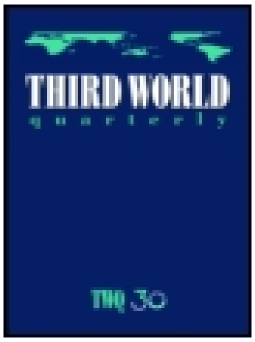

Third World Quarterly

ISSN: 0143-6597 (Print) 1360-2241 (Online) Journal homepage: http://www.tandfonline.com/loi/ctwq20

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To cite this article: Jason Hickel (2018): Is it possible to achieve a good life for all within planetary boundaries?, Third World Quarterly, DOI: 10.1080/01436597.2018.1535895

To link to this article: https://doi.org/10.1080/01436597.2018.1535895

Published online: 10 Dec 2018.

THIRD WORLD QUARTERLY
https://doi.org/10.1080/01436597.2018.1535895

TWQ Routledge Taylor & Francis Group

Is it possible to achieve a good life for all within planetary boundaries?

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ABSTRACT
The safe and just space framework devised by Raworth calls for the world's nations to achieve key minimum thresholds in social welfare while remaining within planetary boundaries. Using data on social and biophysical indicators provided by O'Neill et al., this paper argues that it is theoretically possible to achieve a good life for all within planetary boundaries in poor nations by building on existing exemplary models and by adopting fairer distributive policies. However, the additional biophysical pressure that this entails at a global level requires that rich nations dramatically reduce their biophysical footprints by 40–50%. Extant empirical studies suggest that this degree of reduction is unlikely to be achieved solely through efforts to decouple GDP growth from environmental impact, even under highly optimistic conditions. Therefore, for rich nations to fit within the boundaries of the safe and just space will require that they abandon growth as a policy objective and shift to post-capitalist economic models.

ARTICLE HISTORY
Received 05 May 2018
Accepted 25 September 2018

KEYWORDS
Sustainable development
planetary boundaries
de-growth
ecology

Introduction

Over the past few years there have been a number of research findings and conceptual innovations that pose significant challenges to development theory. The first and most significant of these is the research on planetary boundaries. Drawing on data from Earth System science, Rockstrom et al. and Steffen et al. have identified a number of critical boundaries that are essential to observe in order to maintain the planetary biosphere – boundaries on climate change, biodiversity loss, ocean acidification, land-system change, nitrogen loading, phosphorous loading, freshwater use, atmospheric aerosol loading, chemical pollution and stratospheric ozone depletion.[1] The researchers concluded that five of these boundaries have been overshot: climate change, biodiversity loss, nitrogen loading, phosphorous loading and land-system change. For two of the others (ocean acidification and freshwater use), the process of degradation is two-thirds of the way toward the boundary, relative to pre-industrial levels. Ozone depletion is the only process that has been brought under control, thanks to a successful campaign in the 1980s. For chemical pollution and aerosol loading, the data are not yet robust enough to yield conclusions.

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Building on this framework, Kate Raworth has argued that any vision for development would have to somehow fit within planetary boundaries: in other words, resources should be mobilised to improve social indicators toward certain minimum thresholds, but without exceeding ecological limits.[2] Raworth termed this the 'safe and just space' and conceptualised the objective as a matter of fitting within a 'doughnut', with the outer border of the doughnut represented by planetary boundaries and the inner border represented by social foundations. Drawing on the most popular submissions of national governments to the Rio +20 Conference on Sustainable Development, Raworth identified 12 social priorities: health, education, income and work, water and sanitation, energy, networks, housing, gender equality, social equity, political voice, and peace and justice.

Building on Raworth's intervention, a team of researchers led by Daniel O'Neill at the University of Leeds published the ground-breaking paper 'A good life for all within planetary boundaries'.[3] The study is the first attempt to determine whether fitting inside the proverbial doughnut is possible, given existing relationships between social performance and resource use for 151 nations. For each nation, the study looks at progress with respect to 11 social thresholds, which overlap substantially with those identified by Raworth (see Table 1).

The study also looks at each nation's per capita resource use over seven biophysical categories and compares these against global planetary boundaries rendered in per capita equivalents (see Table 1).[4] Five of the categories are derived directly from the planetary boundaries framework (climate change, phosphorous loading, nitrogen loading, freshwater use and land-use change), while two other commonly used indicators have been added: ecological footprint and material footprint. The biophysical indicators are rendered in consumption-based terms, so that the ecological impact of goods and services is attributed to the nations in which they are consumed, regardless of where in the world they are produced.

