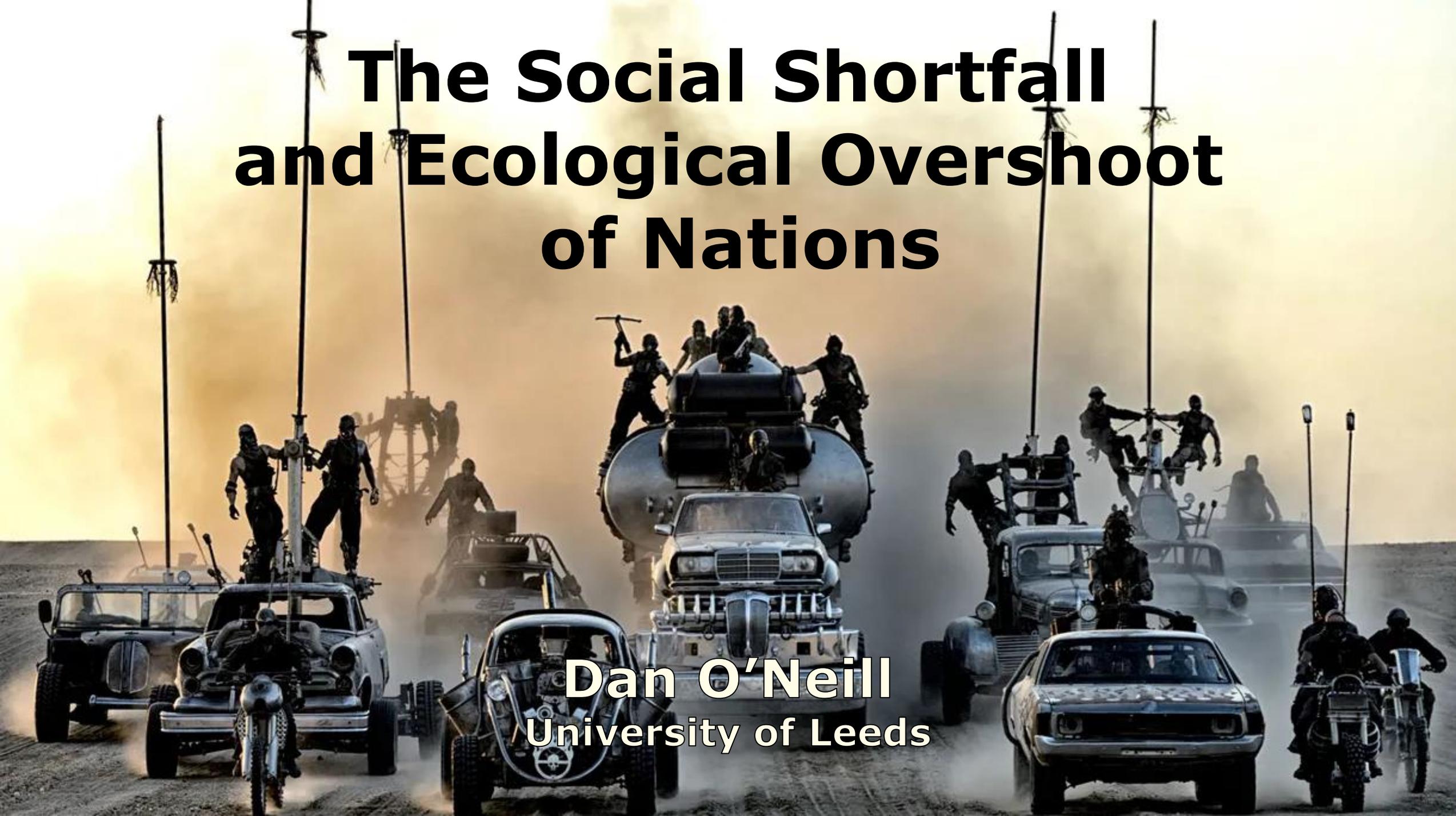


The Social Shortfall and Ecological Overshoot of Nations

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A good life for all within planetary boundaries

Daniel W. O'Neill^{1*}, Andrew L. Fanning¹, William F. Lamb² and Julia K. Steinberger³

Humanity faces the challenge of how to achieve a high quality of life for over 7 billion people without destabilizing critical planetary processes. Using indicators designed to measure a 'safe and just' development space, we quantify the resource use associated with meeting basic human needs, and compare this to downscaled planetary boundaries for over 150 nations. We find that no country meets basic needs for its citizens at a globally sustainable level of resource use. Physical needs such as nutrition, sanitation, access to electricity and the elimination of extreme poverty could likely be met for all people without transgressing planetary boundaries. However, the universal achievement of more qualitative goals (for example, high life satisfaction) would require a level of resource use that is 2–6 times the sustainable level, based on current relationships. Strategies to improve physical and social provisioning systems, with a focus on sufficiency and equity, have the potential to move nations towards sustainability, but the challenge remains substantial.

This Article addresses a key question in sustainability science: what level of biophysical resource use is associated with meeting people's basic needs, and can this level of resource use be extended to all people without exceeding critical planetary boundaries? To answer this question, we analyse the relationships between 7 indicators of national environmental pressure (relative to biophysical boundaries) and 11 indicators of social outcomes (relative to sufficiency thresholds) for over 150 countries. Our study measures national performance using a 'safe and just space' framework^{1,2} for a large number of countries, and provides important findings on the relationships between resource use and human well-being.

