commentary

European Academies Science Advisory Council

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Increasing Urgency for Transformative Change

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Summary

The impacts of accelerating warming of the climate are causing much damage and loss of life in Europe and the rest of the world. At the same time, biodiversity loss continues and humanity's consumption of the planet's resources grows. There is little evidence that humanity has yet adapted its demands to the reality of a finite planet. As a result, the boundaries that maintain a safe living space for humanity are increasingly being crossed. This declining situation is despite huge expansions in 'green' technologies such as wind, solar, battery and others.

In parallel with the incontrovertible evidence, political will to address these challenges in many parts of the word appears to be waning. A chasm is thus widening between the objectively defined needs for change towards a sustainable future, and public/political willingness to take appropriate measures, with disinformation widespread and special interests skilled at propaganda and greenwashing. In this update of EASAC's 2020 Perspective on transformative change, we present a clear picture of the challenges facing humanity, the inadequacies of current measures, the growing risks, and options for more effective actions within the European Union. It is hoped that this can inform policy-makers that these issues are not overplayed and will not go away; and trigger debates and progress towards their solution.

We first summarise trends in the past 5 years (since EASAC's 2020 Perspective) on a range of key indicators.

- Trends for **climate change** are negative – emissions and atmospheric concentrations of greenhouse gases continue to rise, along with average temperatures and climate-related damage.
- The economic costs of **climate extremes** in the European Union totalled €162 billion over the past 3 years while more than 60,000 heat-related deaths occurred in Europe's 2022 summer heatwave.
- **On resource consumption**, demand has continued to rise and recycling rates decline so that now circularity in the global economy is just 7.2% (lagging behind Europe's around 50%).
- **Biodiversity** continues to decline and its future will depend very much on policies yet to be implemented.

Looking at our planet as a system, of the nine **planetary boundaries** that determine a safe operating space for humanity, six have been breached. The overall conclusion is thus that adverse trends related to planetary sustainability and long-term survivability continue. Indeed, some trends are worsening: for instance, the increases in atmospheric concentrations of carbon dioxide and methane are accelerating, while recycling rates have fallen. Warming has already triggered natural positive feedback loops that, together with the increased emissions from forest fires suggest the Earth Systems may be evolving out of human control. The resulting risks of extreme scenarios are underestimated in climate models and thus overlooked by policy-makers.

This bleak picture may appear disappointing in view of the extensive public debates, international and national commitments, new regulations and market incentives that have taken place in recent years. We look at some of these measures and conclude that they have yet to be sufficiently implemented to reverse current negative trends. **Green growth** has had some beneficial impacts, but is insufficient to address the scale of the problem. Undertakings to remove the massive **subsidies to fossil fuels** have yet to be honoured, the **fossil fuel industry** fights effectively to preserve its business, governments remain obsessed with **gross domestic product (GDP)** as a measure of success, and there is little evidence of sufficient **decoupling** of economic growth from demand for energy and resources. A similar gap between countries' commitments to reverse biodiversity loss and action is also seen.

We examine why the measures taken have had so little impact and point to the daunting obstacles that lie in the path of the transformative changes required, because they would involve systemic, synergistic, structural, political, practical, and individual changes. International studies identify barriers from legal systems, property rights and excessive consumption, the short-term political cycle, the rise of autocracy and capture of democratic processes by powerful elites. The short-term pressures of business typified by private equity and political polarisation are incompatible with the holistic and long-term approach required to transform to a sustainable economy within planetary limits. Resistance also comes from our own innate characteristics that drive us to compete, consume and resist rational action to avoid threats that are not immediate such as catastrophic climate breakdown.

What then can be done? We point out that, first, we should stop underplaying the risks of our current trajectory. The risks of catastrophic climate breakdown are extremely high compared with those we are prepared to accept in other aspects of society. Proper recognition of these should add a sense of urgency to debate; indeed, there are now rational reasons for considering the risks of societal collapse at regional and even global scales, and for better understanding how this may be avoided.

We summarise a range of policy options starting with the current economic system as its starting point. GDP should be replaced by indicators that avoid the perverse incentives that drive our economies to ever greater climate, biodiversity and resource impacts. Chief executives and shareholders should cease treating environmental and social impacts as externalities for society to address; stakeholder capitalism could be an improvement, but may not be aligned with the broader issues of biodiversity loss, global inequality or the scale of global issues such as climate change. To redesign economic and social policies to a pathway towards well-being for all within planetary boundaries, political leaders should cease the perverse target of GDP growth and ask the following questions. Is the economy optimised for resilience? Is it improving the lives of the majority? Is it perceived as reasonably fair? Does it protect our planet and the well-being of future generations?

We introduce the comprehensive lists of necessary changes that feature in international studies aimed at phasing out unsustainable activities, speeding up responsible and innovative ways of meeting human needs, and promoting social acceptance of the necessary transformations. Other approaches that introduce more radical changes are also briefly described: post-growth, de-growth and sufficiency.

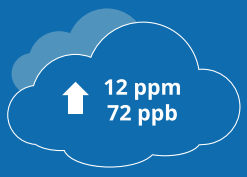
We conclude by observing that the comprehensive post-COVID policies of the previous European Commission and Parliament (2019–2024) went further to address these issues than most other countries, and thus provide a strong foundation for the current Commission and Parliament on which to build. We point current policy-makers to several areas on which EASAC has advised over recent years and which we will seek to support in our future work.

Dealing with the Planetary Crisis

5 Years of Global Negative Trends

Recycling rate down by 20.8%

Coal comsumption up 1.3 billion tonnes



Increase of CO_2 and CH_4
(CO_2 up by 3.6 ppm from 2023–24)

Biodiversity still declining

Extreme weather cost increased by €44 billion
(EU only)

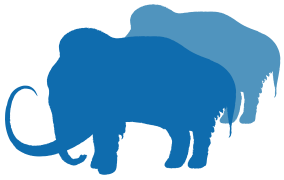
Increase of subsidies for fossil fuels 52.2% to €6.7 trillion

6 out of 9

Almost 7 planetary boundaries breached

CO_2 levels exceeding those of 3.3 million years ago

In the Pliocene, temperatures were around 3 °C hotter and sea levels were 20 metres higher



5 Policy Actions
for a Sustainable Future

Rethink economic growth: Move beyond GDP-centric growth models towards sustainability-focused well-being indicators

End harmful subsidies: Stop fossil fuel subsidies and ensure a just transition to clean energy

Promote circular economy: Improve recycling and resource efficiency to increase circularity

Protect biodiversity: Enforce stricter regulations on habitat preservation and restoration

Base policies on facts: Prioritize scientific evidence over political expediency in decision-making

1 Background

Damage to life and property are becoming ever more obvious and attributable to the extreme weather expected in a warming climate (Figure 1.1), which has led many to abandon the value-neutral term 'change' to better reflect the associated damage and risk and refer instead to climate 'breakdown', 'catastrophe', 'crisis', etc.

As damages grow, current policies appear inadequate to tackle climate and other planetary crises in biodiversity loss and material consumption, and calls for **transformative change** have strengthened within the Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES), the International Resource Panel (IRP), the Lancet Planetary Health–Earth Commission and elsewhere. As a result, EASAC Council asked its Environment Programme to update its earlier review of transformative change (EASAC, 2020) and explore policy options, with particular focus on the European Union (EU) after the 2024 elections.

2 Are current trends worsening?

Looking back on the data used in EASAC (2020), we can illustrate trends in the climate, biodiversity and resource fields by comparing some of the headline indicators that lead to concerns over humanity's future (Table 2.1).

Trends for climate change are negative: emissions and associated atmospheric concentrations continue to rise, along with average temperatures and climate-related damage. Moreover, there appear to be two positive feedback processes in the climate system operating that are aggravating global warming. The first is that higher surface temperatures are decreasing the formation of low-lying clouds, which decreases the Earth's albedo, leading to greater warming (Goessling *et al.*, 2025); the second is that the high increase in the atmospheric concentration of methane observed since 2007 is likely, at least in part, to be due to increasing natural emissions from permafrost thawing in the Arctic and higher temperatures in wetlands in tropical and subtropical regions (Zhang *et al.*, 2017; Dean *et al.*, 2018). In addition, warming in Europe is much higher than the global average[1], and the economic costs of extremes have risen with the past 3 years totalling €162 billion (Figure 2.1). Warming also has negative impacts on many aspects of human health (van Daalen *et al.* 2024), with Ballester *et al.* (2023) estimating more than 60,000 heat-related deaths in Europe's 2022 summer heatwave.