Table 1. Social and biophysical indicators covered in the dataset provided by O'Neill et al. (2018).

Social indicator	Threshold
Life Satisfaction	6.5 on 0–10 Cantril Scale (Gallup World Poll)
Healthy Life Expectancy	65 healthy life years
Nutrition	2700 kcal per person per day
Sanitation	95% with access to improved sanitation facilities
Income	95% living on more than US$1.90 per day
Access to Energy	95% with access to electricity
Education	95% enrolment in secondary school
Social Support	90% say they have relatives or friends they can depend on
Democratic Quality	0.8 on −2.5–2.5 scale, average of Worldwide Governance Indicators on voice, accountability and political stability
Equality	70 on 0–100 scale, based on Gini coefficient of household disposable income
Employment	94% of the labour force employed
Biophysical indicator	**Boundary**
CO_2 Emissions	1.6 tonnes of CO_2 per person per year
Phosphorous	0.9 kilograms P per person year
Nitrogen	8.9 kilograms N per person per year
Blue Water	574 cubic meters H_20 per person per year
eHANPP	2.6 tonnes C per person per year
Ecological Footprint	1.7 global hectares (gha) per person per year
Material Footprint	7.2 tonnes per person per year

O'Neill et al. state that 'no country meets basic needs for its citizens at a globally sustainable level of resource use'.[5] Indeed, the general trend shows that 'the more social thresholds a country achieves, the more biophysical boundaries it transgresses, and vice versa'.[6] Many wealthy nations do well on social indicators, but significantly transgress biophysical boundaries. Meanwhile, many poorer nations remain within biophysical boundaries, but perform poorly on social indicators. The paper illustrates this result in a graph that plots each country according to the number of social thresholds it achieves and the number of biophysical boundaries it has transgressed.[7] The only countries that have achieved all of the social thresholds have transgressed at least five of the biophysical boundaries. And the only countries that remain entirely within all of the biophysical boundaries have achieved at most three of the social thresholds. The most promising outlier is Vietnam, which has achieved six of 11 social thresholds while transgressing only one biophysical boundary.

This study brings us to the cutting edge of inquiry in sustainable development. The results are not encouraging: 'It shows that meeting the basic needs of all people on the planet would result in humanity transgressing multiple environmental limits, based on current relationships between resource use and human well-being'.[8] O'Neill et al. conclude: 'If all people are going to lead a good life within planetary boundaries, then our results suggest that provisioning systems must be fundamentally restructured to enable basic needs to be met at a much lower level of resource use'.[9] In what follows I will build on O'Neill et al.'s data to argue that it is theoretically possible to achieve a good life for all within planetary boundaries in poor nations by using existing policy options. However, the safe and just space framework requires de-growth strategies among rich nations and at an aggregate global level.

Some nations come close to achieving a good life for all within planetary boundaries

According to O'Neill et al.'s paper, the best-performing country is Vietnam, which has achieved six of the social thresholds while transgressing only one biophysical boundary (CO_2 emissions). Vietnam falls short on life satisfaction, sanitation, equality and democratic quality (with no data for education). While Vietnam provides an interesting case, it fails to achieve the basic aspirations laid out in the SDGs and therefore cannot be held up as an ideal model.

There are other interesting cases to investigate, however, although these tend to be obscured in the original results. O'Neill et al. have chosen to represent social thresholds and biophysical boundaries in binary terms. In other words, a country has either achieved the social threshold or it has not; and it has either overshot a biophysical boundary or it has not. This is a sensible approach, but it can give a misleading impression of how badly a country performs. For instance, if a country is just 1% over all seven biophysical boundaries, it would register at the highest possible level of biophysical overshoot (seven out of seven). Similarly, if a country is just 1% under all 11 social thresholds, it would register as a complete failure on the social scale (0 out of 11). In such cases, the binary measure may end up obscuring countries that are quite promising.

