50 years 'Limits to Growth' - where are we now, where should we go?

Background paper for the European Resource Forum 2022

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1 Background

Appearing in 1972, shortly before the OPEC oil crisis, the book "Limits to Growth" was a wake-up call to the world about the risks posed by resource scarcity. It also ushered in the use of computer-based modelling to play out potential scenarios of the future and report results across multiple indicators. Indicators and modelling are now central elements of the "language" around sustainability. But the debate continues: what are the limits to growth? Can we decouple resource use from economic activity in a way that enables growth to continue? How do we stay within a "safe operating space" for the planet? Without growth, how could we effectively ensure the existence of jobs and social stability while fighting poverty?

1.1 1972: Limits to Growth

In 1972, the "Limits to Growth" report (Meadows et al., 1972) presented findings from 12 global scenario analyses through the year 2100. The published results contained a grim warning: a continuation of population and economic growth trends would put humanity on a collision course with Earth's capacity to sustain the associated supply of resources and to absorb the resulting pollution. The book provoked lively reactions from the public. Bardi & Alvarez Pereira (2022) summarised one of its key impacts as follows:[1] „The Limits to Growth disrupted the conviction that conventional 'development' and its expansion to the whole globe, as a programme of modernization and industrialization under Western hegemony, was necessary and legitimate for the sake of the progress of humanity" (p. xi).

At least in western world regions, reactions were shaped by geopolitical conditions such as the peaking of US oil production in the early 1970s and the subsequent global oil crisis of 1973, as well as an emerging debate regarding capitalist lifestyles. However, given the long tradition of growth-critical discourses in the economic sciences,[2] the broad public impact achieved by this report can hardly be attributed to these accompanying factors alone.

What distinguished this report from all previous social science studies was the use of what were then state-of-the-art computers to simulate global development scenarios under altered framework conditions. The system dynamics simulation model World3 was used for a parametrisation of multidimensional cause-effect relations at the global level and their projection up to the year 2100. This methodological novelty greatly facilitated the dissemination of key messages from this report in a way that was also accessible for a mass audience.[3] While different authors

[1] This quote is taken from a report to the Club of Rome which also commissioned the original Meadows et al. 1972 study, that was issued on the occasion of the 50th anniversary of the initial report.
[2] See for example Malthus 1826 or Jevons 1865 as prominent early references in this regard.
[3] A somewhat similar explanation of the background of the huge commercial success of the Meadows et al., 1972 report can be found, for example, in Döring und Aigner-Wagner 2022.

provided different figures regarding the total number of sold publications,[4] the report was clearly an extraordinarily influential bestseller in the field of environmentally relevant publications.

1.2 2022: Limits to Growth +50

Two follow-up reports to the 1972 publication were published in recent decades (Meadows et al., 2004; Randers, 2012). Compared to the 1972 publication, however, these follow-up reports did not achieve nearly the same level of attention.

It is too early to decide today what kind of attention the 50-year anniversary follow-up to "Limits to Growth" will receive. This follow-up report to the Club of Rome, entitled "Earth for All: A Survival Guide for Humanity" (Dixson-Declève et al., 2022), relies on a new system dynamics model Earth4All to test future scenarios. The Earth4All model was designed by Jørgen Randers, a co-author of "Limits to Growth". The book focuses on two scenarios, called "Too Little Too Late" (largely a continuation of current trends in the economic system) and "Giant Leap" (a concerted economic transformation to a resilient civilisation). Comparing the outcomes for these two scenarios, the authors conclude that five turnarounds are needed and can be achieved by 2050: 1) ending poverty; 2) addressing gross inequality; 3) empowering women; 4) making our food system healthy for people and ecosystems; and 5) transitioning to clean energy (pp. 5-7). The authors estimate that the required investment in sustainable energy and food security equals 2% to 4% of global income overall (higher in the near term) with an active role for governments to marshal and steer these investments. They call for extraordinary interventions to address inequality and propose policies to ensure that no more than 40% of national incomes go to the wealthiest 10% (p. 6). They also set policy goals of stabilising the world population at below nine billion by 2050 and GDP growth of 5% annually for low-income countries until GDP is greater than US$15,000 per year (p. 20).

