solutions to successfully tackle the present socio-climate quandary. Our research provides a simple procedural synthesis to help identify and coordinate the required agents' capacities to implement transformative solutions aligned with such climate goal in different contexts. Our research shows how to identify the required capacities, conditions and potential policy interventions which could eventually lead to the emergence of positive tipping points in various social–ecological systems to address the 2–1.5 °C policy target. Our insights are based on the participatory downscaling of global Shared Socio-economic Pathways (SSPs) to Europe, the formulation of pathways of solutions within these scenarios and the results from an agent-based economic modelling.

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Introduction

The challenge of meeting the UNFCCC CoP21 goal of keeping global warming 'well below 2 °C and to pursue efforts towards 1.5 °C' ('the 2–1.5 °C Paris target') calls for the accelerated development of human capacities to implement transformative solutions in multiple contexts of action [1,2••,3]. In the present situation, it is essential not just to consider command-and-control policies for a 'rapid decarbonisation' [4] which would likely keep the root social causes, individual motives and incentive structures of excessive GHG emissions intact, but more importantly, and in terms of societal transformations, to identify the systemic conditions for a 'rapid sustainabilisation'. This quest involves first of all, finding out more about which are the key dynamics that would eventually allow a fundamentally reversion of the current unsustainable and inequitable trends in the use of the Earth's resources [5,6] and second, to explore the possibilities for individual and collective interventions in such dynamics given the limitations of existing governance arrangements.

This research has two main goals. On the one hand, it reviews the literature on tipping points from a sustainability science perspective and calls for research efforts to better characterize their use in policy making. Given our research focus, we concentrate on the notion of *positive tipping points*, understood as emergent properties derived from complex systems dynamics that allow rapid transformations in individual and collective practices so as to reach evolutionary-like solutions to the present socio-climate quandary. In this regard, we provide a simple operational synthesis and framework aimed at identifying

and supporting the building of agent capacities and system conditions conducive to such positive transformations [7•]. Our approach is based on the acknowledgement of the structural uncertainty about when, where, how or even if such new fundamentally new system conditions, or positive tipping points, will emerge. It also recognizes that social–ecological dynamics are subject to multiple non-linear, irreversible and cumulative processes that cannot be anticipated. However, it is also based on the assumption that social–ecological systems can somehow be navigated intentionally to achieve certain desirable goals, targets or more broadly *visions*.

Assessing positive tipping points in a high-end climate World

Positive tipping points in social–ecological systems

Most research in sustainability science and integrated assessment has focused on examining the catastrophic, abrupt nature of tipping points in biophysical systems or the implications of the realization of such crises or of crossing such negative thresholds for policy and action [8–10,11•,12••,13,14]. However, and with few exceptions [15••,16], little attention has been paid so far to trying to identify and characterize the possible emergence of *positive tipping points* in social–ecological systems dynamics. In the context of climate change 'beneficial social tipping points' have been already referred to those which 'increase societal resilience and reduce climate change damages via mitigation or adaptation, whereas harmful social tipping points are more likely to occur where there are low levels of societal resilience, under which societal risks increase because of failure to effectively adapt or mitigate' [17••]. Such beneficial systemic changes may be derived from the synergetic, multiplicative learning feedback effects of deliberate implementation of transformative solutions developed in multiple contexts of action [18]. In this way, the articulation of learning feedbacks between multiple deliberate transformations at small system scales may be needed to achieve the long-term resilience at higher levels [19]. Addressing the question on how to achieve the Paris target precisely falls under these concerns [20]. It is neither possible to predict the exact moment, shape, dynamics or consequences of such required far-reaching changes in the configuration of global social–ecological systems nor if they will ever happen. However, and using an integrated research perspective, it may be possible to provide an operational framework to recognize the various conditions, capacities and concrete pathways of solutions, as well as the incentives [21], which could eventually lead in concrete contexts of action or subsystems to the emergence of positive tipping points. The later would increase our likelihood of successfully meeting the 2–1.5 °C Paris target.

Tipping points fundamentally and irreversibly change the structure and the intrinsic functioning of a given system of reference. Some authors argue that early warnings and exceeding a threshold of concern about the acceptability of imminent occurrence of a tipping point may lead to 'adaptation turning points' in climate action [22] although this may be hard to put in practice. Some tipping points in certain systems may be unintentional and unexpected, others the result of deliberate actions. Trying deliberate or active transformations to achieve a fundamentally different kinds of systems may be necessary when the present institutions or systems' goals become unattainable [19,23,24]. However, global social–ecological systems — for which global warming is but only a symptom and amplifier of its unsustainable dynamics, are constituted by many 'systems of systems' [25] each of which being determined by its own logics, complex dynamics and effects on other systems. For instance, a tipping point in the way that global communication systems operated occurred with the introduction of the internet, rather suddenly and unexpectedly and the ultimate effects of this transformation cannot yet be forecast; governance systems also follow their own rationales, mainly still under the nation-state interests and constraints and thus are largely resistant to change; the structure and the functioning of global energy and resource property systems are determined by price and market competition rules which in turn may be in conflict with other more traditional or local cultural systems in the use of natural resources; the building of institutional systems has also undergone tipping points in history, for example, when certain civil rights have been achieved, including the end of slavery, the end of child labour, the right of women to vote or to have access to education. The consolidation of the IPPC can be also seen as a tipping point in the development of science for policy to address the climate quandary, albeit with limited effects on global transformation [26]. Hence, both collective and individual social actions operate in multiple socio-cultural, technological, governance, bio-physical and knowledge systems which interact with many other systems at the same time and at many levels. Therefore, it is hard to think of the existence of a single transformative solution or a single tipping point in one single system that would lead to the achievement of the 2–1.5 °C target. Instead, multiple *positive tipping points* in multiple systems of action will be needed to achieve this aim.

There is little knowledge about which kinds of specific changes or *transformative solutions* are to be needed. Ultimately, such transformative solutions should be able to create new kinds of systemic conditions that eliminate the ultimate causes of the persistent problems. For this reason, we understand *positive tipping points* as emergent properties of systems that would allow the reaching of evolutionary-like transformative solutions to successfully tackle the present socio-climate quandary.

However, we admit that on the one hand, agents will only be able to act upon and apply transformative solutions to a limited, albeit crucial, number of systems in which they