We can correct for this problem with a different approach. O'Neill et al.'s data is available on the project's website.[10] Biophysical indicators are all standardised to the same scale, with the boundary for each indicator rendered as 1 and current values rendered as a ratio of the boundary. For instance, the boundary for CO_2 emissions is 1.6 tonnes of CO_2 per person per year. The UK emits 12.1 tonnes of CO_2 per person per year, while Bangladesh emits 0.4 tonnes of CO_2 per person per year. Since the boundary is rendered as 1, then the UK's emissions are rendered as 7.48 (over the boundary) while Bangladesh's emissions are rendered as 0.28 (under the boundary). Social indicators are also standardised to a single scale, with the lowest actually-existing value for a given indicator rendered as 0, the threshold rendered as 1 and current values rendered as a ratio of the threshold.[11] UK life satisfaction is 1.1 (over the threshold) while Bangladesh is 0.58 (under the threshold). Given how the data are normalised, we can determine a country's average distance from the biophysical boundaries and average distance from the social thresholds, such that each country has a single biophysical score and a single social score. For example the UK's average biophysical score is 4.10, while its average social score is 1.10. These results are useful in that they allow us to compare countries' performance vis-à-vis biophysical boundaries and social thresholds, but because the underlying indicators are normalised from different scales and therefore weighted differently in the average, they should not be taken as standalone figures.[12]

Figure 1 renders all nations' average scores on a scatter plot along social and biophysical axes (excluding nations for which fewer than half of the social or biophysical data points are available). The result shows that achievement on social indicators rises rapidly as biophysical pressure increases, but reaches a kink-point at or near the average biophysical boundary, after which it begins to flatten off. If we focus on this kink-point, we see that a number of countries manage to come quite close to the social threshold while remaining within biophysical boundaries on average (most notably Moldova, Algeria and Vietnam, all of which exceed 0.9 on the average social scale), while other countries achieve the social threshold while only slightly overshooting average biophysical boundaries (most notably Costa Rica and Cuba).

Cuba is the obvious exceptional performer, but as data for Cuba is only available for five of the 11 social indicators, the result is not robust; I have kept Cuba in the scatterplot for

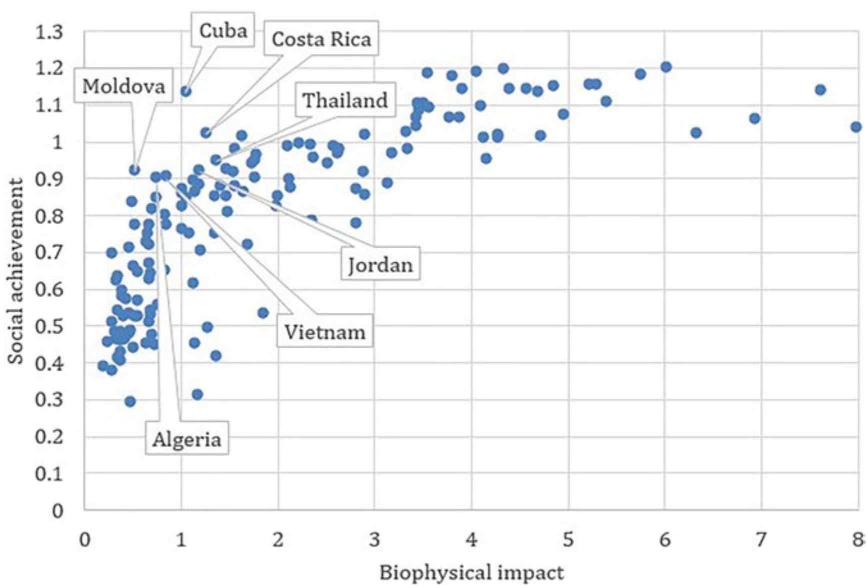

Figure 1. Ecological efficiency of nations: scatterplot of average biophysical impact with respect to planetary boundaries (horizontal, with boundary as 1) versus their achievement with respect to social thresholds (vertical, with threshold as 1)

reference only. Of the remaining high-performers on the social scale, Costa Rica is perhaps the most promising. Costa Rica has a high average social score of 1.03, with an average biophysical score of 1.25. Costa Rica's strong performance is reflected also in its top ranking in the Happy Planet Index, which weighs life expectancy and life satisfaction against ecological footprint. Costa Rica's success on social indicators like healthy life expectancy, education and life satisfaction is due largely to its strong commitment to universalism, with a public health and education system that delivers impressive outcomes with relatively little money.[13] Costa Rica matches or even exceeds most high-income nations in these indicators with a fraction of their GDP per capita (US$11,800).

