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Sustainablility Impulses from Wuppertal

The Regenerative Economy and Planetary Boundaries: Research and Impact Agenda

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Summary

The Earth has exceeded its ecological carrying capacity: six out of nine Earth planetary boundaries have already been surpassed. The corresponding Earth system is destabilising as a result, from the climate and biogeochemical cycles to biodiversity. This decline threatens not only ecosystems worldwide, but also the very foundations of human life on earth. European political and economic strategies still focus primarily on mitigating economically induced damage through technological efficiency gains. However, this only allows us to freeze the current state – at best – while we are already well outside of the safe operating space for humanity. Therefore, new strategies are needed that deliver more than mere damage avoidance. Regenerative economics is one such strategy.

A regenerative economy actively contributes to the restoration of ecosystems and supports the regeneration of natural systems. This issue of In Brief shows that the path back within planetary boundaries requires a fundamental mindset shift. Economic success should be linked to the restoration of the health of ecological and social systems. This, in turn, requires new approaches to impact-oriented research, combined with concrete steps to change the current economic system.

1. Why Net Zero and Recycling are Not Enough

Ecological problems caused by human activities continue to increase worldwide with dramatic consequences. Progress in relation to climate protection, reducing resource consumption and preserving biodiversity has been insufficient to date, with environmental crises escalating further. An international research team led by Katherine Richardson showed that six of the nine planetary boundaries had already been significantly exceeded by 2023. Staying within these boundaries is essential for a stable and resilient Earth system, which includes a stable climate and preserving biodiversity, freshwater and the oceans (see Fig. 1). Exceeding these boundaries increases the risk of abrupt and irreversible environmental changes, such as the polar ice caps melting and massive biodiversity losses, which in turn threaten the foundations of human life on Earth. Current projections from the Global Tipping Point Report show that we are getting closer and closer to these tipping points of environmental change – without knowing exactly when we will reach them or what effect they will have. It is, therefore, impossible for us to achieve a controlled stop just in time to avoid these tipping points.

This creates a dire need for new solutions, not only to lessen the negative impacts of human activity on the environment, but to support the recovery of the Earth system. Regeneration must become the overarching goal for sustainable economic activity. Net Zero strategies are insufficient without accompanying measures to support the recovery of ecological and social systems. At best, they stabilise an already critical state. Thus, a **stronger focus should be placed on understanding and supporting the Earth system's recovery processes**.