A safe and just space

There have been two recent, complementary advances in defining biophysical processes, pressures and boundaries at the planetary scale. The first is the planetary boundaries framework, which identifies nine boundaries related to critical Earth-system processes³. The boundaries jointly define a 'safe operating space', within which it is argued the relatively stable conditions of the Holocene may be maintained⁴. Of the seven measured planetary boundaries, four are currently transgressed (biosphere integrity, climate change, biogeochemical flows and land-system change)⁵.

The second advance is the estimation of environmental 'footprint' indicators for multiple types of biophysical resource flows. Footprint indicators associate specific environmental pressures (for example, CO₂ emissions, material extraction, freshwater appropriation) with the consumption of goods and services⁶. This approach assigns responsibility for embodied resource use to final consumers, and includes the effects of international trade.

We combine these two approaches to measure sustainability at the national scale, by comparing national consumption-based environmental footprints to 'downscaled' planetary boundaries⁵. The nascent literature proposes a number of different ways that planetary boundaries could theoretically be downscaled to national equivalents⁷, taking into account factors such as geography, international trade and equity⁸. Some studies apply a top-down approach that distributes shares of each planetary boundary to countries based on an allocation formula^{9–11}, while others apply a bottom-up approach that associates local or regional environmental limits with each planetary boundary^{12,13}.

Within our analysis we apply a top-down approach that distributes shares of each planetary boundary among nations based on current population (a per capita biophysical boundary approach). While the environmental justice literature emphasizes the need for differentiated responsibilities in practice¹⁴, a per capita approach allows us to explore what quality of life could be universally achieved if resources were distributed equally. It is an important question to address given that it is often claimed that all people could live well if only the rich consumed less, so that the poor could consume more¹⁵. We acknowledge that an annual per capita boundary may not be an appropriate way to manage resources that are geographically and temporally bounded (for example, freshwater use, where river-basin geography and a monthly timescale may be more appropriate in practice¹⁶). Moreover, a deeper understanding of equity may require some notion of shared responsibility between producers and consumers¹⁷.

Here, we adopt a human needs-based approach to defining and measuring social outcomes, drawing on the work of Max-Neef¹⁸ and Doyal and Gough¹⁹. Human needs theory argues that there are a finite number of basic human needs that are universal, satiable and non-substitutable. 'Need satisfiers' can vary between individuals and cultures, but arguably have certain universal characteristics that may be measured empirically²⁰.

The theory of human needs developed by the above authors underpins the safe and just space (SJS) framework proposed by Raworth¹, and described in her book *Doughnut Economics*². The framework combines the concept of planetary boundaries with the complementary concept of social boundaries. It visualizes sustainability in terms of a doughnut-shaped space where resource use is high enough to meet people's basic needs (the inner boundary), but not so high as to transgress planetary boundaries (the outer boundary).

The SJS framework includes 11 social objectives, which were selected by Raworth based on a comprehensive text analysis of government submissions to the Rio+20 conference. The objectives reflect the main social goals mentioned in the majority of submissions, and thus align well with contemporary policy, including the social objectives in the United Nations Sustainable Development Goals (SDGs)²¹. The SJS framework also has important precedents in the ecological economics literature, namely the objectives of sustainable scale, fair distribution and efficient allocation²².

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The social shortfall and ecological overshoot of nations

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Previous research has shown that no country currently meets the basic needs of its residents at a level of resource use that could be sustainably extended to all people globally. Using the doughnut-shaped 'safe and just space' framework, we analyse the historical dynamics of 11 social indicators and 6 biophysical indicators across more than 140 countries from 1992 to 2015. We find that countries tend to transgress biophysical boundaries faster than they achieve social thresholds. The number of countries overshooting biophysical boundaries increased over the period from 32–55% to 50–66%, depending on the indicator. At the same time, the number of countries achieving social thresholds increased for five social indicators (in particular life expectancy and educational enrolment), decreased for two indicators (social support and equality) and showed little change for the remaining four indicators. We also calculate 'business-as-usual' projections to 2050, which suggest deep transformations are needed to safeguard human and planetary health. Current trends will only deepen the ecological crisis while failing to eliminate social shortfalls.

The doughnut-shaped 'safe and just space' framework (also called the 'doughnut of social and planetary boundaries') has received widespread attention as a holistic tool for envisioning human development on a stable and resilient planet^{1,2}. However, despite the urgent need to define, and move towards, a safe and just future³, little is known about the pathways of countries over time with respect to the multi-dimensional social and ecological goals of the doughnut. This article advances integrated global sustainability research by assessing whether any countries have lived within the doughnut in recent decades, or are on track to do so in the future, on the basis of current trends.

The doughnut combines two core concepts: (1) an ecological ceiling that avoids critical planetary degradation, which is informed by the planetary boundaries framework for Earth-system stability⁴; and (2) a sufficient social foundation that avoids critical human deprivation, which is closely aligned with the 12 social priorities of the Sustainable Development Goals⁵. The doughnut visualizes the goal of meeting the needs of all people within the means of the living planet⁶.