While this approach gives us a sense for the *general* biophysical efficiency of nations in generating social outcomes, it is not consistent with the logic of the planetary boundary framework as it allows good performance on some biophysical indicators to compensate for poor performance on others. Just because a country lives within the boundary for one biophysical indicator (e.g. nitrogen) does not mean it can then exceed the boundary for another (e.g. CO_2 emissions). Overshoot of any boundary is potentially catastrophic; this is why O'Neill at al. have adopted the binary approach. A similar caution applies to the social indicators: just because a country exceeds the threshold for life expectancy does not mean it can ignore education. Also, for the nutrition indicator, a score of more than 1 does not necessarily mean better, since additional calorie intake could indicate obesity and related problems. It is possible to refine the methodology in order to prevent the compensation effect and adhere to the principles of the planetary boundary framework. To do so, Figure 2 uses the following settings: (1) For nations that have scores less than 1 for *all* biophysical indicators, the scores are simply averaged. Therefore, in Figure 2, nations that do not transgress any planetary boundaries are depicted as

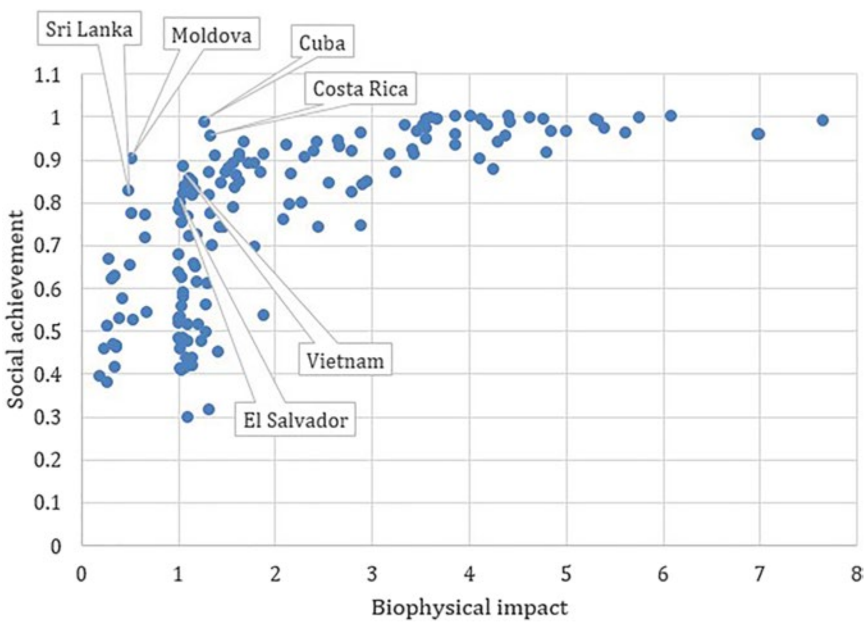

Figure 2. Ecological efficiency of nations, excluding the compensation effect: scatterplot of average biophysical impact with respect to planetary boundaries (horizontal, with boundary as 1) versus their achievement with respect to social thresholds (vertical, with threshold as 1).

having total biophysical scores less than 1; (2) For nations with overshoot on one or more biophysical indicators, the overshoot (i.e. aggregate distance over 1) is added up and then divided by seven (the total number of biophysical indicators) to yield the extent of average biophysical overshoot. Therefore, in Figure 2, nations that overshoot even one planetary boundary have total biophysical scores greater than 1, even if they are under the boundary on all of the other indicators; (3) For the social scale, the compensation effect is removed by ignoring values that exceed threshold levels, so that no value exceeds 1. For example, the UK's life satisfaction score of 1.1 is rendered as 1. The scores are then simply averaged. This method will be used in all of what follows.

The results show that of nations that remain within all biophysical boundaries, Moldova does the best on social indicators, with an average social shortfall of 10% (or a score of 0.9).[14] Of the social high-performers, Costa Rica is the most efficient with average social shortfall of 4% (a score of 0.96) and average biophysical overshoot of 33% (a score of 1.33). Other notable nations include Vietnam, Sri Lanka and El Salvador. Again, the result for Cuba is not robust and is included only for reference.

Some social thresholds can be achieved with little additional biophysical pressure

