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Sustainability transitions and transformations: different purposes, shared agenda

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Commentary

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Abstract

Non-technical summary. This commentary responds to the argument advanced by Geels that technical innovations are more likely than social innovations to accelerate sustainability action and transformative change. Drawing on a comparison between sustainability transition and transformation theories, the article argues that these conceptualizations come with different strengths and limitations, and therefore, they should be considered distinct analytical traditions serving different purposes but also having the capacity to complement each other. In terms of implications, the comparison suggests that responding to sustainability challenges requires sustained societal commitment to advancing both technical and social innovations, rather than an overreliance on technological acceleration alone.

Technical summary. This commentary responds to Geels's argument that technical innovations are more likely than social innovations to accelerate change toward more sustainable practices, and that socio-technical transition theory is more compatible for analyzing such change than transformation approaches. It argues that sustainability transitions and sustainability transformations are distinct analytical traditions with different purposes. First, theoretical focus: transition scholarship foregrounds innovation dynamics, sectoral reconfiguration, and governance, whereas transformation scholarship foregrounds deeper system-wide change and the conditions under which societies reorganize. Second, spatial–temporal orientation: transitions research excels at reconstructing how change unfolds over time, while transformation research typically adopts a prospective, cross-scale orientation linking change to wider systemic challenges. Third, approaches to sustainability change differ: transitions research explains mechanisms but offers less guidance for judging whether outcomes are sufficient, whereas transformation research more readily invokes sustainability reference frames to evaluate adequacy. These differences can be complementary if terminology, analytical reference points, and the aims of the analysis are explicit. The commentary concludes that clearer evaluative criteria are needed to connect debates about acceleration to adequacy relative to sustainability goals, and that effective responses require sustained societal investment in both technical and social innovation.

Social media summary. Sustainability transitions and transformations are different but complementary ways to understanding systems' change.

1. On innovations and their system-level theorization

Frank Geels, a widely recognized foundational figure in socio-technical transitions research, recently published an Intelligence Briefing titled *Why sustainability transitions are starting to accelerate via technical innovations but not through social innovations: five reasons and some critiques of transformations research*. In the briefing, he argues that 'technical innovations offer greater potential than purely social innovations to accelerate sustainability transformations in the next 5–10 years' and that 'the socio-technical transitions framework seems better suited and more policy relevant for the topic of acceleration [of relevant changes] than influential approaches in the transformations literature' (Geels, 2026). Coming from a scholar best known for theorizing the interplay between technical and social factors, and their capacity to enable or impede transformative change, these claims may appear more straightforward than one might expect.

Geels's central claim is that technical innovations align more readily than social innovations with key acceleration mechanisms and therefore offer greater near-term potential to address pressing sustainability threats. Although he does not explicitly put technical and social innovations, nor transition and transformation theories, in order of priority, the structure and style of his argumentation may nevertheless invite such a reading. This impression arises partly because technical innovation is presented as closely associated with well-established transitions scholarship, whereas social innovation is mapped

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onto transformations research, which in his reading suffers from limited conceptual clarity. The sense of a theoretical juxtaposition is further reinforced by Geels's characterization of transformation-oriented approaches such as sufficiency, frugality, and degrowth as reliant on 'wishful thinking' and likely to remain unappealing 'except perhaps for a minority of deep green citizens and academics' (Geels, 2026).

In this commentary, I argue that sustainability transition and transformation are best understood as distinct conceptualizations that serve different analytical purposes and have different intellectual histories, aims, strengths, and limitations. For this reason, their (perhaps unintended) juxtaposition is not only unnecessary but also potentially counterproductive. I first outline the broad development of these traditions and clarify their key conceptual and analytical differences, and after that, I argue for treating transitions and transformations as complementary perspectives. I conclude by reflecting on implications for future theorizing of societal change processes.

2. Comparing transition and transformation theories

Contemporary societies face a sustainability polycrisis: multiple, simultaneous, and deeply interconnected developments, ranging from climate change, chemical pollution, and biodiversity loss to the structural overconsumption of planetary resources, widening social inequalities, health challenges, and geopolitical conflicts (Mark et al., 2025; Schweizer & Juhola, 2024). Because these challenges are systemic in nature, responses must also be systemic. Both transition and transformation theories seek to make sense of system-level dynamics, but they do so with different emphases and theoretical delineations. Recognizing these differences is an important starting point for assessing their respective roles and contributions in sustainability research and practice. It is also worth noting that sustainability transition and transformation have often been used interchangeably, almost as synonyms, which adds complexity to efforts to conceptualize and compare them (Hölscher et al., 2018).