As emissions continue to rise, the natural land and ocean processes that remove carbon dioxide (CO_2) from the atmosphere become even more important. Pan *et al.* (2024) found only slight reductions in uptake of CO_2 by global forests between 2010 and 2020 compared with the 1990s and 2000s, but recent figures (Piyu *et al.* 2024) show that the amount of carbon taken up by land has collapsed, and forests, plants and soil absorbed almost no carbon in 2023. Some weakening in the oceans' carbon sink has also been reported (Hua *et al.*, 2024). This is contrary to the assumptions in climate models that removals of CO_2 by natural processes will decline only slowly as the climate heats up. With regard to the EU's target under the Land Use, Land Use Change and Forestry Regulation of 310 million tonnes of CO_2 equivalent (Mt CO_2e) net removals for 2030, current harvesting of forests for bioenergy and degradation through climate-related pest outbreaks, drought and forest fires (currently an average loss of 3.4 Mt CO_2e per year from 2017 to 2022) would need to be reversed and uptake increased to 8.3 Mt CO_2e per year if that target were to be met (Korosuo *et al.*, 2023).

Figure 1.1 Examples of recent extreme weather in the EU attributable to climate change: Valencia floods (WWA, 2024) and Greece wildfires (Jones et al., 2024). Photograph credit: istock.

[1] For instance, between 2013 and 2023, global mean temperatures were 1.19 to 1.22 °C warmer than the pre-industrial level, whereas European land temperatures increased by 2.12 to 2.19 °C. (https://www.eea.europa.eu/en/analysis/indicators/global-and-european-temperatures)

Table 2.1 Trends over recent years in some key indicators

Indicator	Date	Value	Date	Value	Trend
Atmospheric CO_2	6/2019	415 ppm	6/2024	427 ppm	↓ Negative
Atmospheric methane	4/2019	1860 ppb	4/2024	1932 ppb	↓ Negative
CO_2 emissions	2019	36.8 (energy); 4.3 (land)	2024	37.4 (energy); 4.2 (land)	↓ Negative
Coal consumption	2019	7.5 billion tonnes	2024	8.8 billion tonnes	↓ Negative
Global population	2019	7.7 billion	2024	8.2 billion	↓ Negative
Global material footprint	2017	92 billion tonnes	2022	98.5 (12.28×8.021)	↓ Negative
Resource productivity (kg/USD)	2010	1.16	2017	1.16	Unchanged
Circularity (global recycling rate)	2018	9.1%	2023	7.2%	↓ Negative
Planetary boundaries	2015	3 of 9 exceeded	2024	6 of 9 exceeded with 7th near threshold	↓ Negative
Global temperature anomaly (from 1961 to 1990 average)	2017/8	0.8	2023/4	1.14 (equivalent to 1.45 above pre-industrial)	↓ Negative
Extreme weather costs for EU	2017 and 2018	€56 billion	2022 and 2023	€100 billion	↓ Negative
Biodiversity loss		–2% to –5% per decade		Future –7% to +1% depending on assumptions and model	↓ Negative

Sources: www.NASA.gov; IRP (2024); Pereira *et al.* (2024); https://www.circularity-gap.world/2023; Global Carbon Project; Caesar *et al.* (2024); International Energy Agency (IEA). Abbreviations: USD, US dollars; CO_2, carbon dioxide; ppb, parts per billion; ppm, parts per million.

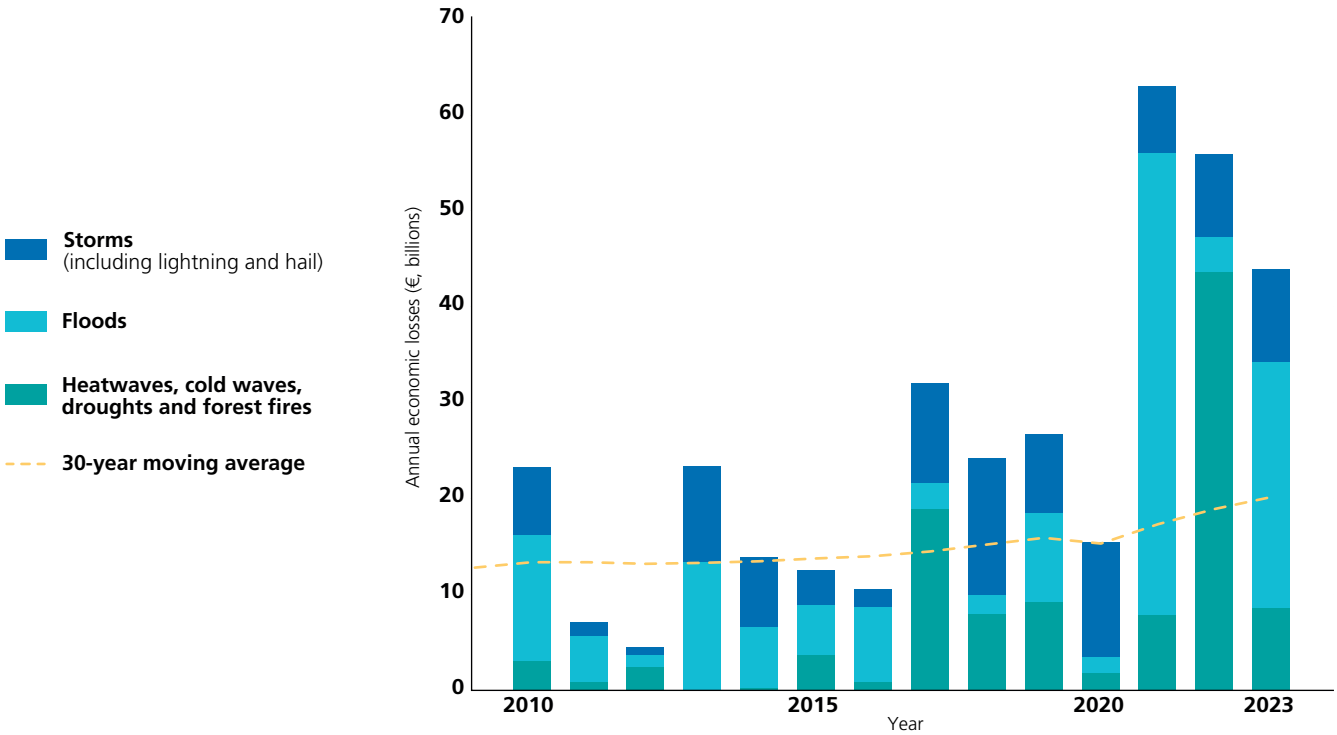


Figure 2.1 Annual economic losses caused by weather- and climate-related extreme events in EU Member States (in billions of euros, 2023 prices): EEA (2024).

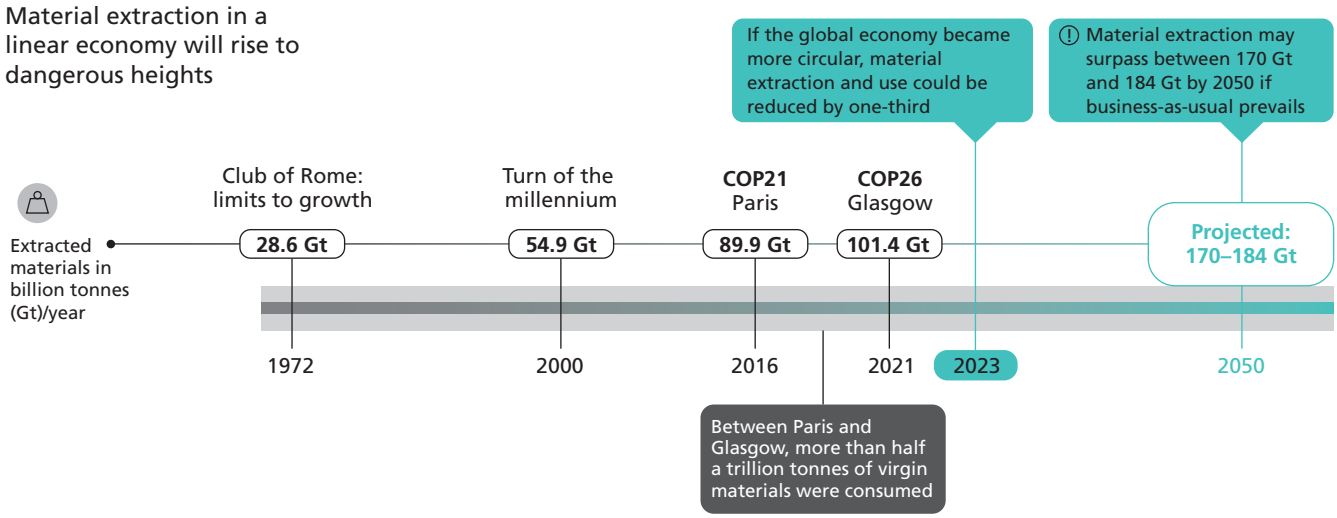


Figure 2.2 Continued growth in global material extraction (redrawn from IRP, 2024).