Some social indicators are more resource intensive than others. O'Neill et al. demonstrate that 'the social indicators most tightly coupled to resource use are secondary education, sanitation, access to energy, income and nutrition', as these are related to physical needs and all clearly require resource inputs (including education, which, at least in its modern institutional form, requires material infrastructure and supplies).[15] All of these social indicators have a coefficient of determination (R^2) greater than 0.5 with respect to most of the biophysical indicators.[16] In other words, more than 50% of performance on these indicators is explained by resource use. The more 'qualitative' social indicators are not as tightly coupled to resource use: life satisfaction, equality, social support, democratic quality and employment. All of these have R^2 values less than 0.5 for most biophysical indicators. Social support has R^2 of less than 0.4 for most biophysical indicators. Equality has R^2 of less than 0.3 for most biophysical indicators. Employment has no statistical relationship with resource use at all. According to O'Neill et al.'s data, nations that achieve the thresholds of these qualitative indicators also have very high levels of resource use. But this needn't be the case. Given the weak relationship between qualitative indicators and resource use, it is theoretically possible to achieve the thresholds with relatively little additional biophysical pressure. In fact, some of them can be achieved without any additional biophysical pressure at all. For instance, a country could achieve the equality threshold by simply shifting income from rich households to poor households (through higher wages, progressive taxation or direct transfers, for instance) and could achieve high employment by, say, shortening the working week and sharing necessary labour. Such policy moves would require no additional resource use, in and of themselves (although they may entail shifts in the composition of resource consumption).

If this is the case, there may be an argument for removing the five qualitative indicators from the aggregate analysis, to clarify the challenge when it comes to social thresholds that *do* require more intensive resource use to achieve. As Figure 3 illustrates, rendering the data this way makes the kink-point significantly sharper. Under these parameters, a number of other promising countries come into view. As with Figure 2, Figure 3 uses the refined method to correct for the compensation effect. The results show that Sri Lanka and Moldova have average social shortfall of only 6% (a score of 0.94) while remaining entirely within biophysical boundaries. Costa Rica comes close to a social score of 1 (0.99) with average biophysical overshoot of 33% (1.33). Cuba also achieves a social score of 0.99, with a biophysical score of 1.27, and this time the result is more robust (with four of six data points). Tunisia is the best overall performer according to this approach, with a social score of 0.98 and a biophysical score of 1.17.

We can take this a step further. Even for some of the indicators that *are* tightly coupled with resource use, minimal thresholds can be achieved without any additional biophysical pressure. For example, the income threshold calls for 95% of the population to be living on more than US$1.90 per day. According to research by Chris Hoy and Andy Sumner, three-quarters of the global poverty gap at US$1.90 could be covered through national-level redistribution (without any growth at all), simply by reallocating public resources from fossil fuel subsidies and surplus military spending and using the money to fund direct transfers to the poor, assisted by a modest rate of progressive taxation.[17] Nine of the 10 middle-income countries with the highest numbers of people in poverty (including India, China, Brazil, Indonesia and the Philippines) could use redistribution to achieve the income indicator without any additional biophysical pressure. Indeed, the redistributive policies suggested by Hoy and Sumner may even reduce biophysical pressure.[18] Low-income nations, however, can only cover about 37% of the poverty gap on average.

It may be possible to use the same method of national redistribution to achieve other resource-intensive social indicators – for example, by investing in universal social services for healthcare, education and electricity provision. Hoy and Sumner's data shows that the nine high-poverty middle-income countries that can cover the poverty gap through redistribution can do so an average of more than 20 times over. In other words, even after achieving the social threshold for income they would have plenty of financial resources left over

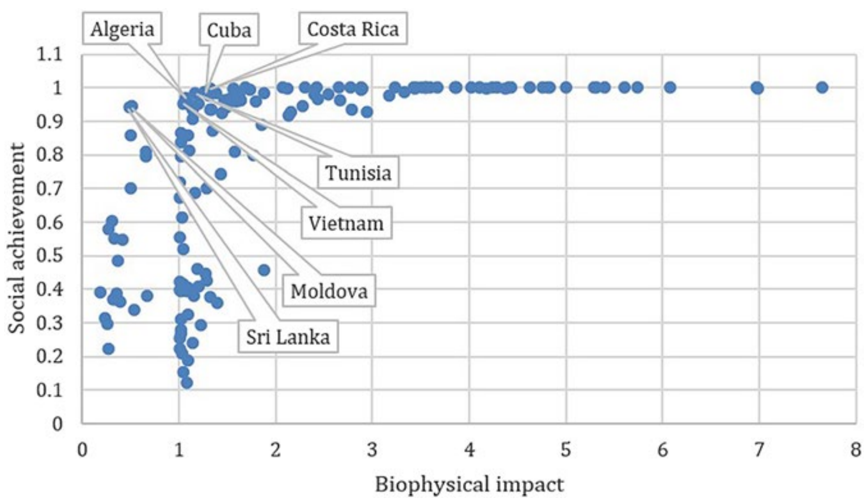

Figure 3. Ecological efficiency of nations, excluding the compensation effect and excluding "qualitative" social indicators: scatterplot of average biophysical impact with respect to planetary boundaries (horizontal, with boundary as 1) versus their achievement with respect to social thresholds (vertical, with threshold as 1).

for other social investments. This would not be possible for most low-income nations, however, which lack the aggregate resources even to cover shortfall on the income threshold.