Empirical research that combines social and biophysical indicators in the doughnut framework is maturing, and the framework has been applied to evaluate the performance of cities^{7,8}, regions^{9,10}, countries^{11,12} and the world as a whole^{1,4}. In general, places that do well in terms of social achievement use resources at unsustainable levels, while places that use resources sustainably do not reach a sufficient social foundation¹.

A large body of empirical research finds diminishing returns in social performance as resource use increases, and this finding holds across different social indicators or baskets of indicators, such as life satisfaction, life expectancy or composite indices, together with CO₂ emissions^{13,14}, energy use^{15–17}, ecological footprint^{18–20} and others²¹. Modellers have described the impact on planetary boundaries of achieving the Sustainable Development Goals²², the socioeconomic effects of CO₂ mitigation pathways^{23,24} and the energy requirements

of meeting a set of basic needs^{25,26}. However, these studies either do not disaggregate from the global to the national scale or do not include multiple planetary boundaries and social indicators. To date, O'Neill et al.¹ provide the only global cross-national analysis of the level of resource use associated with achieving minimum social thresholds using the safe and just space framework, but their study is limited to a single year.

There is an emerging view that achieving social thresholds without overshooting biophysical boundaries requires a dual focus on curbing excessive affluence and consumption by the rich while avoiding critical human deprivation among the least well off^{27–29}. A better understanding of country trajectories with respect to the doughnut could provide insights into the type of action needed to transform unsustainable systems of social and technical provisioning³⁰.

Biophysical boundaries and social thresholds

We gathered historical data from 1992 to 2015 and analysed national performance on 6 consumption-based environmental indicators (relative to downscaled biophysical boundaries) and 11 social indicators (relative to social thresholds) for over 140 countries (Table 1). We also used these data to estimate dynamic statistical forecasting models within each country, which act as empirical constraints on a simple 'business-as-usual' projection of current trends for each social and biophysical indicator, out to the year 2050.

The 11 social indicators include 2 measures of human well-being (self-reported life satisfaction and life expectancy) and 9 need satisfiers (nutrition, sanitation, income poverty, access to energy, education, social support, democratic quality, equality and employment). To assess social performance over time, we compared these indicators with the minimum threshold values identified by O'Neill et al.¹, with some adjustments and caveats (Table 1 and Methods). Since the social support indicator series does not begin until 2005, only ten indicators were considered in total for cross-national comparisons over the 1992–2015 analysis period.