On resource consumption, demand has continued to rise (Figure 2.2) and recycling rates decline globally so that now circularity in the global economy is just 7.2% (in contrast to the EU's rate averaging around 50%[2]). Biodiversity continues to be threatened and future declines will depend very much on policies, with forecasted outcomes ranging from significant acceleration in biodiversity loss to some recovery.

Looking at our planet as a system, nine planetary boundaries that determine a safe operating space for humanity have been monitored since 2015, and the latest 'Planetary Health Check' (Caesar *et al.*, 2024) shows that six have breached safe levels. As shown in Figure 2.3, those transgressed are Climate Change, Biosphere Integrity, Land System Change, Freshwater Change, Biogeochemical Flows and the Introduction of Novel Entities. Only three processes remain unbreached: Ocean Acidification (increasing trend and close to its boundary), Atmospheric Aerosol Loading (decreasing global trend) and Stratospheric Ozone Depletion (no trend).

Caesar *et al.* (2024) point out that it is the relative climatic stability over the past 10,000 years that has allowed humanity to develop complex civilisations and that there are many examples of how past societies collapse when climate has shifted locally. Human impacts due to continued growth in global consumption and in population are shifting humanity away from our 'safe operating space', bringing with it more frequent extreme weather, wildfires, reduced plant productivity and water scarcity on the global scale.

Building on the planetary boundary framework, the Earth Commission (Lancet, 2024) introduced the concept of Earth System Boundaries (ESBs) to delineate a 'Safe and Just Operating Space' for humanity by including social justice. This seeks to not only preserve the Earth's biophysical systems but also to ensure equitable access to resources, and to minimise harm to humans and other living beings. Using this approach, eight ESBs have been defined of which seven have already been exceeded (biosphere functional integrity, natural ecosystem area, climate, phosphorus, nitrogen, surface water, and groundwater) while the eighth ESB (air pollution) has been transgressed at the local level. Adding the concept of Earth System justice (ensuring well-being across generations, nations and communities) has resource implications and implies that, in today's economic and social setup, even if everybody in the world were to live with only the minimum necessary access to resources, ESB would be transgressed, so that radical societal transformations and technological changes are necessary.

Caesar *et al.* (2024) point out that current climate change has been linked to 7,348 major disasters globally over the past two decades, resulting in 1.23 million deaths and USD2.97 trillion in economic losses. Decreased crop yields due to droughts and heatwaves are straining food security, while 2.2 billion people lack safely managed drinking water, and 3.5 billion lack adequate sanitation, contributing to 1.4 million deaths annually. Furthermore, 2 billion tons of waste are generated each year, with 45% mismanaged, leading to hazardous pollution and nearly 7 million deaths linked to air pollution. In 2023, 600 million people were already living outside the optimal human climate niche (Zu *et al.*, 2020). Atmospheric concentrations of CO_2 are now higher than those in the Pliocene warm period 3.3 million years ago, when temperatures were around 3 °C hotter and sea levels

[2] https://ec.europa.eu/eurostat/web/circular-economy/monitoring-framework.

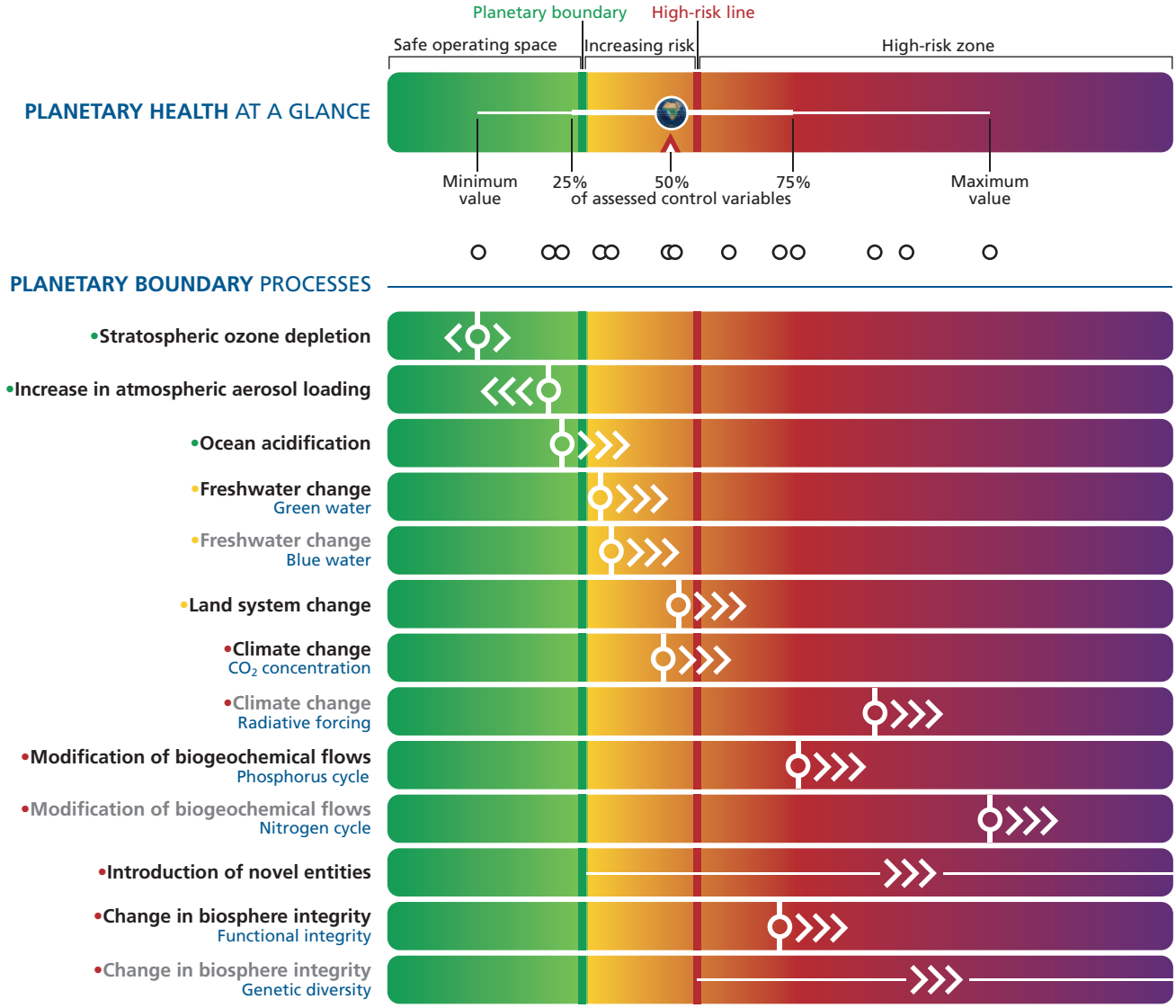


Figure 2.3 Status of the critical planetary boundaries and processes (Caesar and Sakschewski et al., 2024).

were at least 20 metres higher (de la Vega *et al.*, 2020). Ripple *et al.* (2024) conclude that '*We are on the brink of an irreversible climate disaster*'.

The overall conclusion is thus that adverse trends related to planetary sustainability and long-term survivability continue. Indeed, some trends are worsening: for instance the increases in atmospheric concentrations of CO_2 and methane are accelerating[3], resource consumption growth continues while recycling rates have fallen. Similar conclusions on worsening trends were reached in the United Nations 2024 review of progress in reaching the 2030 Sustainable Development Goals targets (UN, 2024a).

3 Are current policies effective?

Our earlier review identified some changes to the economic system aimed at making it more compatible with sustainable development and we briefly update these.