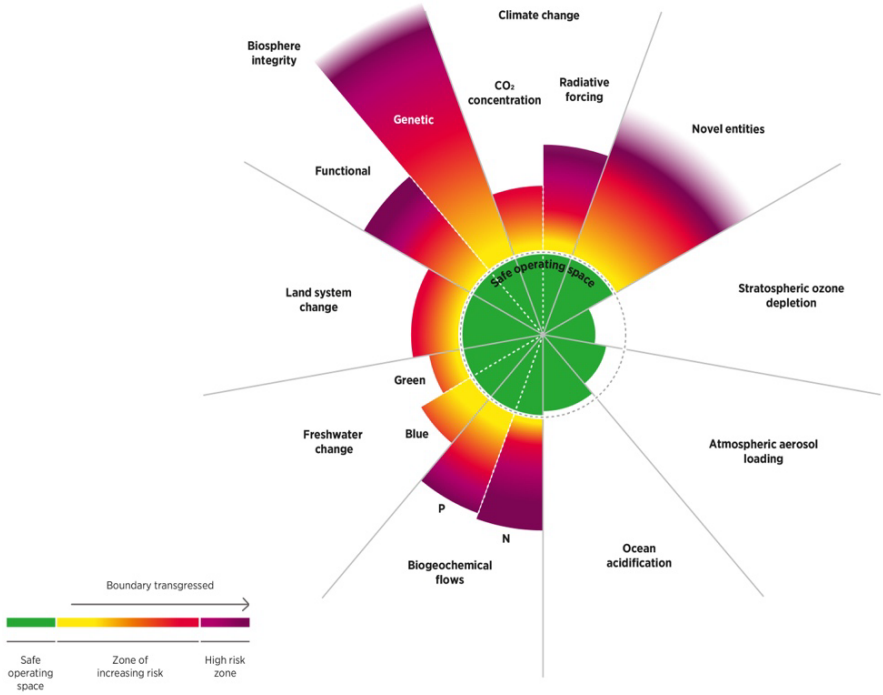

Fig. 1: *State of the planetary boundaries: The figure by Richardson et al. shows the state of the planetary boundaries in 2023. Six of the nine defined boundaries have already been exceeded, leading to a destabilisation of the Earth system that threatens the foundations of human life on Earth.*
Source: *Illustration by the Wuppertal Institute, closely adopting the original figure by Richardson et al. (2023). The original figure is distributed under a Creative Commons Attribution NonCommercial License 4.0 (CC BY-NC).*

This calls for a shift in perspective. Currently, the economy is still regarded as separate from the health of the environment and society. In future, all actors will have to understand themselves and their economic activities as part of the Earth and human systems. Furthermore, all actors must prioritise returning these systems to a safe operating space for humanity, as defined by the planetary boundaries.

2. The Approach: Regeneration and Restoration of Natural Systems

The key question is: How must we change our economic activities to contribute to the regeneration of the Earth system? It is important to emphasise that regenerative economics is not yet a fully developed concept: no generally accepted definition exists at present. Its relationships with other concepts and debates (such as efficiency, green growth, steady-state economics, post-growth, degrowth and sufficiency) remains unclear. Nevertheless, in the current discourse, a common understanding has emerged, with regenerative economics moving beyond merely avoiding damage and instead aiming to actively restore and improve social and ecological systems. This is also a key distinguishing feature, both from conventional approaches that hope for technological progress through business as usual, and from concepts such as green growth or other "weaker" forms of sustainability.[1]

Definition: What is a Regenerative Economy?

According to Piero Morseletto, the regenerative economy can be understood as a combination of **restorative and regenerative** approaches:

- **Restoration** occurs externally, as an attempt to restore something, thus bringing a system artificially into a healthy state again, e.g. by reforesting fallow land.
- **Regeneration** occurs through mechanisms inherent in the system as "functional self-renewal".

A key message is, therefore, that actors external to the system cannot create regenerative processes: they can merely support systemic conditions conducive to regenerative processes, so that the processes can unfold in the system and renew it. Consequently, the mission is to develop human practices that enable the system to preserve itself based on its internal processes.

This requires comprehensive knowledge of local system processes**. Both restoration and regeneration can only take place at the site of impact**, as the specific conditions and interactions can only be directly influenced there. This also allows for a clear distinction between regenerative economics and compensation strategies, such as offsetting environmental impacts or emissions. Offsetting usually occurs in geographically separate systems, such as through reforestation measures on other continents. Consequently, it does not address the degenerative dynamics at the originally damaged site or achieve the desired improvement, and instead merely attempts to compensate the negative impact elsewhere in mathematical terms.

The goal of transforming the economy and society in accordance with regenerative principles is to ensure the **long-term resilience** of the Earth system and thus secure the basis for a good life

[1] *The main distinction between "strong" and "weak" sustainability is that strong sustainability focuses on changing political and economic systems and recognizes that nature has an intrinsic value. Weak sustainability, on the other hand, views natural systems as mere suppliers to the economic system, which must be managed to preserve them for human use (Chakori et al., 2025).*

for all. Based on the findings of Zisopoulos and his team, it is advisable to adopt **an understanding of regenerative economics** that aims to enable the **self-renewal** of the Earth system – or, more specifically, its return to the safe operating space of planetary boundaries and its long-term stabilisation within these boundaries. Instead of repairing damage exclusively from the outside, the focus should also be on supporting processes that enable systems (from individual living beings to entire ecosystems) to renew themselves. A fundamental understanding of system boundaries and resources, as well as all influencing factors—including nature itself—is essential. However, this approach must be adapted to specific problems and entities in a system-specific and context-specific manner and requires continuous learning and iteration.