2 Ongoing developments

2.1 Achievements

Looking back over the last 50 years, extensive policy advancements have been made towards the implementation of sustainable development processes. In Germany, for example, reference can be made to the following institutional developments: the German Environment Agency was founded in 1974; Germany's Federal Environment and Consumer Protection Ministry was founded in 1986; and in 1994, the goal to protect natural resources for future generations was included in the German constitution.

Comprehensive environmental legislation is nowadays understood by many industrialised societies as a self-evident feature of successful governance. This view facilitated the establishment of remarkable multinational agreements over the last decade: The Paris Agreement, a legally binding international treaty on climate change mitigation intended to limit global warming to well below 2° Celsius compared to pre-industrial levels, entered into force in 2016.[5] The

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[4] „The Limits to Growth, published in 1972, marked a turning point in thinking about the environment, selling some 30 million copies in 30 languages" (https://donellameadows.org/archives/the-history-of-the-limits-to-growth/). "The book entitled *The Limits to Growth (LtG)* is known to many. It has been printed in 3-4 million copies in at least 36 languages." [Randers in Bardi & Alvarez Pereira 2022, p. 45].

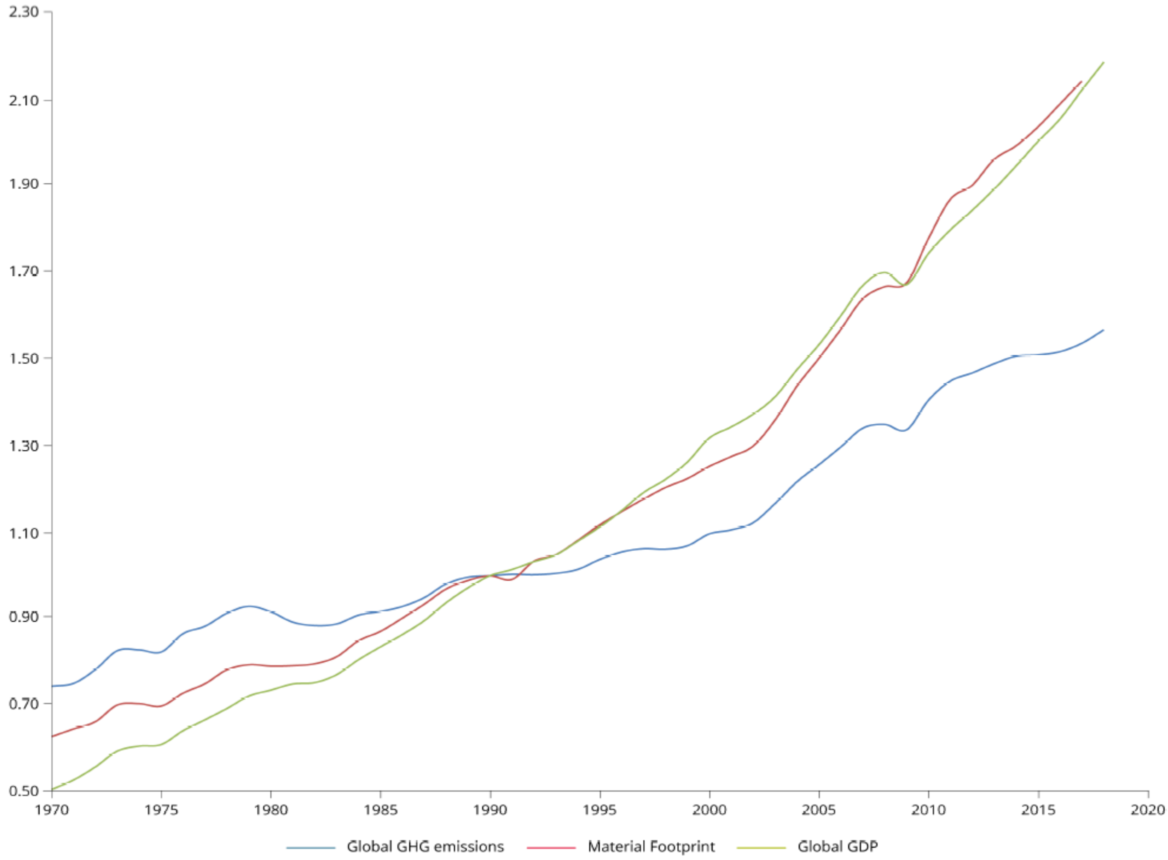
[5] For more on the Paris Agreement, see https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