3.1 Green growth

After the COVID-19 pandemic disrupted global economic activity, there was a call in many countries to focus on 'green growth' as economies recovered (IMF, 2020)[4]. The EU launched its European Green Deal and this seemingly remains a central feature of the Commission's priorities after the 2024 elections. There

[3] The annual increment in atmospheric CO_2 levels was 0.93 for 1959/60, 1.17 for 1999/2000 and 3.3 for 2022/23, and 3.6 parts per million from 2023 to 2024. For methane it was an increase of 8.76 parts per billion in 2018 and 17 parts per billion in 2021.

[4] IMF (2020) categorized greening the economy as investing in climate-smart infrastructure (e.g. renewable energy, modernizing the electric grid, public transport, teleworking), developing and adopting climate-smart technologies (e.g. battery/hydrogen/carbon capture), supporting adaptation (e.g. flood protection, resilient roads and buildings) and avoiding carbon-intensive investments (e.g. fossil-fuel power and high-emissions vehicles).

is, however, long-standing scepticism in scientific circles about the adequacy of the concept of green growth (see, for example, King *et al.*, 2023).

The viability of green growth depends on sufficient **absolute decoupling** of economic growth from emissions and resource consumption. There is, however, little evidence of this. A recent review (Vogel and Hickel, 2023) found 11 high-income countries that achieved some absolute decoupling in CO_2 emissions between 2013 and 2019 but the rate of decoupling would have to increase by a factor of 10 by 2025 if there were to be a 50% chance of meeting the Paris Agreement 1.5 °C target. The Global Resource Outlook by the IRP (2024) saw no evidence of absolute decoupling in raw material use. Green growth policies may have a significant and positive effect on national environment and social governance performance (Niu, 2024) and on green innovation but, in itself, cannot deliver the necessary speed and scale of changes to fight climate change, biodiversity loss, pollution and health impacts. In contrast, a system-based approach is required that will cease current over-consumption and wasteful use of natural resources, and aim to decouple **well-being** and economic development from natural resource or materials use and environmental impacts (IRP, 2024).

While technology may be seen as a future solution, the role of technology and innovation in decoupling is ambivalent. On the one hand, improving the efficiency with which resources and energy are used contributes to decoupling, but on the other hand new technologies such as cryptocurrencies and artificial intelligence create new markets and demands on energy and resources. The overall impact can thus be negative.

3.2 Fossil fuel industry

Subsidies for the production and use of fossil fuels have been repeatedly subject to international agreements to remove them (e.g. at COP26 of the United Nations Framework Convention on Climate Change). Despite this, the International Monetary Fund (IMF) calculates that the USD4.6 trillion of subsidies in 2017 rose to USD7 trillion in 2022. As pointed out in CFMCA (2024), the surge in global energy prices since the Russian invasion of Ukraine and other geopolitical tensions have led to governments increasing subsidies. Dasgupta *et al.* (2021) pointed out that fossil fuel subsidies are only one example of environmentally harmful subsidies and that it is still the norm to subsidise unsustainable practices and private finance in other fields such as transport and agriculture.

There is a widening gap between what is required to mitigate climate change and **real actions in the fossil fuel sector**. The IEA warned in its net-zero roadmap (IEA, 2023a) as did the Intergovernmental Panel on Climate Change (IPCC) (IISD, 2022) that no new coal, oil and gas development is possible if the world is to stay with Paris Agreement temperature limits; yet oil companies have continued to invest in new exploration and resource development, receive approvals from governments and finance to do so. IEA (2024a) estimates that around USD860 billion is expected to be invested in oil and gas supply in 2024, with around USD165 billion to be spent on coal, in direct conflict with a net-zero pathway. Fossil fuel companies remain committed to a massive global expansion of oil and gas production with capacities that greatly exceed the amounts of CO_2 that can be discharged while complying with the Paris Agreement (Kühne *et al.*, 2022). Following the change in the US Presidency, exploration may expand into previously restricted areas in the Arctic.

IEA (2023b) also noted that oil and gas producers are making little contribution to the world's transition to a clean energy system, accounting for only 1% of total clean energy investment globally. Combined with the growth in subsidies, the industry continues to be embedded in an unsustainable path that public policies appear unable to significantly change. Indeed, the oil industry has long sought to counter threats to its profitability by undermining climate science and policy responses (see, for example, Supran and Oreskes, 2022) and is now positioning itself as essential to solving the climate crisis (Mavelli, 2025), seeing the climate crisis as a business opportunity that justifies additional public expenditure on technologies such as carbon capture and storage to allow its business to continue. This is part of a wider reluctance by companies to change historical business paradigms: Censi *et al.* (2023) found that of more than 4000 major international companies, the emissions pathways of most were misaligned with Paris targets, and only 4% were even disclosing their emissions in line with the industry's Task Force on Climate Disclosures.

3.3 Replacing GDP as a measure of progress

The use of GDP in managing the economy and in pursuing its growth encourages unsustainable development due to its excluding social costs, income inequality, environmental impacts, loss of natural capital and impacts on global and regional ecosystems (including climate). Recognising this, the European Commission started the *GDP and Beyond: Measuring Progress in A Changing World* initiative (EC, 2009) to explore alternative indicators (e.g. the Index of Sustainable Economic Welfare and the Genuine Progress Indicator (GPI))[5].

[5] See Corlet Walker and Jackson (2019) for an analysis of GDP alternatives.

Since the EASAC (2020) review, Genuine Progress Indicator measurements have been trialled in some US states and Canadian provinces as well as in Australia but have not replaced GDP as the primary political measure of 'success' or 'failure'. Some countries have started to measure 'well-being' or 'quality of life' that considers other indicators from health, education, and the environment, but New Zealand was the first country to link that to budgetary decisions (Andersen and Mossialos, 2019). The New Zealand 'Living Standards Framework' comprises 38 indicators, which sit across 12 domains of well-being. Because of the link to budgetary decisions, the indicators gain political weight and attention.

Research continues on replacing GDP: for instance, Fox and Erickson (2020) examined the sensitivity of the Genuine Progress Indicator to its components and assumptions in 50 US states, while Van der Slycken and Bleys (2023) compared GDP in the EU with Index of Sustainable Economic Welfare calculations between 1995 and 2017. Both found a disconnect since around 2010–15 when the rise in GDP per head was no longer mirrored in the welfare indicator. On the other hand, in China, Guan *et al.* (2021) conducted a Genuine Progress Indicator survey at the household level and generally found it increasing in line with GDP.

GDP still remains the headline indicator against which the performance of economies is assessed, and political priorities set, and the negative social and environmental effects of economic development continue to be excluded, despite the 2023 UN General Assembly establishing a core priority for countries to move beyond GDP to a measure that '*integrates human well-being, natural capital and sustainable economic development*'.

3.4 Discount rate

EASAC (2020) pointed to the discount rate used in cost–benefit analysis as influencing whether proposals for expenditure now to achieve benefits in the future are seen as justified in economic terms. High discount rates mean that avoiding even catastrophic or existential threats decades in the future has little present value[6].

Dasgupta (2021) argues that the well-being or interest of future generations should be taken fully into account alongside the interests of the present generation, which argues for a low or even zero discount rate when evaluating investment proposals for combatting climate change or preserving biodiversity. There is as yet little evidence of such recommendations being applied by governments (see, for example, Schoenmaker and Schramade, 2024), despite studies (Kotz *et al.*, 2024) that show that climate damages from now to 2050 are six times the mitigation costs required to limit global warming to 2 °C.

3.5 Pricing carbon

Taxes or equivalent market mechanisms to put a price on carbon have been EU policy since 2005 through the Emission Trading Scheme. A recent meta-analysis of the effectiveness of carbon pricing (Döbbeling-Hildebrandt *et al.*, 2024) did find immediate and substantial emission reductions in 80% of the policies studied. Carbon pricing thus remains an important tool that could be much more effectively applied, although questions remain whether policy-makers can overcome political barriers and raise carbon prices high enough to deliver emissions reductions at the scale and pace required. Some sectors such as aviation and shipping remain outside pricing schemes and are recommended by the IMF (2024) as early targets for inclusion.

A further means of pricing carbon is through carbon credit mechanisms such as the Clean Development Mechanism established under the Kyoto Protocol and used by many companies and governments to offset their emissions; this mechanism claims removals of 5 billion tons of CO_2e and a market value of €881 billion in 2023 (https://www.statista.com). Their widespread application has been subject to considerable scepticism with a recent study (Probst *et al.*, 2024) finding that less than 16% of the carbon credits issued constituted real emission reductions in the projects they investigated. COP29 adopted new rules on carbon crediting mechanisms but their effectiveness in achieving real reductions in CO_2 and other GHG emissions will depend on technical factors yet to be established.