3. Restoring and Preserving: The Interplay of Restoration and Regeneration

Understood in this way, regenerative economics represents a paradigm shift and has the potential to enable system resilience for the survival of humanity. Figure 2 illustrates how regenerative approaches differ from previous sustainability strategies: building on the concept of planetary boundaries (see Fig. 1), a “safe operating space for humanity” is outlined within the system boundaries of the Earth's natural systems.

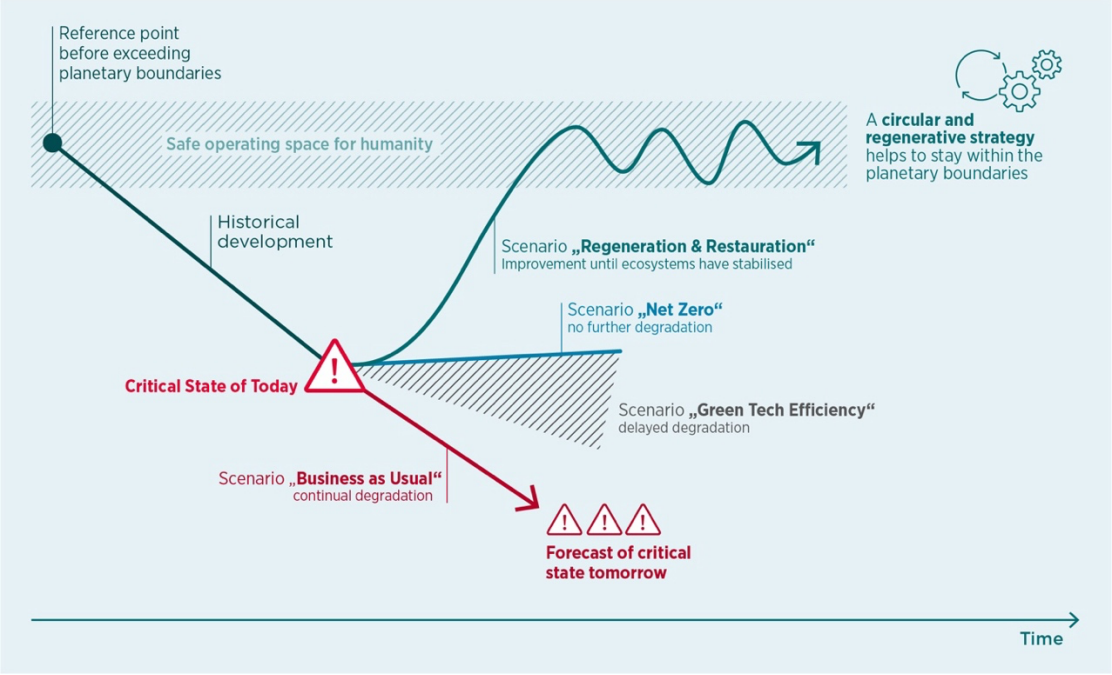

Fig. 2: *Simplified illustration comparing current sustainability strategies and the desired approach of “regenerative economy” in order to return to a safe operating space for humanity.*
Source: *Wuppertal Institute*

The figure also shows that we are already well outside this safe operating space. Some ecosystems are in a critical state. It is therefore easy to see how the scenarios resulting from the various sustainability strategies differ.

- In the **Business as Usual (BAU)** scenario, continuing trends will lead to further deterioration of natural systems.

- **Green Technologies and Efficiency** measures can slow the development in the BAU scenario, but cannot reverse it (delayed deterioration).
- Strategies aimed at preventing further damage, such as climate neutrality **(Net Zero),** seek to ensure that environmental quality does not deteriorate further. The current state is thus essentially "frozen" at the current critical level. The climate-neutral scenario may also offer the potential for a certain degree of system regeneration, but the state of some Earth systems will (initially) continue to deteriorate even in this freeze state due to "overshoot effects". Either way, the aim should not be to stabilise the natural systems outside the safe operating space but to return them within safe limits.
- The **Regeneration & Restoration scenario** supports systems to ultimately renew themselves. The goal is for natural systems to regenerate to such a degree that all of Earth's systems can once again operate within the safe operating space of planetary boundaries. Once the systems are back within the safe operating space, natural processes can maintain their own balance and thus stay within the safe operating space, albeit experiencing small fluctuations in the trend development. These fluctuations are caused both by human activities and by dynamics within the natural systems themselves.