Sustainable Development Goals (SDGs) were adopted by all United Nations Member States in 2015 and are to be achieved by all developing, emerging and industrialised societies by 2030 [6]. The European Green Deal, launched by the European Commission in 2019, is intended to „transform the EU into a modern, resource-efficient and competitive economy, ensuring no net emissions of greenhouse gases by 2050, economic growth decoupled from resource use, no person and no place left behind" (European Commission, 2022). There can be no doubt, then, about the significant changes that have taken place in the policy landscape since 1972 in terms of integrating sustainability aspects into policymaking.

2.2 Remaining gaps

Though some decoupling of economic activity from greenhouse gas emissions has been seen at the global level (see Figure 1), greenhouse gas emissions continue to rise. No meaningful decoupling of material footprint[7] per unit of GDP can be seen at the global level since the publication of Limits to Growth in 1972. At the EU level, 6.5 billion tonnes of globally extracted raw materials were consumed in 2019, which is just 12% less than in 2004 (Eurostat, 2022, p. 225).

Figure 1. Global decoupling trends: relative change in GDP, greenhouse gas emissions and material footprint from 1970 to 2018



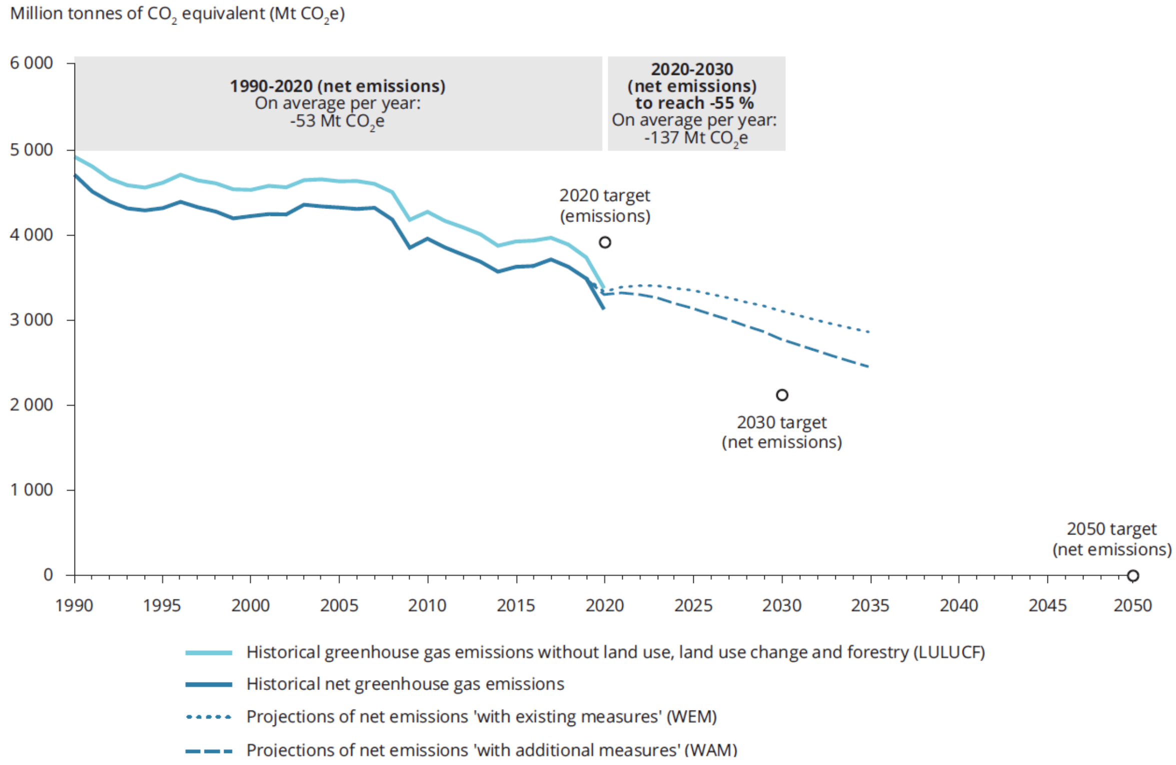
Source: Reproduced from EEA (2022, p. 4). Modified from Wiedmann et al. (2020). Reproduced under the terms and conditions of the Creative Commons CC BY 4.0 licence (https://creativecommons.org/licenses/by/4.0/). Data from Olivier and Peters (2020) for greenhouse gas (GHG) emissions; UNEP and IRP (2018) for material footprint; and World Bank (2020a) for GDP.