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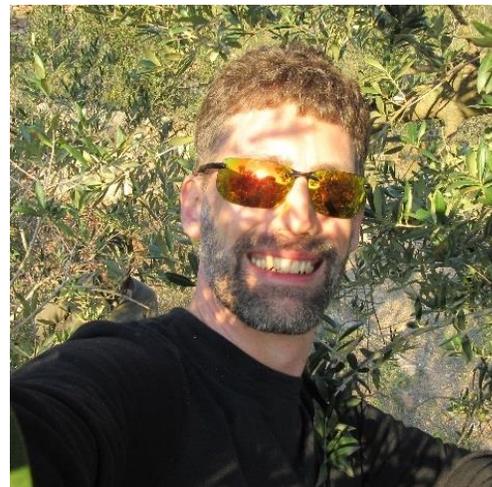
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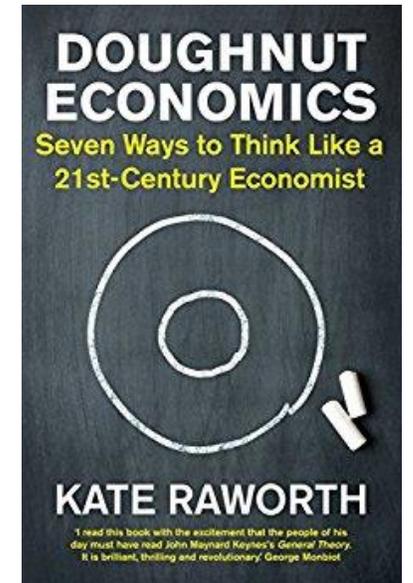
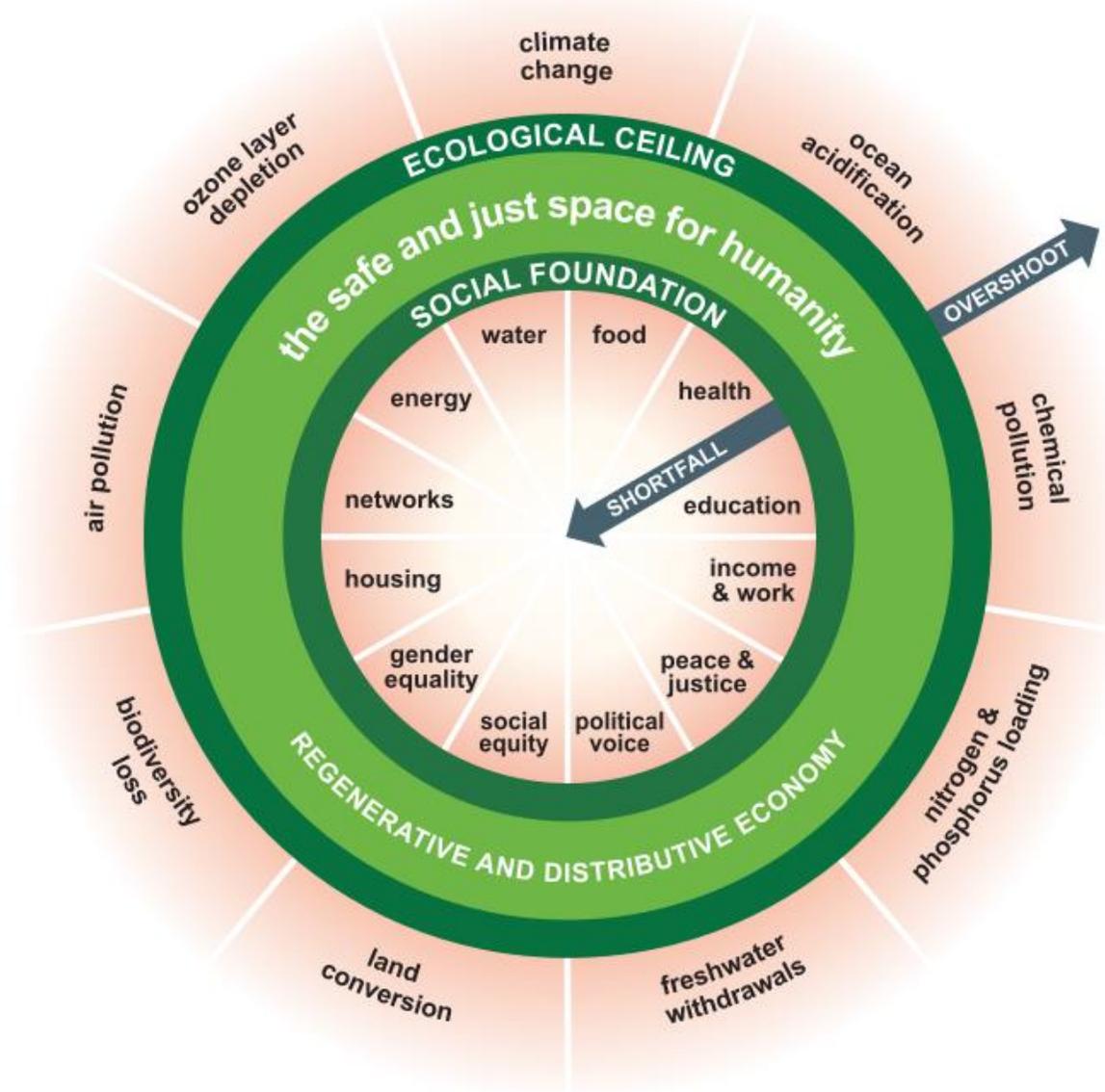
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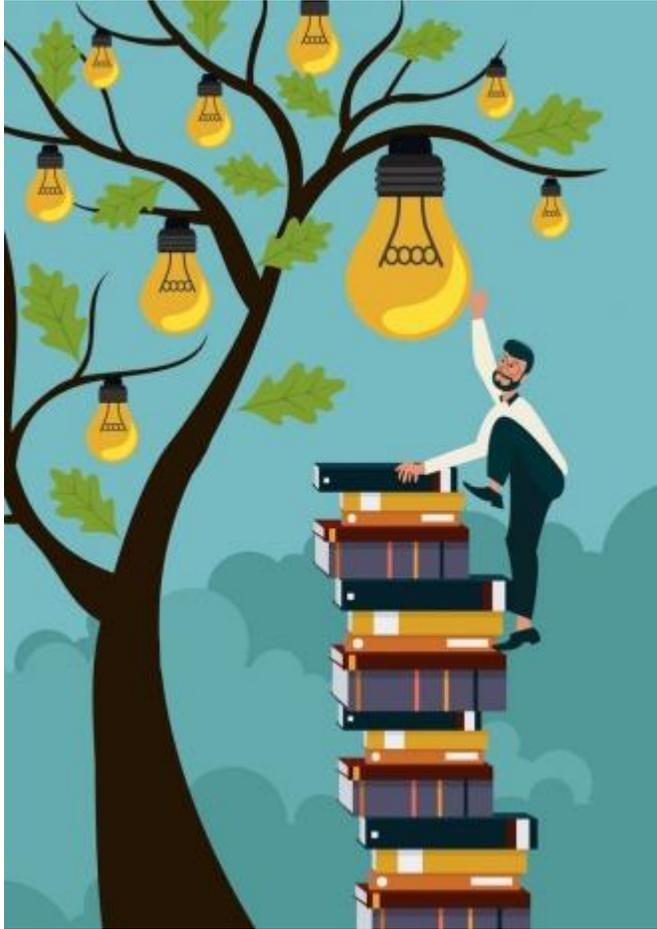
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The Doughnut



Research Questions



- What we know:
 - “No country meets basic needs for its citizens at a globally sustainable level of resource use” (O’Neill et al., 2018)

- What we don’t know:
 - Have any countries ever lived within the Doughnut of social and planetary boundaries?
 - Are any countries on track to do so in future?