4. Circular Economy and Regenerative Economy are Closely Connected

The circular economy is often sweepingly defined as restorative and regenerative. The European Commission describes the circular economy as a "regenerative growth model", which gives back more to the earth than it takes. However, it remains unclear what this means exactly and also what should be restored or regenerated.

The circular economy aims to prevent environmental damage and waste through various strategies, such as reuse, repair, refurbishment and recycling. The goal is to use materials for as long as possible and keep them in circulation. Circular economy strategies such as repair and recycling are considered restorative or regenerative at the product and material level. However, it is important to note that they do not automatically contribute to the restoration or regeneration of ecological systems as a whole.

So, while the circular economy and regenerative economy are closely linked, the circular economy is not automatically regenerative. For example, circular economy strategies can lead to negative rebound effects that overshoot the savings achieved by circular practices and thus cause even more damage than the original economic practice.

With this in mind, it is important to respect the principles of regenerative economy when implementing the circular economy. These principles include broad system boundaries, strategies for avoiding environmental damage and conserving resources, and a focus on stabilising the Earth system. At the same time, the practical approaches of the circular economy are indispensable tools for implementing a regenerative economy.

5. Roadmap for the Transition to a Regenerative Economy: An Integrated Research and Impact Agenda

A strategy that involves merely limiting damage or freezing the current state will not be sufficient to avert the impending collapse of the fundamentals underpinning human life on earth. Instead, a paradigm shift is needed: ecosystems must be systematically rebuilt and actively supported to enable regeneration. The regenerative economy concept encompasses the vision of reshaping economic decisions and processes in such a way that they **not only avoid damage to ecological and social systems**, but **actively restore, support and promote them**.

Despite the urgent need for transformation, the concept of regenerative economics remains in its infancy. An **integrated research and impact agenda** is needed to advance it. Practitioners and researchers will have to collaborate simultaneously to achieve immediate results (transformation). In parallel with practical implementation, there is a need for theoretical elaboration and further development of the concepts embedded in this field of research, which remains relatively small and to drive its continuous refinement.

Regenerative economy is fascinating because it enables humans to live and work in harmony with the ecosystems with which they interact. This provides humanity with new possibilities for action towards meaningful improvement, given that regenerative economics holds the potential to support regeneration and restore ecosystems by better understanding them.

Regenerative economics is transformative because it changes the target values of economic activities and inextricably links economic success with the health of ecosystems.

Regenerative transition means:

Companies not only using resources more efficiently but also understanding and restoring their biological sources.
Cities and regions identifying places of value creation within their local ecosystems and social systems and promoting their regenerative capacity, including concrete measures for restoration on site.
Political strategies and regulation creating framework conditions that support a regenerative economy. Instead of focusing exclusively on technical innovations to increase efficiency, a frame of reference is established with a focus on biological, ecological and social target qualities, such as biodiversity.
Transformative research developing an integrated research and impact agenda that integrates and coordinates research and practice – and develops and refines both restorative and regenerative measures.

What's still missing: The concepts are still vaguely defined; in some cases, regenerative economics and sustainability are used synonymously – which results in regenerative economy losing its transformative meaning.

This is why a broad scientific and societal debate is needed as well as a theory of change. At the same time, regenerative economics should be embedded in existing political debates and sustainability strategies, such as the Sustainable Development Goals, as well as in existing research. Knowledge of ecological and social mechanisms should be used to develop new business models, identify best practices and implement pilot projects. The basic prerequisite for this is the development of knowledge about the ecological and social systems on which human

(economic) activity depends. This requires close cooperation between researchers from different disciplines and practitioners. It will create a holistic understanding that enables us to return to a space within the planetary boundaries. Combined and coordinated research and impact agendas need to be developed, given both the seriousness of the situation and the required pace of change, this research is akin to open-heart surgery. Research and practice must advance hand in hand.

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