All of the promising outliers identified in the graphs above fall into the category of middle-income countries: Costa Rica, Tunisia, Algeria, Vietnam, etc. In light of the above, it should theoretically be possible for these nations to cover their remaining (minimal) social shortfall through redistribution without any additional biophysical pressure. Even more interestingly, countries like Sri Lanka and Moldova, which are presently well within all biophysical boundaries (with an average score of 0.49 and 0.52, respectively) and which have minimal shortfall on non-qualitative social indicators (with a score of 0.94), should be able to cover their social shortfall while still remaining within all biophysical boundaries.

Higher poverty lines make the challenge more difficult

For the income indicator, O'Neill et al. rely on a poverty line of US$1.90 per day (2011 PPP). US$1.90 is the standard international poverty line (IPL) used by the World Bank and the UN's Sustainable Development Goals (SDGs). But the IPL has been widely criticised by scholars as too low to be meaningful.[19] The IPL is based on the national poverty lines of the world's low-income countries, many of which have been set using poor data. What is more, they tell us little about what poverty is like in even slightly better-off countries. In most developing countries, the IPL underestimates poverty when compared to national lines. In India, for example, national data shows that absolute poverty is twice as high as the IPL suggests.[20] In Mexico, the figure is about 10 times as high.[21] Moreover, research shows that in many countries the IPL is not sufficient for basic human health. In India, a child living just above the IPL has a 60% risk of being malnourished. In Niger, babies born just above the IPL face an infant mortality risk of nearly 16%, which is five times the world average.[22]

If US$1.90 is not sufficient to guarantee basic nutrition or infant survival, then we cannot claim that lifting people above this line means bringing them out of poverty – to say nothing of achieving a good life. Rahul Lahoti and Sanjay Reddy argue that people need about US$5.04 per day in order to achieve minimum basic nutrition alone, aside from other requirements.[23] The New Economics Foundation argues that people need about US$7.20 per day to reduce infant mortality down to the world average of 30/1000, which is still five times higher than in developed countries.[24] Research by Peter Edward shows that in order to achieve normal human life expectancy of just over 70 years, people need between 2.7 and 3.9 times more than the IPL, or about US$7.40 per day.[25] This is what Edward calls the 'ethical poverty line'. Longitudinal studies show that, in many regions, something closer to US$10 per day is necessary for a permanent escape from poverty.[26] This conclusion is in keeping with arguments by Charles Kenny and Lant Pritchett, who suggest that the global poverty line should be as high as US$12.50 or even US$15 per day.[27]

If we are to be serious about achieving a good life for all, we cannot rely on the US$1.90 line. Raworth suggests US$3.10 per day for the safe and just space framework.[28] An ethical poverty line of US$7.40 (2011 PPP) per day would be a more reasonable minimum, as it allows for meaningful achievement on the key indicators of nutrition, life expectancy and infant mortality. For most low- and middle-income nations, using this poverty line significantly worsens their average social shortfall. The best performers identified in Figure 3 all drop by as much as 10%. Costa Rica falls from 0.99 to 0.96 (with 21% of the population living on less than US$7.40), while Vietnam drops from 0.95 to 0.83 (with 58% of the population living on less than US$7.40). Note that one problem with this approach to the income indicator is that it does not account for the poverty 'gap' – the extent of shortfall below the poverty line. In other words, nation A and nation B might have the same percentage of people living in poverty, but the people of nation B might be much deeper in poverty than the people of nation A and therefore require more resources to bridge the gap. This nuance is obscured by the income indicator.

Adopting a higher poverty line makes it more difficult to end poverty while remaining within planetary boundaries. At the US$7.40 line, Belarus is the most promising, with minimal social shortfall (a score of 0.98) excluding qualitative indicators, but its average biophysical score is 1.64. Of the nations that achieve all non-qualitative social thresholds, the most biophysically efficient is Oman, which has an average biophysical score of 2.66. In other words, given the existing best-case relationship between resource use and income, achieving a good life for all with an income threshold of US$7.40 per day would require that poor nations overshoot planetary boundaries by at least 64% to 166%.