In this commentary, I treat both transition and transformation theories as broad families of theories, concepts, and approaches that have been linked to sustainability in the literature. This necessarily entails a large degree of simplification. However, such synthesis is appropriate for the purposes of a short commentary because it enables a clearer articulation of the main points at stake.

By transition theories, I refer primarily to socio-technical transitions scholarship (e.g., Geels, 2002; Smith et al., 2010), and to the technological innovation systems approach (e.g., Bergek et al., 2008; Hekkert et al., 2007). By transformation theories, I refer to approaches that foreground more fundamental systems change and transformative systems understanding, including leverage points thinking (Meadows, 1999), transformative research for sustainability (Horcea-Milcu et al., 2024), and established strands of sustainability change scholarship such as resilience thinking (Olsson et al., 2014) and socio-ecological systems (Ostrom, 2009). I compare these bodies of work along three dimensions: (1) their principal theoretical foci, (2) their spatial–temporal orientations, and (3) how they conceptualize and evaluate sustainability-oriented change.

2.1. Theorized focus areas

A key strength of transition-oriented approaches lies in their ability to describe dynamics across system levels, for instance between niches, regimes, and landscapes in the multilevel perspective (Geels, 2002), while also attending to the practicalities of innovation, policy, and industrial change. Although often associated with technology and sectoral change, transitions scholarship has strong roots in the social sciences, which offers valuable tools for analyzing social dynamics, institutional arrangements, and power relations as integral elements of sustainability change (Geels, 2020). At the same time, transition-oriented analyses may remain relatively cautious in addressing the deeper normative and political–economic drivers of unsustainability (e.g., Feola et al., 2021; Newell et al., 2021).

Transformation-oriented approaches, by contrast, typically focus more explicitly on fundamental societal and ecosystem changes, including questions of systemic resilience, adaptability, and the capacity of socio-ecological systems to cope with and reorganize under external pressures (e.g., Olsson et al., 2014). Building on pioneering work on complex adaptive systems (e.g., Folke et al., 2005; Levin et al., 2013), these (typically multidisciplinary) approaches provide strong capacities for analyzing sustainability change at planetary to regional scales (e.g., Steffen et al., 2015). However, the conceptual level at which transformation is often theorized can make it harder to connect directly to the everyday practices, organizational routines, and concrete policy processes through which change is enacted and contested.

2.2. Spatial–temporal orientation

It is worth recalling that socio-technical transition theory did not originate primarily as a sustainability framework, but as part of an ambition to explain broad socio-technical changes. Classic cases, such as the historical shift from sailing ships to steamships in maritime transport, illustrate the explanatory orientation that initially characterized the approach (Geels, 2002). Accordingly, transitions research has often been strongest in descriptively reconstructing how change has unfolded over time and in identifying mechanisms and sequences through which innovations scale and regimes reconfigure. While transitions scholarship increasingly engages with contemporary change processes, and sometimes informs forward-looking policy discussions, it has historically offered somewhat limited conceptual guidance for evaluating alternative future states.

Transformation research more commonly builds a future orientation into its conceptual and analytical frameworks. Recent modeling and synthesis efforts, for example, have combined planetary boundaries with societal functions and governance challenges to illuminate interlinked global risks and trade-offs (e.g., Crona et al., 2023; Lade et al., 2020). Although there is growing interest in cross-sectoral dynamics within transitions research as well (e.g., Kainiemi et al., 2025; Rosenbloom, 2020), many transition analyses still center on explaining how change happens, and how it can be accelerated within a particular sector (Sovacool et al., 2025). Transformation research, by contrast, has persistently highlighted interdependencies and value conflicts across sectors and scales, thereby foregrounding the difficulty of addressing sustainability challenges through isolated interventions (e.g., Horcea-Milcu et al., 2023; Raymond et al., 2023).

In sum, although both transition and transformation approaches can inform future-oriented envisioning, transition theory tends to be more explanatory in character, whereas transformation theory often adopts a more teleological orientation by emphasizing purposeful change toward desirable futures.

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2.3. Approach to sustainability change

Transition theory typically aims to explain how socially constructed physical systems, such as industries, infrastructures, and other sectoral configurations, shift over time through interactions between technology, policy, and social practices. Yet the transition approach might be limited in its capacity to judge whether the direction and magnitude of theorized change are adequate relative to sustainability goals because that is not among the key theorized aspects. As a result, the same analytical vocabulary can be used to describe changes ranging from incremental improvements to more structural reforms.