3.6 Biodiversity

Recognition of the role of nature in human well-being and survival led to the Kunming-Montreal Global Biodiversity Framework in 2022 at COP15 of the Convention on Biological Diversity; this aims to ensure by 2030 that 30% of land area is effectively conserved and managed. Countries agreed to submit new National Biodiversity Strategy and Action Plans by COP16 but only 25 of 195 countries submitted these by the deadline.

The Lancet (2024) review defined an Earth System Boundary for the global land surface that should be largely intact to halt species extinction, secure biosphere contributions to climate regulation and stabilise regional water cycles. By 2018, the area of intact natural land was approximately 15% below this. Ensuring the

[6] The sensitivity of discount rate assumptions can be illustrated by the US Government Interagency Working Group on the Social Cost of Carbon using a 3% discount rate for all future climate damages, to set a USD40/ton of CO_2 cost. As reported in EASAC (2020), Nordhaus used a discount rate of 4% to suggest USD20/ton while Stern used 1.4% to give a price of over USD80 per ton of CO_2.

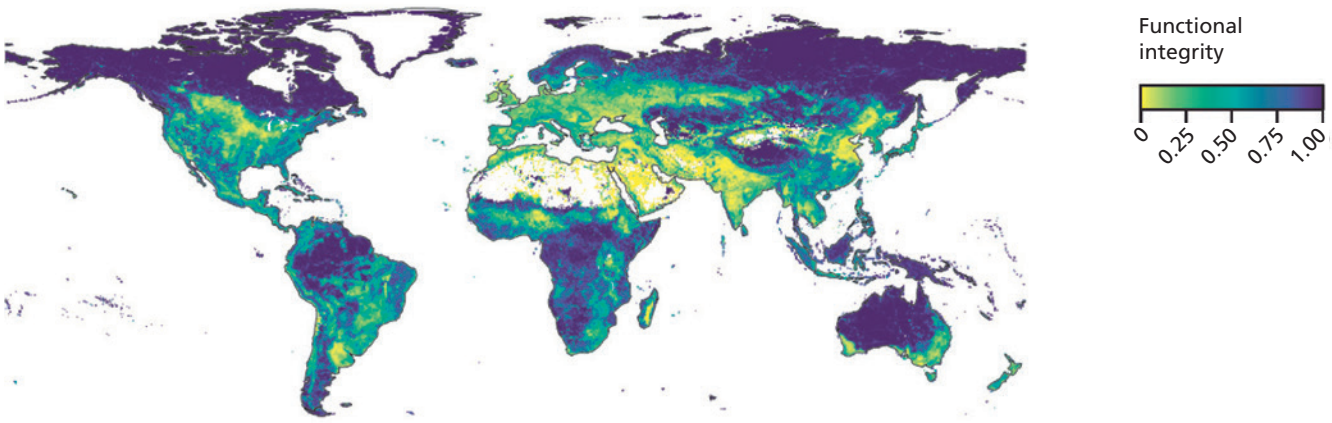


Figure 3.1 Biosphere functional integrity for natural and human-modified lands (Lancet, 2024).

maintenance of Nature's Contribution to People[7] in areas that had already been converted for human use (agriculture, cities, etc.), also necessitated at least 20%–25% of natural or semi-natural habitat per square kilometre. As can be seen from Figure 3.1, billions of people live in areas with less than 20%–25% functional integrity and already exceeding these boundaries.

Global coverage of protected and conserved areas has now reached 17.6% of terrestrial and inland waters and 8.4% of marine and coastal areas (UNEP, 2024). This reflects some progress in increasing the coverage of protected and conserved areas, but this must be accelerated considerably if the 30% target is to be met by 2030.

The above brief overview of some policy responses to the challenges in section 2 points to a lack of progress towards a sustainable future for humanity. The next section considers some of the reasons for this.

4 Obstacles to change

The current situation where negative trends have yet to be stabilised let alone reversed, strengthens calls for transformative change involving systemic, synergistic, structural, political, practical, and individual changes. Or as described by IPBES (2024), as fundamental system-wide shifts in **views**—ways of thinking, knowing and seeing; **structures**—ways of organising, regulating and governing; and **practices**—ways of doing, behaving and relating. Such changes would challenge 'business as usual' that has evolved over centuries and given rise to current legal and regulatory systems, and many barriers to challenging the status quo are to be expected: some overt and some hidden within rules or behaviours that have developed over decades.

IPBES (2024) assign such barriers to (1) relations of domination over nature and people; (2) economic and political inequalities; (3) inadequate policies and unfit institutions; (4) unsustainable consumption and production patterns including individual habits and practices; and (5) limited access to clean technologies and uncoordinated knowledge and innovation systems. Many more actions and resources are devoted to blocking transformative change (such as lobbying by vested interest groups) than those devoted to the conservation and sustainable use of biodiversity.

Lancet (2024) cites barriers to be overcome if change is to be transformative as:

- Legal barriers (e.g. long contracts that guarantee access to resources without attention to environmental protection).
- Property rights that convert common lands to private ownership.
- Political and institutional barriers from short-term political cycles and polarisation of social and environmental issues.
- Autocracy and powerful elites control elections, repress unions and punish protest.
- Excessive personal consumption being encouraged while pollution costs are externalised.
- Shifts to lower-carbon energy systems being undermined by the risk of stranded assets and effects on powerful interests. Current subsidies to sectors such as fossil fuels, extractive industries and fishing are huge and strongly protected.

[7] These include pollination, pest and disease control, water quality regulation, soil protection, natural hazards mitigation, climate and recreation.

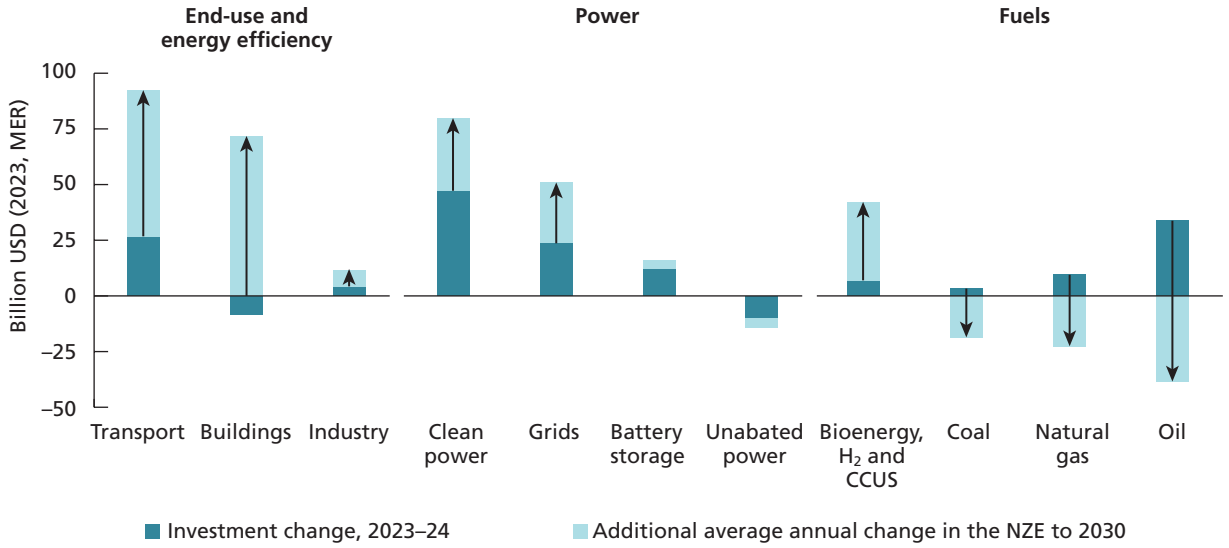


Figure 4.1 Investment changes in 2023–24 and changes required to comply with the IEA net-zero scenario (IEA, 2024b). Abbreviations: CCUS, carbon capture, utilisation and storage; MER, market exchange rate; NZE, net-zero emissions.