Of course, some of this could be covered by national redistribution. But at US$7.40 per day, it would be much more difficult for global South countries to end poverty by this method alone. Hoy and Sumner show that three-quarters of the global poverty gap could be ended at US$5 per day with national redistribution along the lines that they propose. At US$10 (the next highest poverty line they examine), only 17% of the global poverty gap could be covered. Only six of the high-poverty middle-income nations they examine could end poverty at US$5 per day with national redistribution, while none could end poverty at US$10 per day. One way to end poverty at these higher thresholds is by growing the domestic economies of global South countries, so that they generate new resources that could be redistributed toward poverty eradication; but this would exacerbate the transgression of planetary boundaries. Alternatively, income could be better distributed globally. There are two ways to accomplish the latter: (1) change the rules of the global economy – on trade, debt, tax evasion, capital flows, global governance, etc – to make it fairer to global South countries, thus allowing them to claim a greater share of global GDP (and, hopefully, use the additional resources to achieve social thresholds); or (2) redistribute income through, say, a universal basic income or universal social services funded by a financial transaction tax, a carbon tax, a resource extraction tax, a wealth tax and so on.[29]

The above analysis illustrates how sensitive the income indicator is to the definition of poverty. That said, there may be reasons to question the utility of relying too heavily on income as a key indicator of a good life. If the purpose of setting an income threshold is to allow for meaningful achievement on indicators like nutrition, life expectancy and infant mortality, then it is not clear that income needs to be included in the analysis if these other indicators are already represented. Indeed, doing so may penalise countries that are able to deliver high levels of human well-being without high levels of income.

Achieving a good life for all will exacerbate global ecological overshoot

As I have argued above, it is theoretically possible – under already-existing conditions and with known policy measures – for nations to achieve all key social thresholds without exceeding biophysical boundaries. For the low-income countries clustered toward the vertical axis in the graphs, which are well under biophysical boundaries, this will entail at least some increase in their biophysical footprint. This in turn means increasing the *global aggregate* biophysical footprint as well, which is problematic given that planetary boundaries are already being overshot on a global level. The O'Neill data shows global overshoot on CO_2 emissions, phosphorous, nitrogen, ecological footprint and material footprint. If this is the case, then the only way for all global South nations to achieve all social thresholds without triggering further overshoot is for rich nations to significantly diminish their biophysical footprints.

We can use the O'Neill dataset to quantify this. Let us assume that there is a 'boundary model' of efficient development whereby poor nations can achieve all social thresholds without overshooting planetary boundaries (as I have argued, is theoretically possible). If poor nations implement this model and achieve all social thresholds while increasing their biophysical footprints up to the boundary for each indicator, how much additional biophysical pressure would this represent on a global scale? Tables 2–5 show existing global scores on five biophysical indicators. They exclude indicators for land and water, as the O'Neill data show that it is possible to achieve a good life for all with relatively low per capita use of land and water, as many nations with full social achievement are within the boundaries for these indicators.

Table 2 shows what global resource use would be if poor nations (those with average social scores less than 1 and average biophysical scores less than 1) implemented the boundary model of development and increased their biophysical footprints to 1 for each indicator. The final row in Table 2 shows the additional overshoot that this would entail, rendered as a percentage of the planetary boundary. The results show that development according to the boundary model entails exacerbating global overshoot by an average of 19%. This assumes no additional resource use by rich nations.

We can test a more optimistic scenario using what we might call the Sri Lanka model, whereby we assume that poor nations can achieve all social thresholds while increasing their biophysical footprints up to the level of Sri Lanka for each indicator. Sri Lanka's average social shortfall is minimal, with a score of 0.94 (excluding the five qualitative social indicators), and as a middle-income country it should have the capacity to cover this shortfall through national redistribution, without any additional biophysical pressure. Table 3 shows that if poor nations implement the Sri Lanka model, it would entail minimal additional biophysical pressure, exacerbating global overshoot by an average of only 2%.

Table 2. Per capita consumption of resources relative to planetary boundaries, with development according to Boundary model.

	CO_2	Phosphorus	Nitrogen	Ecological Footprint	Material Footprint
Boundary model	1	1	1	1	1
World	3.21	2.22	2.31	1.32	1.41
World with development according to Boundary model	3.33	2.46	2.51	1.50	1.64
Additional overshoot	12%	24%	20%	18%	23%

Table 3. Per capita consumption of resources relative to planetary boundaries, with development according to Sri Lanka model.

	CO_2	Phosphorus	Nitrogen	Ecological Footprint	Material Footprint
Sri Lanka	0.65	0.17	0.21	0.68	0.45
World	3.21	2.22	2.31	1.32	1.41
World with development according to Sri Lanka model	3.27	2.23	2.32	1.37	1.44
Additional overshoot	2%	1%	1%	4%	2%

Table 4. Per capita consumption of resources relative to planetary boundaries, with development according to Tunisia model.