Although certain streams of transition research have also addressed deep and long-term transitions (e.g., Schot & Kanger, 2018), the main discussion has tended to concentrate on bounded system settings where change is assessed primarily in relation to the starting point of a theorized transition, rather than being situated within broader biophysical or social thresholds. This further complicates efforts to distinguish between change that is significant in relative terms, often associated with weak sustainability, and change that is sufficient in absolute terms, often associated with strong sustainability (Neumayer, 2013). Different theoretical approaches vary in the extent to which they assume natural capital can be substituted by human-made capital, and this assumption should be carefully considered when evaluating their suitability for particular research contexts.

It is important to note that the same development may be interpreted differently depending on the theoretical perspective adopted. For example, the increased use of electric vehicles in personal mobility can be understood as a successful transition in the transport sector (Geels, 2026), but also as an incomplete sustainability transformation if it does not sufficiently reduce the overall socio-metabolic stress generated at the system level (Levänen et al., 2026). This illustrates how theory shapes analytical focus by influencing what is included in the analysis and what remains outside its scope.

While transformation approaches more often attempt to relate theorized changes to broader sustainability reference frames, such as planetary boundaries or explicit sustainability goals, both traditions still face a risk of selective emphasis, i.e., focusing on certain sustainability dimensions while neglecting others. It remains common, for instance, for studies to privilege environmental indicators to such an extent that social and/or economic concerns are treated as secondary or omitted altogether (Komp-leukkunen & Levänen, 2026). This leaves unresolved questions about how developments across sustainability dimensions may interact, conflict, or reinforce one another (e.g., Jenkins et al., 2018).

3. Implications

Both sustainability transition and transformation scholarship seek to improve understanding of how more sustainable societal arrangements can be advanced across scales and contexts, and in this sense, they share a common agenda. At the same time, the two traditions have emerged from distinct intellectual histories, which have shaped differences in their theoretical emphases, spatial–temporal orientations, and in how sustainability-oriented change is conceptualized and evaluated. What, then, follows from the foregoing comparison of sustainability transition and transformation theories, particularly regarding the capacity of technical and social innovations to address or mitigate contemporary sustainability challenges? I highlight three points.

First, while I broadly agree with Geels (2026) that technical innovations are often better positioned than social innovations to activate key acceleration mechanisms, it would be unwise to place disproportionate reliance on technological change, especially if this entails deprioritizing social renewal. There is, at present, no basis for assuming that even significant technological advances would, on their own, be sufficient to bring socio-ecological systems to operate within planetary boundaries. Moreover, insofar as contemporary sustainability threats are driven to a substantial extent by consumption patterns and lifestyles among affluent and middle-class populations in the Global North (e.g., Chancel et al., 2025), it is difficult to assume that the necessary changes will primarily emerge from, or be accelerated by, technological development alone. In the context of a polycrisis, what is required is sustained societal commitment to advancing both technical and social innovations, even if the acceleration of the latter is more difficult to achieve.

Second, the relationship between technical and social innovation should not be framed as an either–or phenomenon. Rather, technical and social innovations are often intertwined through multiple mechanisms (e.g., Lyon et al., 2026). For instance, technical innovations may foster social learning, which can subsequently enhance understanding of the types of technologies needed to address the polycrisis. In this sense, greater attention should be paid to how technical and social innovations may co-evolve, emerging hand in hand through mutually reinforcing processes of development and change. In practice, this requires a more nuanced understanding of diverse ways of knowing, being, and doing in the contexts of transition and transformation (e.g., West et al., 2024), as well as new approaches to fostering dialogue among different actors (e.g., Colloff et al., 2021).

Third, even if one accepts Geels's (2026) suggestion that transitions scholarship may appear more conceptually developed than parts of the transformations literature, this does not warrant downplaying the kinds of complex system dynamics foregrounded in transformation-oriented approaches. Without an evaluative lens that relates innovations to their absolute sustainability implications, such as performance relative to ecological carrying capacity and critical social thresholds, we cannot credibly assess their contribution to sustainable development. Hence, we need analytical approaches that make it routine to judge whether theorized changes are adequate relative to the challenges they are intended to address.

Transition and transformation theories can indeed offer complementary perspectives on the same empirical phenomena, as for example Fisher et al. (2022) have previously proposed. That complementarity, however, is only productive when terminology, analytical reference points, and the specific aims of the analysis are made explicit.

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