Methods

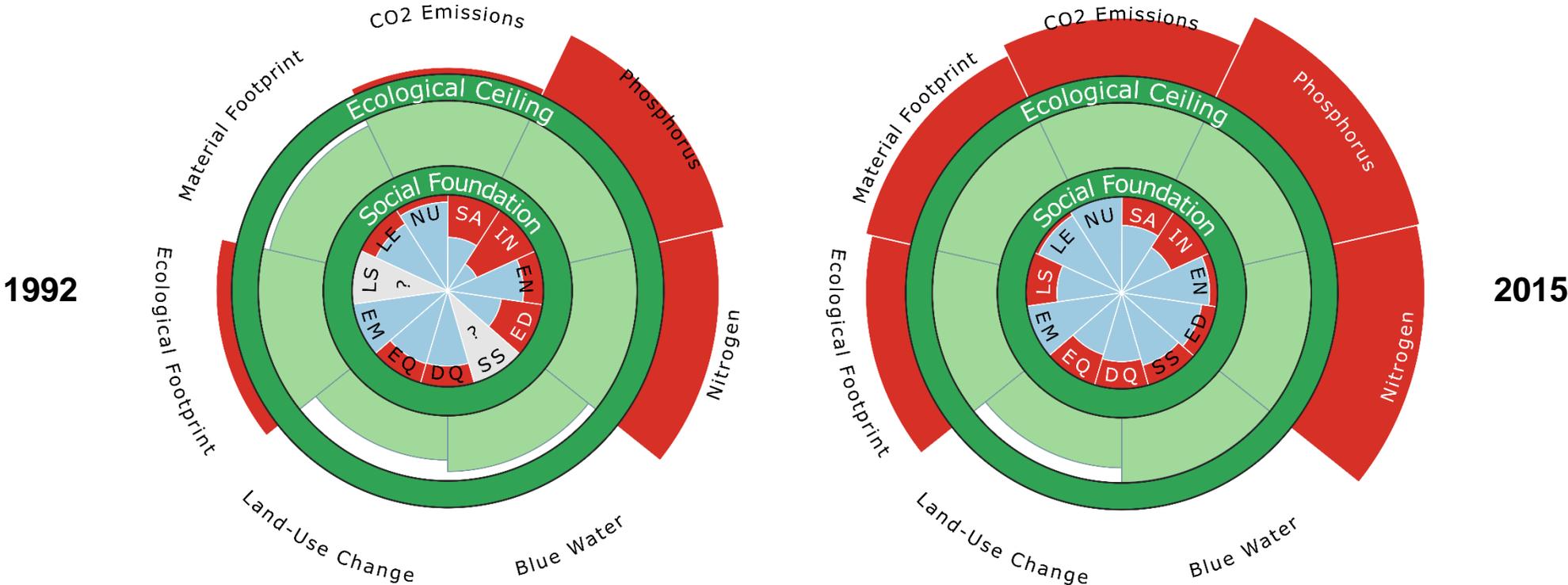


- ❑ Gathered historical data from 1992 to 2015
- ❑ Analysed 6 consumption-based environmental indicators (relative to downscaled planetary boundaries) and 11 social indicators (relative to social thresholds) for >140 countries
 - Analysis accounts for international trade and changes in population
- ❑ Estimated BAU projections for each country to 2050
 - Dynamic statistical forecasting model (Exponential Smoothing or ARIMA)

Indicators and Thresholds/Boundaries

Indicator	N	Threshold/ boundary		Unit
Social				
Life satisfaction	45 (119)	6.5		[0-10] Cantril ladder scale
Life expectancy	147	74		Years
Nutrition	137	2,700		Kilocalories per person per day
Sanitation	137	95		Population with access to improved sanitation, %
Income poverty	114	95		Population earning above \$5.50 per day (2011 PPP), %
Access to energy	131	95		Population with access to electricity, %
Secondary education	129	95		Gross enrolment in secondary school, %
Social support	(118)	90		Population with friends or family they can depend on, %
Democratic quality	144	7		[0-10] scale
Equality	125	70		[0-100] scale (equivalent to Gini index of 0.3)
Employment	148	94		Labour force employed, %
Biophysical		1992	2015	
CO ₂ emissions	147	Population share of cumulative emissions		MtCO ₂ yr ⁻¹
Phosphorus	136	1.1	0.8	kg yr ⁻¹ P
Nitrogen	136	11.3	8.4	kg yr ⁻¹ N
Land-system change	142	3.3	2.4	tC yr ⁻¹
Ecological footprint	145	2.1	1.7	gha
Material footprint	147	9.1	6.9	t yr ⁻¹