Major wealth owners may resist the taxation needed to fund public services and public investments, yet these higher-income groups dominate CO_2 emissions (Nielsen *et al.*, 2021) with the richest 0.1% of the world's population emitting 10 times more than the rest of the richest 10% combined, exceeding a carbon footprint of 200 tonnes of CO_2 per head annually (Chancel, 2022). Private jet flights continue to increase with the resulting CO_2 emissions rising by 46% between 2019 and 2023 (Gössling *et al.*, 2024).

Recent years have seen an increase in short-term pressures incompatible with the holistic and long-term approach required to transform to a sustainable economy within planetary limits. For instance, Private Equity is estimated to control more than USD13 trillion invested in more than 50,000 companies worldwide (Ballou, 2023). Their primary business model of leveraged buyouts places short-term wealth extraction to reward investors and the new management in potential conflict with longer term sustainability. Accordingly, companies taken over by private equity go bankrupt at 10 times the rate of publicly owned companies (Alvin and Wong, 2024); this business model is dependent on national governments maintaining preferential tax treatments and allowing avoidance of liability for their portfolio companies' debts, and is thus a political choice.

Although investment in clean energy projects has risen sharply, growing at an average rate of 6.3% per year from 2020 to 2023, financial institutions continue to invest in the 'brown' economy: direct finance to new fossil fuel plants still slightly outstripped investments in clean power generation in 2023, reaching USD33.4 billion (Climate Policy Initiative, 2024; IEA, 2024a). The 'exnovation' (Heyen *et al.*, 2017) seen in the phase-out of some coal-fired power in some countries has yet to spread to a deliberate phase-out of all unsustainable technologies, products, and practices. IEA (2024b) point to the major difference between current decisions in fossil fuel industries and those needed to move towards net zero, as shown in Figure 4.1. IEA also point to sustainable finance falling by 25% on 2021, while voluntary moves by the finance sector to green its operations appear to be reversing with the withdrawal of major US banks from the Net Zero Banking Alliance. Moreover, investments in fossil fuels remain high, even in banks that portray themselves as 'environmentally conscious' (CEPR, 2023). Such limited responses may reflect the inherent limitations of shareholder capitalism in addressing 'externalities' such as climate change and biodiversity loss (section 5).

These are just some illustrations of how the global economy remains driven by underlying forcing factors that impede transformation of the economy; many more examples in other sectors are found in Lancet (2024) and IPBES (2024).

While most studies concentrate on reforming economic systems, attention is also turning to the innate characteristics of individual citizens in post-industrial societies. Santos *et al.* (2024) identify six characteristics that work against rationale action to avoid catastrophic climate breakdown: (1) the dopaminergic reward system; (2) time discounting in intertemporal decisions; (3) human-nature interconnectedness; (4) self-interest and utility; (5) cooperation and free-riding; (6) international geopolitical and geo-strategic relations. All have evolved over millennia and have contributed to human prosperity and well-being when humanity's impact on the planet was small. These characteristics, however, now act as barriers to adapting to the

existence of planetary boundaries. A similar approach by Merz *et al.* (2023) sees individuals as having evolved to seek pleasure and avoid pain; work to acquire resources from competitors; display dominance, status or sex appeal; as well as a tendency to procrastinate rather than act in the absence of immediate threats to survival. Merz *et al.* point to the economic system exploiting these characteristics to create burgeoning demand, driving increased consumption, and the marketing industry as needing to redirect its expertise to help shift social norms relating to reproduction, consumption and waste. Costanza (2023) draws an analogy of society's dependence on fossil fuels with an individual's drug addiction where it is rarely effective to directly confront an addict concerning the damage they are causing to themselves and to others.

How to resolve such fundamental disconnects between drivers of individual behaviour and a sustainable future is an active research topic for sustainability and behavioural scientists. Addressing such basic human characteristics is particularly difficult in democracies since the transformations can be easily portrayed as threatening fundamental rights or principles leading to populist resistance to change. A key concept under discussion is that of leverage points for societal transformations such as reconnecting people to nature, restructuring institutions (Abson *et al.*, 2017), environmental governance, mainstreaming green behaviours, finance and taxation (e.g. ERC, 2024) and indigenous knowledge (IPBES, 2024).

5 Considering the future

Policy-makers face formidable challenges in addressing the trends described above, so in this section we present evidence that the risk of ineffective policy responses is great, and that alternative models to the status quo are under active research.

5.1 Assessing the real risks

Policy responses to the negative environmental trends described above are generally based on median projections of the various expert bodies (IEA, IPCC, etc.), yet in most other areas of society (human health, property values, insurance, etc.) policies are based on avoiding worst-case risks. Climate model projections of temperature rise show probabilities tailing off slowly after the median value so that high-impact extreme outcomes remain a risk that would be regarded as high in other fields. For instance, Wagner and Weitzman (2015) pointed out that, under one scenario, a 3.4°C median warming was associated with a 10% risk of temperatures exceeding 6°C, an existential threat. Such extreme risks may be ignored by policy-makers in contrast to risk-based industries such as insurance where a 10% risk of total loss would be unacceptable. The uncertainty above has been reduced to an extent since (Gillett, 2024) but uncertainties still surround the basic question of climate sensitivity where the IPCC 2021 assessment found an 18% probability that a doubling of CO_2 levels would lead to more than 4.5°C warming. A recent analysis by Ricard *et al.* (2024) re-examined the probabilities of different climate sensitivities and found that catastrophically warm predictions are more plausible than previously thought, a concern supported by findings that regional heatwaves are currently outpacing climate model simulations (Kornhuber *et al.*, 2024). The precautionary principle would argue that such outcomes should be overtly considered by policy-makers.

Climate 'trigger points' form a critical role in scenarios of rapid or catastrophic climate change and are already in motion: the Arctic tundra now emits more carbon than it stores (NOAA, 2024), carbon loss due to intense droughts and fires in the Amazon and Boreal forests, accelerating ice melt in Greenland and Antarctica[8], and the most recent finding that the natural carbon sink capacity has suddenly fallen. There are also means through which crossing one tipping threshold increases the likelihood of tipping another ('tipping cascade'; Klose *et al.*, 2021). There is thus a risk that the previous targets for achieving climate stability (currently being substantially missed) may be inadequate as natural positive feedbacks in the Earth System are awakened.

A further example of underestimating risk comes from the short-term recording of extreme weather impacts, generally measured in terms of immediate fatalities and damage estimates. These may, however, be just a fraction of the long-term consequences. For instance, in the case of tropical cyclones, Young and Hsiang (2024) found that the complex chains of events that were triggered by the disaster itself led to additional mortality persisting for 15 years; the average of 24 immediate deaths in government statistics proved to be huge underestimates to the ultimate 7,000–11,000 excess deaths that could be traced to the after-effects of the original disaster.

This is leading some to research probabilities and mechanisms of global societal collapse through second- and third-order effects of warming such as crop failures that lead to starvation, mass migration and intra- and interstate conflict (see, for example, Kemp *et al.*, 2022; Steel *et al.*, 2022). On the specific role of forests, Bologna and Aquino (2020) developed a model on rates of deforestation, population growth, resource consumption and technological growth, which indicated a less than 10% probability of society surviving without facing a catastrophic collapse by 2100. Cotton-Barratt

[8] See EASAC (2022a) and Armstrong *et al.* (2022) for a review of tipping points.

et al. (2020) looked at a range of possible drivers of human extinction, postulating a high risk of human extinction by 2100.

Steel *et al.* (2022) see collapse resulting from direct impacts of warming on rising sea levels, drought, flooding, extreme heat, etc. undermining agriculture, water availability, and other essential bases of civilisation. These add to pre-existing socio-political stresses triggering actions such as bans on food exports or warfare, which spread destabilisation, ultimately leaving global society vulnerable to collapse. Richards *et al.* (2021) discuss the pathways to societal collapse through climate change and food insecurity. Beard *et al.* (2021) develop an analytical framework to help explore climate change's contribution to 'Global Catastrophic Risk', while Kemp *et al.* (2021) propose a research agenda to allow an 'integrated catastrophe assessment' to be done. A review of the growing literature on social collapse is found in Brozovics (2023).

Responding to such alarming scenarios through transformative change is hampered by the inherent difficulty for the current energy-dense globalised industrial society to break away from fossil fuel dependence (Gunn *et al.*, 2019) and the perverse result that the required changes and societal impacts generate populist resistance that may overwhelm the advocates for transformative change. As Scranton (2015) observes, for this reason, humanity continues to feed the system that burns fossil fuels at increasing rates despite the strengthening evidence of the ultimate threat to its existence.