[6] See https://www.un.org/sustainabledevelopment/

[7] "Material Footprint is the attribution of global material extraction to domestic final demand of a country. The total material footprint is the sum of the material footprint for biomass, fossil fuels, metal ores and non-metal ores" (UN Statistics Division, 2022).

The EU aims to completely decouple its economic activity from greenhouse gas emissions. The European Climate Law sets legally binding targets of reducing greenhouse gas emissions in the EU to 55% below 1990 levels by 2030 and reaching net-zero emissions of greenhouse gases in the EU by 2050.[8] As can be seen in Figure 2, net emissions will need to decline by an average of about 137 million tonnes of CO_2e per year going forward, over twice as fast as the average annual decline of 53 million tonnes seen in the EU since 1990.

Figure 2. Historical trends and projections of greenhouse gas emissions in the EU



Source: Reproduced with permission from EEA (2021, p. 8)

Current global development patterns indicate that the use of some resources is accelerating dramatically. To name only some prominent examples from the recent past: China used more cement between 2011 and 2013 than the U.S. economy used throughout the entire 20th century.[9] In 2015, US oil producers surpassed their previous production records set in the early 1970s and the US became the world's largest producer in 2018.[10] In 2020, the United States formally left the Paris Agreement. In 2021, Working Group I of the IPCC's Sixth Assessment Report (AR6) confirmed widespread and intensifying climate change trends worldwide.[11]

2.3 Environmental limits: planetary boundaries

The concept of planetary boundaries provides a contemporary view of the key impact variables that require monitoring along with the issue of how to account for the limits of human activity on the planet. It was put forward by Rockström et al. (2009) as a means of identifying a safe operating space for humanity on Earth. Planetary boundaries are divided into nine categories and

[8] For more information on the European Climate Law, see https://climate.ec.europa.eu/eu-action/european-green-deal/european-climate-law_en

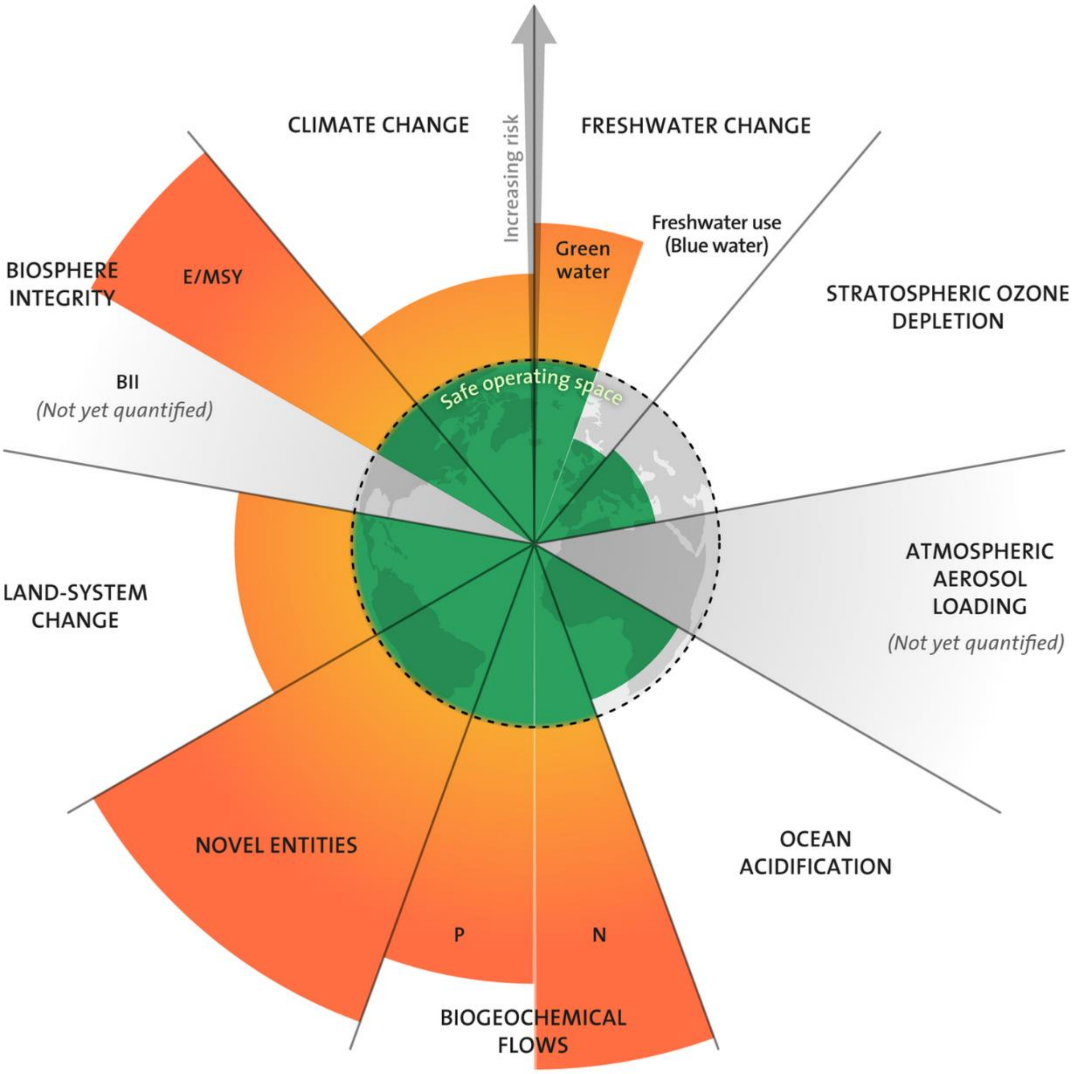
[9] https://www.washingtonpost.com/news/wonk/wp/2015/03/24/how-china-used-more-cement-in-3-years-than-the-u-s-did-in-the-entire-20th-century/