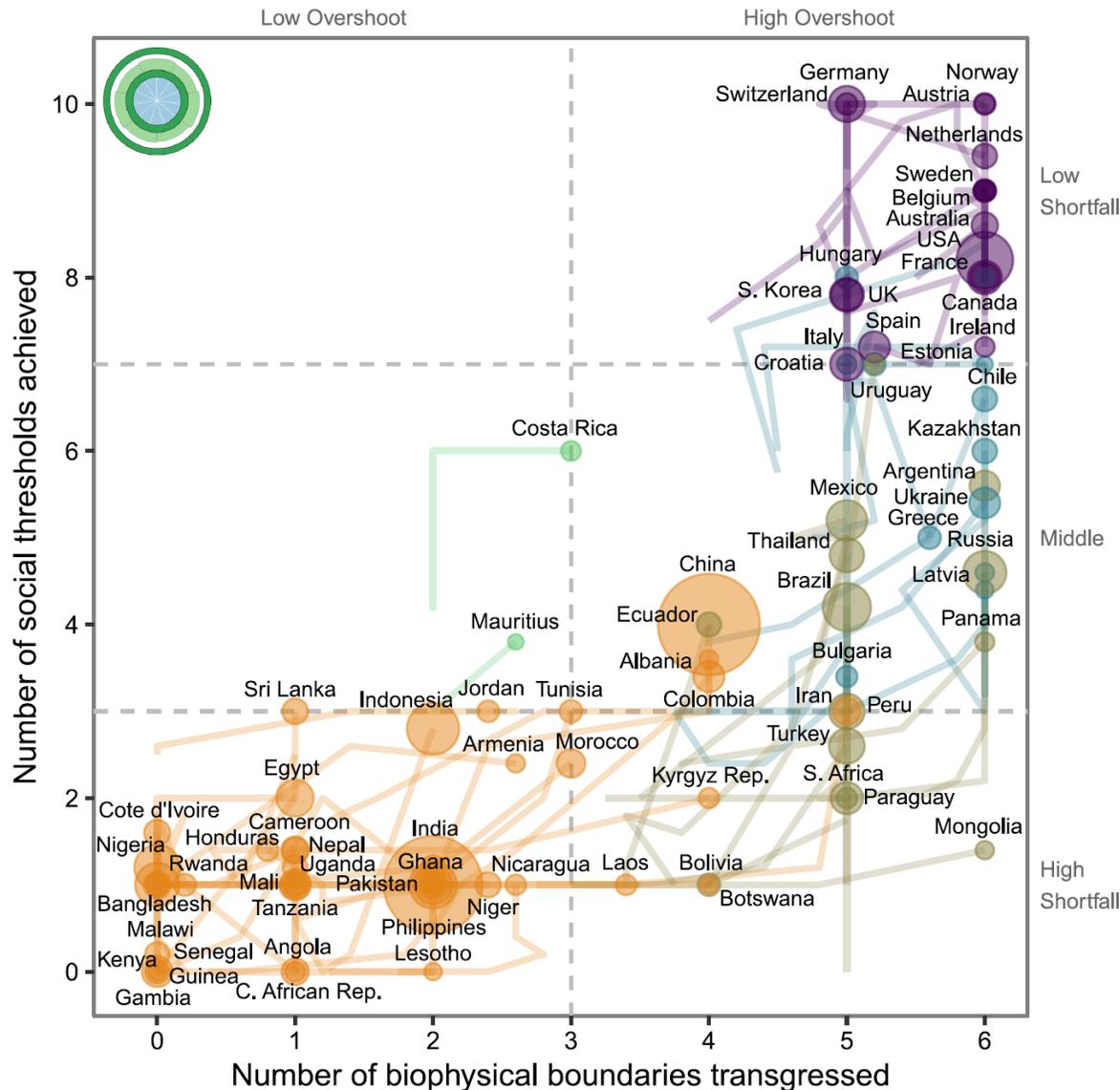
Global Results



LS	Life Satisfaction	IN	Income Poverty	DQ	Democratic Quality
LE	Life Expectancy	EN	Access to Energy	EQ	Equality
NU	Nutrition	ED	Secondary Education	EM	Employment
SA	Sanitation	SS	Social Support		