5.2 Alternative economic models

The conventional economic model offered today is still founded on the basic principles developed from the 19th century, when the world population and economy was a fraction of what it is today (what Herman Daly described as an 'Empty World'). Today we live in a 'Full World', yet nature and the environment are still outside the basic economic model and the adverse effects treated as 'externalities' that now include the existential threats of climate change, ecosystem decline, biodiversity loss and water scarcity. Many books have been written on shareholder capitalism and how to moderate corporations' raison d'être to create value for its shareholders and leadership by treating environmental and social impacts as externalities for society to address; and on the degree to which the fiduciary duty of executives should consider long-term external impacts of their businesses (see, for example, Park, 2015). Alternatives such as stakeholder capitalism (Beck and Ferasso, 2023) have been proposed to consider employees, suppliers, communities, customers and other stakeholders. However, stakeholders' interests may not be aligned with the broader issues of biodiversity loss, global inequality or the scale of global issues such as climate change, leading to calls for more fundamental changes or redesigns of economic systems[9].

The degree of challenge can be judged from studies (Fanning *et al.*, 2022) that show that no country meets the basic needs of its residents at a level of resource use that could be sustainably extended to all globally. Indeed, across more than 140 countries from 1992 to 2015, the number of countries overshooting biophysical boundaries increased from 32%–55% to 50%–66%, with improvements in just 5 of 11 social indicators[10]. 'Business as usual' projections to 2050 showed that current trends will only deepen the ecological crisis while failing to eliminate social shortfalls, and that deep transformations are needed to safeguard human and planetary health. A range of solutions are proposed.

5.2.1 Working within current socio-economic systems

Dixson-Declerve *et al.* (2022) describe an Earth System model that can test/validate different policy options and distinguish between a baseline scenario, where political dysfunction and perpetual crises deepen, and transformative change that effectively addresses poverty, inequality, gender inequality, food systems and energy. They consider how to redesign economic and social policies to a pathway towards well-being for all within planetary boundaries. Instead of a focus on economic growth, political leaders should instead ask the following questions. Is the economy optimised for resilience? Can it become independent of economic growth? Is it improving the lives of the majority? Is it perceived as reasonably fair? Does it protect our planet and the well-being of future generations? Does it help deliver the prime goal of a state: to keep citizens safe and secure over the long term? Are we measuring and valuing the right things?

Comprehensive lists of necessary changes feature in IPBES (2024), Lancet (2024), IRP (2024) and aim at phasing out unsustainable activities, speeding up responsible and innovative ways of meeting human needs, and promoting social acceptance of the necessary transitions. Both supply and demand sides have to be addressed. IPBES (2024) sets out five strategies from the perspective of biodiversity (Table 5.1).

IPBES (2024) do see the possibility of transforming economic and financial paradigms so that they

[9] EPRS (2023) provided a comprehensive overview of these issues in the EU context.
[10] Those improving included life expectancy and educational enrolment, while worsening indicators were social support and equality.

Table 5.1 IPBES' five strategies towards transformative change

Strategy	Description
1	Conserve, restore and regenerate places of value to people and nature that exemplify biocultural diversity.
2	Drive systematic change and mainstreaming biodiversity in the sectors most responsible for nature's decline: the agriculture and livestock, fisheries, forestry, infrastructure and urban development, mining and fossil fuel sectors.
3	Transform economic systems for nature and equity: including internalising environmental costs and redefining goals, metrics and indicators to include social, environmental and nature values.
4	Transform governance systems to be inclusive, accountable and adaptive.
5	Shift societal views and values to recognise and prioritise human-nature interconnectedness and adjust social norms on consumption, well-being, etc.

Table 5.2 Action towards sustainable resource use (IRP, 2024)

1. Global and national institutionalisation of resource use in sustainability agendas and environmental agreements.
2. Defining global and national resource use paths.
3. Internalising the environmental and social costs of resource extraction.
4. Redirecting, repurposing and reforming public subsidies for sustainable resource use.
5. Channelling private finance towards sustainable resource use.
6. Incorporating resource-related risk into public and central bank mandates.
7. Trade governance for fair and sustainable resource use.
8. Enabling local resource value retention in producer countries.
9. Developing action plans to improve access to affordable and sustainable goods and services.
10. Raising awareness and regulating marketing practices that lead to over-consumption.
11. Setting up monitoring and evaluation systems to establish priorities and developing ambitious circular economy action plans.
12. Developing and reinforcing regulations to boost circular economy business models.
13. Building circular economy capacity and coalitions.

prioritise nature and social equity over private interests. But this would require fundamental changes so that international agreements would be required to curb unsustainable consumption and production in global supply chains; to downscale production and consumption, particularly in high-income countries and by high-consumption actors; and to focus on cultures of sufficiency and governance (such as increased taxes or fines on environmentally harmful activities and binding regulations on pollution and ecosystem protection).

IRP (2024) calls for vastly increased efficiency by which natural resources are used, a redistribution of wealth and access to resources between rich and poor (both individuals and countries) and avoiding the rebound effects that have resulted from many previous improvements in productivity. Well-being should become the objective across all policies (as opposed to consumption) with specific actions listed in Table 5.2. Similar aims are to be found in the idea of 'regenerative capitalism' (Fullerton, 2015).

Critical to a redirection of the current economy is the replacement of GDP as a measure, and its growth as a political objective (section 2.3). Evidence continues to mount on the inability of GDP-based policies to deliver on societal and environmental needs. For example, almost two-thirds of all new wealth since 2020 has been captured by the richest 1% (Oxfam, 2023). Its failure to encourage actions that address health and environmental issues in the food industry is also demonstrated (FOLU, 2021), where current economic signals drive unhealthy and environmentally damaging practices that incur huge costs on society that are avoided by the industry. As recommended by the European Economic and Social Committee (EESC, 2019), a **well-being** economy would protect ecosystems, conserve biodiversity and deliver a just transition to a climate neutral way of life; it would not depend on GDP growth and would align taxation, subsidies and other policies with the goal of achieving a just transition to a well-being economy.

In encouraging transformative change, it is also recommended to seek long-lasting positive synergies between human and biophysical systems, integrating insights from social and natural sciences (Otto *et al.*, 2020; Tabara, 2023; Eker *et al.*, 2024). For instance, pricing policies and targeted investments that bring clean technologies below the threshold of cost-parity with fossil fuels (Sharpe and Lenton, 2021). Other system thinking and approaches have been analysed for food and land use (FOLU, 2021) and for reaching net zero by 2050 (Systemiq, 2023). The concept of 'Provisioning-systems' is also potentially useful in understanding and identifying solutions that transform the way human needs are met with much lower demands for resources and energy. (Fanning *et al.*, 2020; Schaffartzik *et al.* 2021). Such systems approaches can identify less resource-intensive ways of providing actual needs. For example, electrifying vehicles may seem an effective way of reducing emissions from the transport sector but is associated with large

material demands as well as the need to provide the road infrastructure. Using a provisioning-systems perspective could promote solutions such as improving public transport or reducing the need for transport by designing and developing more condensed urban centres, enabling telework and telehealth services (IRP, 2024).

Current system failures persist despite bodies such as the World Economic Forum (2020) pointing to the dependency of over half of the world's GDP on nature and its services, and that transformative changes offer more than USD10 trillion in business and 395 million jobs globally by 2030. Resistance to change in current economic systems is illustrated by fossil fuel companies showing little sign of using their recent high returns to speed diversification away from their main businesses (for instance to existing renewables such as solar or wind, or to new energy sources such as geothermal or natural hydrogen). Whether the necessary changes can be delivered through current systems is still questioned; indeed some (e.g. Holgerson, 2024) point to capital's flexibility in both causing environmental damage and repairing it, and that activities that destroy nature remain profitable and have little difficulty in finding investors. There is thus much debate on fundamentally different approaches.

5.2.2 Degrowth Beyond or Post (Agnostic-) growth

EASAC (2020) introduced some economists' attempts to integrate longer term environmental issues into the economic system, and to stay within planetary boundaries (e.g. 'doughnut economics'; Raworth, 2018). Such economic literature has expanded with many studies and books on degrowth or post-growth economic models (see Weidmann *et al.* (2020) for an overview). The economic degrowth debate is already into its 'Tenth International Degrowth Conference' with its strong focus on advancing human and environmental well-being, promoting cooperation, democracy, inclusiveness, transparency and solidarity. Focusing on degrowth reflects concerns that the current economic structure that rewards short-term profits and growth are fundamentally incapable of adjusting to the constraints required to stay within planetary limits.