[10] Scholz und Wellmer 2021.

[11] https://www.ipcc.ch/2021/08/09/ar6-wg1-20210809-pr/.

define specific dimensions wherein transgressing a boundary "may be deleterious or even catastrophic due to the risk of crossing thresholds that will trigger non-linear, abrupt environmental change within continental- to planetary-scale systems" (Rockström et al., 2009, p. 1). The concept is continually updated, with quantified "safe operating limits" now identified for indicators in eight of the nine categories (Steffen et al., 2015; Wang-Erlandsson et al., 2022). Within six of the categories, planetary boundaries have already been exceeded (see Figure 3). This transgressing of multiple planetary boundaries highlights the need for national policymakers to better address the global footprint of their countries' domestic production and consumption patterns, as well as the impacts of international trade.

Figure 3. Planetary boundaries



Source: Azote for Stockholm Resilience Centre, based on analysis in Wang-Erlandsson et al. (2022). Licenced under CC BY-NC-ND 3.0. Available at: https://www.stockholmresilience.org/research/planetary-boundaries.html.

3 Moving forward

3.1 Potential and limitations of science-based modelling and simulation

The main impact variables of the original Limits to Growth simulations were population, per capita food supply, industrial output per capita, provision of services per capita, exploitable resources and pollution (Turner, 2012). From an environmental perspective, the most intensively discussed findings concerned the long-term availability of raw materials and the development of global pollution levels (primarily regarding global greenhouse gas emissions).

Comparing this modelling approach with the concept of planetary boundaries, it becomes clear that much more detailed models are required for evidence-based scientific assessments of environmentally relevant developments. On the one hand, this concerns the number of mapped impact variables. On the other hand, verification is also required as to whether the modelling of the future dynamics of these impact variables considers all relevant cause-effect relationships to the required extent. Compared to the original World3 model, the newly designed Earth4All model makes significant progress in this respect. One of the key conceptual developments in this regard is the differentiated treatment of socioeconomic developments and their associated impacts in the context of physical planetary boundaries. The World3 model did not adequately represent fundamental economic interrelationships. However, in stark contrast to the World3 model, the Earth4All model explicitly aims to depict the evolution of human well-being by explicitly accounting (apart from climate change impacts) for development trends in concretely specified economic indicators (disposable incomes, government spending, income distribution between workers and owners). Also, the non-substitutability of raw materials as necessary inputs for industrial production processes, which was fundamentally assumed in all World3 modelling studies, is no longer considered as a limiting factor in Earth4A simulations. As a result, the modelled system dynamics change significantly. This facilitates the identification of decoupling scenarios that cannot be depicted by the World3 model.