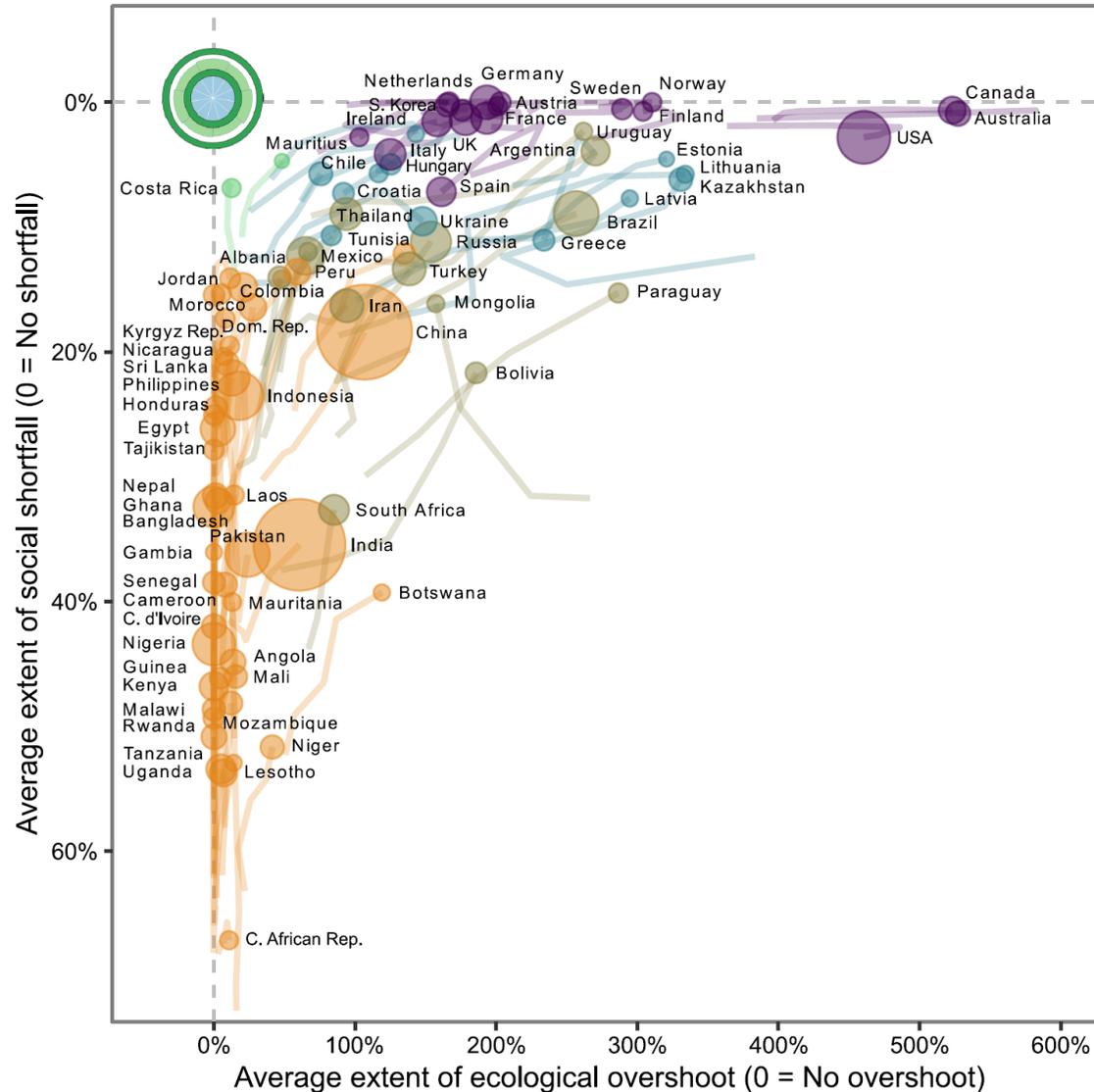
- ❑ Humanity is closer to reaching the social thresholds than it was in the early 1990s
- ❑ But it has overshoot two additional boundaries
- ❑ Billions of people still live in countries that do not achieve most of the social thresholds

Charting National Trends: 1992–2015



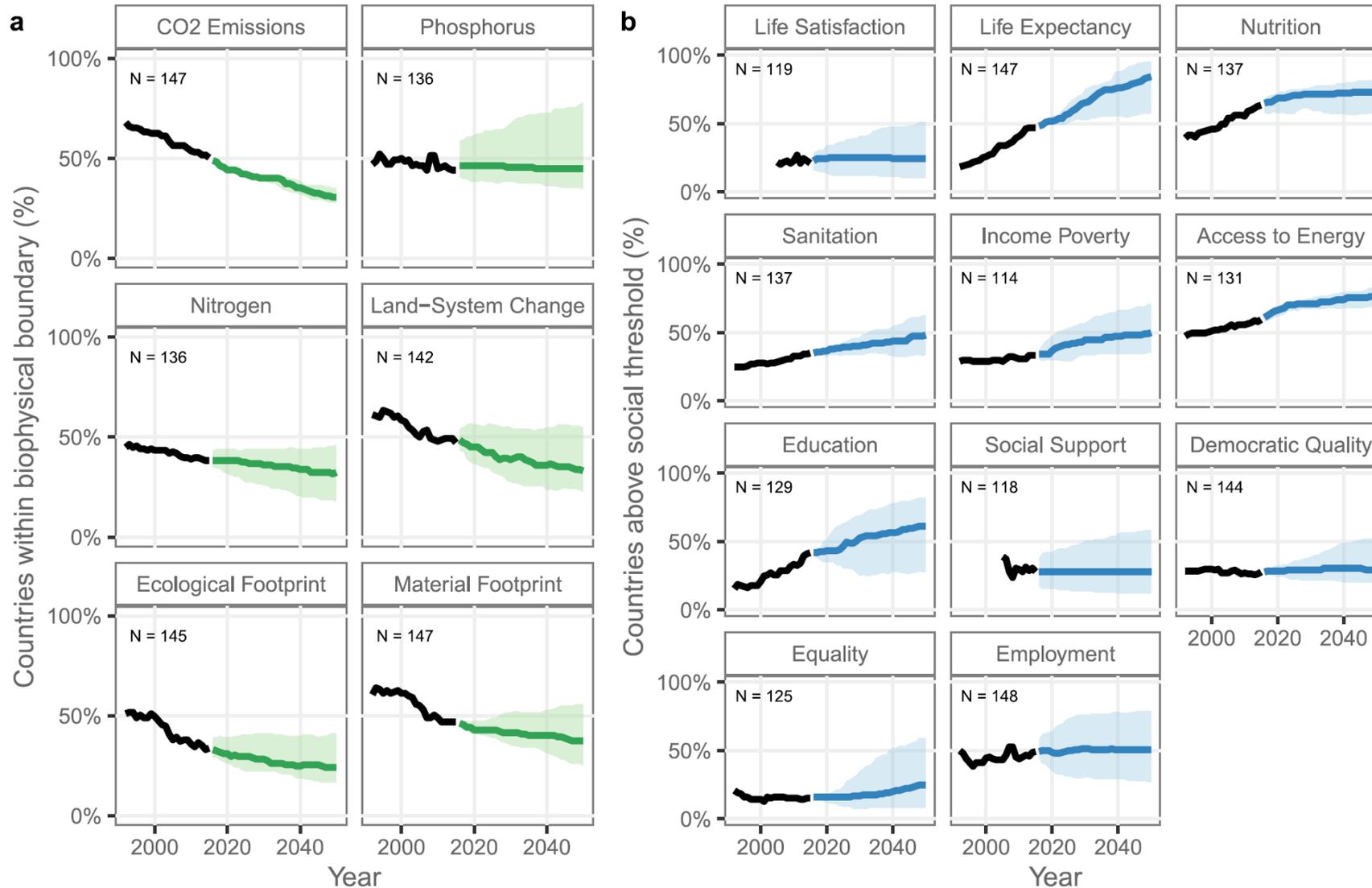
- We want countries to be in the top-left corner, where no country is — or has ever been?
- Most countries are failing to achieve the majority of the social thresholds (~ 4 of 10 achieved on average), and failing to stay within biophysical boundaries (~ 2 of 6 respected)
- Countries tend to transgress most of the biophysical boundaries before achieving a substantial number of social thresholds
- Costa Rica does better than other countries, but it still transgresses half of the planetary boundaries