Degrowth may be seen as in direct conflict with every political objective of the past 150 years (Van den Bergh and Kallis, 2012). Post-growth mainly argues in favour of growth independence. A-Growth and Beyond Growth seek to secure the well-being of people and nature regardless of economic growth, for instance as discussed in the Beyond Growth conference hosted by the European Parliament in May 2023 (Table 5.3).

Table 5.3 Aims of the Beyond Growth Conference 2023

1. What narrative is needed to guide progress towards a European Union that aims to prosper, rather than to grow?
2. What policies and indicators are needed to build a society that focuses on satisfying the well-being of its citizens while respecting planetary boundaries?
3. What governance structures are needed to deal with today's interlinked environmental, social and economic challenges and ensure that all policy areas contribute to the EU's common objectives?
4. How to address inconsistencies between existing EU policies and a European post-growth economy agenda, and how to realign priorities accordingly?

In support of the post-growth paradigm, ecological economists point out that advanced economies have found it very difficult to maintain annual increases in GDP (secular stagnation), and have resorted to ultra-low interest rates and huge injections of central bank money. Instead of chasing growth for the sake of it, developed economies should stop growing to allow the world to live within its environmental means and leave enough resources for the poorest countries to develop. Such a post-growth (OECD, 2020; EEA, 2021, Likaj *et al.*, 2022) policy would focus on society's paramount objectives, which in the richer countries should be environmental sustainability, improved well-being, declining inequality, and greater economic resilience.

Hickel *et al.* (2020) advocate that wealthy economies should abandon growth of GDP as a goal, scale down destructive and unnecessary forms of production to reduce energy and material use, and focus economic activity around securing human needs and well-being. This means scaling down destructive sectors such as fossil fuels, mass-produced meat and dairy, fast fashion, advertising, cars and aviation, including private jets. At the same time, there is a need to end the planned obsolescence of products, lengthen their lifespans and reduce the purchasing power of the rich. A green jobs guarantee is advocated. Instead of prioritising the short-term financial interests of shareholders, companies should prioritise social and environmental benefits and take social and ecological costs into account.

Scientists increasingly recognise the need to explore post-growth pathways. To advance the science, the European Research Council has a comprehensive research portfolio (ERC, 2024) related to transformative change with 300 projects related to rethinking economic, food, or energy systems[11].

[11] For example, the REAL project seeks to better define post-growth pathways to achieve dramatic reductions in energy and resource use, while at the same time ending poverty and ensuring decent lives for all; https://www.realpostgrowth.eu/

Pathways towards post-growth require radical shifts. The key is to complement the prevailing efficiency approach with demand reduction on a wide scale, directly address over-consumption, wasteful and resource-inefficient practices, and stop less-necessary or harmful forms of production. Sectors with high pollution levels, such as fossil fuels, fast fashion and industrial agriculture, may generate financial value, but they erode ecological and social values, subtracting from (future) wealth. There is thus an urgent need for economic and neighbouring sciences to redesign economies to cope with zero or negative GDP growth.

An element of the debate on growth is the concept of **'Sufficiency'**, defined by the IPCC as '… *practices that avoid the demand for energy, materials, water and land while providing well-being for all within planetary boundaries*'. As Fletcher *et al.* (2024) state, humanity needs to end values and habits that destroy the Earth and replace with new ones that can navigate the future more wisely; by addressing the root causes of sheer numbers, mindless individualism, profiteering and competition. A Sufficiency Manifesto was published in 2023 by 75 European organisations and research institutes that urged the EU to make the idea of sufficiency one of the cornerstones of its policies (EEB, 2024). The term is also relevant to a recent report (UN, 2024b) which recommends a policy of reducing the production of what is not needed on the basis of sufficiency and human rights principles, in contrast with current practice of what they term 'growthism'. IRP (2024) stress that the long-term goal has to be an economy where **sufficiency** is at the core.

Then a critical question becomes to define the level of biophysical resource use that will meet the basic needs of all people on the planet without exceeding critical planetary boundaries. As yet, EU policies on energy and climate have not sought to include the concept of sufficiency in energy (Zell-Ziegler *et al.*, 2021) despite its featuring in 39% of citizen assembly recommendations on energy and climate plans (Lage *et al.*, 2023).

6 Building on the EU's leading position

While the philosophical debate continues, it is worth noting that the EU has recognised many of the above issues in its legislative programmes and has developed a comprehensive strategy that is leading by world standards. The Climate Law, 'Fit for 55' and 'Farm to Fork' packages aim for adjusting socio-economic systems, namely the mobility, food, manufacturing, housing and energy systems to reduce climate impacts. The circular economy packages aim to improve Europe's resource productivity and reduce waste, while the Sustainable Finance Initiative aims to strengthen environmental, social and governance disclosures and increase the availability of green finance.

Drawing on previous EASAC studies (science-advice-europe.eu), we present in Table 6.1 a list of policy options that would strengthen the EU's contribution to transformative change while at the same time reflecting current concerns over competitiveness and security. EASAC will continue to support Europe's policy-makers in addressing these challenges.

Table 6.1 Policy options for the EU that contribute to transformative change

Policy	Action	Benefit
Circular economy	Strengthen to increase recycle rates, especially, plastics and critical materials. Extend product life and deter obsolescence. Encourage preferential use of secondary over virgin materials.	Greater resilience and security in supply to the EU economy; reduced material consumption.
Emission reductions	Maintain Fit for 55 strategies but ensure measures make real contributions to reducing atmospheric levels of greenhouse gases.	Avoid perverse and costly technologies such as bioenergy/BECCS, and hydrogen from fossil fuels.
GDP replacement	Decide an alternative indicator and apply.	Reduce dependence on GDP and its growth as a perverse and simplistic political objective with one for the well-being economy.
Carbon pricing	Strengthen and expand its application and apply levels compatible with carbon targets. Ensure carbon credit schemes achieve their objectives.	Key means of achieving climate targets but needs border adjustment on imports failing to apply equivalent measures.
Nature restoration	Support implementation in Member States of the Nature Restoration Law. Move economy from being extractive to regenerative.	Achieves commitments to the Convention on Biological Diversity. Improved ecosystem services to support well-being through pollinations, air and water filtration, reduction of natural hazards, etc.
Fossil fuel subsidies	Eliminate.	Precondition for phasing out over-consumption of fossil fuels.

Table 6.1 Policy options that contribute to transformative change (continued)

Policy	Action	Benefit
Other environmentally harmful subsidies	Remove incentives for unsustainable practices in transport, spatial development, agriculture, etc. Stronger application of the 'polluter pays' principle.	Better direction of market forces towards societally beneficial outcomes and more effective use of public finances.
Fossil fuel industry	Stimulate industry cooperation and action to reduce emissions; work with IEA.	Instead of opposition, the industry may recognise its primary responsibility for climate mitigation, and develop non-fossil fuel energy alternatives.
Agriculture	Transform agriculture (Báldi *et al.*, 2023), encourage regenerative agriculture (EASAC, 2023) and sustainable use of pesticides (EASAC, 2022b).	Reduce climate impact while improving food quality and security. Integrate diet with climate and biodiversity impacts to improve health while reducing land and climate impacts. Adjust subsidy schemes.
Land sink (land use, land-use change and forestry)	Recognise that trends are negative and indicate over-harvesting. Phase out support for forest removal for bioenergy.	Restore land sink as a counter to emissions.
Green finance	Tighten criteria in the EU taxonomy to make it a more effective driver of investment away from the 'brown' to the green economy.	Steer the power of private investments to a sustainable future.
Competition	Work in World Trade Organization and United Nations to protect from economies that pay little attention to environmental and sustainability issues.	Protect competitiveness.
Demand	Policies to counter unsustainable trends in demand, e.g. in aviation and transport. Apply the provisioning-systems approach to meet people's needs in more resource-efficient, smart ways.	Reverse current negative trends while still meeting peoples' needs.
Adaptation	Recognise increasing risks and strengthen adaptation policies.	Resilience against increasing extremes of climate change.

Glossary

EC European Commission
EEA European Environment Agency
ESB Earth System Boundary
EU European Union
GDP Gross domestic product
IEA International Energy Agency
IMF International Monetary Fund
IPBES Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services
IPCC Intergovernmental Panel on Climate Change
IRP International Resource Panel

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