Since the development of World3, the processing power of computers has increased to a degree that was rather unimaginable in the late 1960s.[12] Over the decades, this heightened simulation potential has been continuously harnessed by various modelling teams in the development and further refinement of assessment models. Various simulation models have become well established for environmentally relevant policy assessments. Depending on the respective scientific background of the model authors, each of them provides very detailed insights into the interplay of causal drivers involved in analyses of areas such as climate change, land use change and material flows. See, for example, Hatfield-Dodds et al. (2017) as just one example from the field of international resource policy.

If these models are already capable of mapping, monitoring, and simulating planetary boundaries, the question arises whether and to what extent the newly designed Earth4All model provides new insights in this respect. To adequately assess this question, an exchange and in-depth methodological discussion between experts from the respective modelling traditions would be necessary. The establishment of appropriate discussion formats as well as an open-minded, active participation of a variety of modelling teams should therefore be encouraged in

[12] To illustrate these developments, a prominent example notes that the processing power of the Apollo 11 Guidance Computer (which was responsible for navigating the Apollo spacecraft to the moon in the late 1960s) does fall short compared to that of processors currently employed in USB chargers (https://forrestheller.com/Apollo-11-Computer-vs-USB-C-chargers.html).

the future. This could provide noteworthy feedback to the direct supporters of the World3 approach for the further development of the Earth4All model. Moreover, it could certainly provide a general impetus towards better, more targeted cooperation between different expert groups in simulation studies of complex global environmental interdependencies.

3.2 Sustainable well-being: where do we want to grow?

The dynamics of World3 simulations may be stabilised primarily by reducing population growth and/or economic growth. Proponents of degrowth call for directly slowing down or reversing growth. However, sustained per capita economic growth is currently an official SDG target (Target 8.1). This may be particularly relevant for regions in the Global South. However, in an integrated world economy, can we even imagine degrowth for the Global North coupled with simultaneous sustainable growth for the Global South? Or would growing demand from the Global South then boost economic growth in other regions of the world? Could this growth then be decoupled from pressures on the planetary boundaries?

In the briefing “Growth without economic growth” (EEA, 2022) the authors explore whether new narratives around the concept of growth - narratives that re-examine what is meant by "growth" and "progress" in the EU - are possible:

> “In liberal societies, a multiplicity of values is cherished. The European heritage is much richer than material consumption. The fundamental values of the EU are human dignity, freedom, democracy, equality and the rule of law, and they cannot be reduced to or substituted by an increase in GDP. If there are limits to economic growth and to the current trajectory (i.e. ‘plan A’), plan B to achieve sustainability is to innovate lifestyles, communities and societies that consume less and yet are attractive to everybody and not only individuals with an environmental, spiritual or ideological interest. Plan B is extremely challenging. Economic growth is highly correlated with health and well-being indicators, such as life expectancy and education. Thanks to economic growth, the portion of the world’s population living in extreme poverty, as defined by the poverty line of USD 1.90 a day, fell from 36% in 1990 to 10% in 2015” (EEA, 2022, p. 9, citing World Bank, 2020).

The EEA briefing describes alternative schools of thought on growth that have emerged, including degrowth, post-growth, green growth, and doughnut economics. The publication “Earth for All” calls for rapid growth in the renewable energy sector and higher incomes in low-income countries. However, regarding economic growth in higher-income countries, the authors state that “generally, political leaders should be agnostic about growth” and call on political leaders and voters to focus on creating an economy that is fair, optimised to improve the lives of the majority, and where economic growth is responsible growth (p. 24).

Guiding questions for the plenary discussion:

1. How can we ensure that the results of scientific modelling are given greater consideration in politics?
2. Is addressing limits to growth and the finite nature of natural resources a useful approach to environmental policy?
3. Decoupling of well-being from environmental impacts seems to be occurring at different rates for different resources and pollutants. What are the prospects for the specific decouplings needed to stay within the planetary boundaries?

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