Charting Extent of Overshoot/Shortfall: 1992–2015



- Wealthy countries have increased their extent of ecological overshoot, from 3.0x beyond the ecological ceiling on average, to 3.5x, with little change in social performance
- Poor countries have improved their social performance (from 43% below the social foundation to 33% below), but also increased their extent of overshoot (from 6% beyond the ecological ceiling to 19% beyond it)

BAU Projections to 2050



If trends continue:

- Most of the biophysical indicators will get worse
 - The exception is phosphorus

- Many of the social indicators will improve
 - Half of countries would achieve 7 out of 11 thresholds by 2050
 - Less than 1/3 of countries set to achieve thresholds for life satisfaction, social support, democratic quality, and equality

What Does It All Mean?



- ❑ No country is currently moving towards the Doughnut
- ❑ The road we're on is likely to deepen the climate and ecological crisis *and* fail to eliminate social shortfalls (lose-lose!)
- ❑ Countries with high levels of social achievement have levels of resource use far beyond anything that could be sustainably extended to all people
 - The extent of ecological overshoot has been increasing
- ❑ Low-income countries have reduced social shortfalls, but they are transgressing biophysical boundaries faster than are achieving social thresholds
- ❑ An unprecedented transformation is needed in **all** countries to reverse current trends and move towards the Doughnut

What Does It All Mean?



- Wealthy countries need to dramatically reduce their resource use to avoid critical planetary degradation
 - The transition is unlikely to be achieved with improvements in resource efficiency alone
 - Wealthy countries need to move beyond the pursuit of economic growth
 - Social support, democratic quality, and equality most in need of transformation, and are only weakly coupled to resource use
- Poorer countries need to rapidly accelerate social performance to eliminate critical human deprivation
 - A focus on meeting basic needs is required
 - Capacity building and sovereign economic development
 - Nutrition, sanitation, and income poverty deserve priority attention

The Website

A Good Life For All Within Planetary Boundaries 🔍

HOME NATIONAL TRENDS ▼ NATIONAL SNAPSHOTS ▼ RELATED RESEARCH ▼ DOWNLOAD DATA IN THE NEWS ABOUT

A Good Life For All Within Planetary Boundaries

For at least the last 30 years, no country has met the basic needs of its residents at a globally sustainable level of resource use. How does your country compare with others on achieving the goal of a safe and just future for all? How many social goals does it achieve? How many planetary boundaries does it transgress?

National Trends (New!)

Countries have been transgressing planetary boundaries faster than they have been meeting the basic needs of their residents. Explore the progress of nearly 150 countries over time using interactive charts and doughnut plots from our recent 2021 study, [The Social Shortfall and Ecological Overshoot of Nations](#), published in *Nature Sustainability* (and summarised in [\[media outlet\]](#)).

PATHWAYS

COUNTRY TRENDS

PERU ▼

Click or tap on the images above to see the unsustainable pathways that countries have followed from 1992 to 2015, or dig deeper into individual country trends to see how environmental and social performance have changed over time with respect to the Doughnut of social and planetary boundaries.

Comments / Questions



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The Fine Print (a.k.a. Limitations)



- Our projections may be optimistic as they are based on within-country historical trends, and do not consider the potential social disruption from increased ecological overshoot
 - Although countries may overshoot biophysical boundaries for some time, this cannot continue indefinitely
- The statistical forecasting models we have applied are constrained by historical data, and thus our projections show only what is probable given current relationships
 - The projections assume current provisioning systems and policies and do not consider the types of radical transformations that have been suggested by degrowth and post-growth scholars