	CO_2	Phosphorus	Nitrogen	Ecological Footprint	Material Footprint
Tunisia	1.7	1.14	0.96	1.02	1.24
World	3.21	2.22	2.31	1.32	1.41
World with development according to Tunisia model	3.61	2.53	2.49	1.51	1.76
Additional overshoot	40%	31%	18%	19%	35%

Table 5. Per capita consumption of resources relative to planetary boundaries, with development according to Costa Rica model.

	CO_2	Phosphorus	Nitrogen	Ecological Footprint	Material Footprint
Costa Rica	1.72	1.2	1.14	1.29	1.41
World	3.21	2.22	2.31	1.32	1.41
World with development according to Costa Rica model	3.62	2.55	2.57	1.65	1.84
Additional overshoot	41%	33%	26%	33%	43%

Sri Lanka is an outlier, however (along with Moldova). We can be more conservative by using the Tunisia model. Tunisia's average social shortfall is even less than Sri Lanka's, with an overall score of 0.98 (excluding the five qualitative social indicators). Its biophysical footprint is in overshoot, but minimally so. As a middle-income country, it should be able to cover its social shortfall through national redistribution. Table 4 shows that if poor nations implement the Tunisia model, it would entail exacerbating global overshoot by an average of 29%.

Relying on the above models means making assumptions about the political feasibility of national redistribution, and about the ability of nations to achieve qualitative social thresholds without any additional biophysical pressure. While these assumptions are theoretically valid, we have no evidence for them among existing national examples. We can be more realistic by using the Costa Rica model. Costa Rica has minimal average social shortfall (with a score of 0.99) across all 11 social indicators, including the qualitative ones, and therefore requires no speculation on the possibility of achieving qualitative social indicators without any additional biophysical pressure, and there are no concerns about the feasibility of national redistribution. Table 5 shows that if poor nations implement the Costa Rica model, it would entail worsening global overshoot by an average of 35%.

Rich countries will need to adopt de-growth strategies

Tables 2–5 demonstrate that while it is possible for poor nations to achieve a good life for all within planetary boundaries, the additional resource use that this entails would significantly exacerbate *global* overshoot of planetary boundaries, given the high degree of overshoot that presently characterises rich economies. This conclusion holds true for all four development models explored above. The only way to achieve a good life for all within planetary boundaries is for overshoot nations to significantly reduce their biophysical footprints.

Table 6 quantifies the average biophysical reductions required of overshoot nations under three different scenarios. Row 1 assumes that all poor nations achieve social thresholds by increasing their biophysical footprints to planetary boundaries for each indicator (the 'boundary model' of development), and shows the average reductions required of overshoot nations

Table 6. Average biophysical footprint reduction from current levels required of overshoot nations.

	CO_2	Phosphorus	Nitrogen	Ecological Footprint	Material Footprint
Boundary model	70%	59%	60%	33%	39%
Tunisia model	53%	55%	61%	32%	30%
Costa Rica model	52%	53%	56%	22%	23%

to get global biophysical footprints down to the level of planetary boundaries (average reductions of 52% from current levels required). Row 2 assumes that poor nations achieve social thresholds by implementing the Tunisia model, and shows the average reductions required of overshoot nations to get global biophysical footprints down to the level of Tunisia (average reductions of 46% required). Row 3 repeats the exercise for convergence at the biophysical scores of Costa Rica (average reductions of 41% required). Note that convergence at the Tunisia and Costa Rica models would still entail overshooting planetary boundaries (except for Nitrogen in the case of the Tunisia model).

Theoretically, it should be possible for overshoot nations to reduce their biophysical consumption down to planetary boundaries without falling below social thresholds even while improving performance on social indicators. Indeed, this is what O'Neill et al. argue. But it may not be possible for them to do so while at the same time pursuing continuous GDP growth.

There is strong evidence for this in relation to the material footprint indicator, which measures extraction and use of biomass, minerals, fossil fuels and construction materials. Material footprint is a key indicator in that it pertains to a broad range of ecological concerns, including deforestation, meat consumption, overfishing, greenhouse gas emissions and environmental damage due to mining. To reduce material footprint while at the same time pursuing GDP growth requires absolute decoupling of GDP from material use. Three recent studies (Dittrich et al., Schandl et al., UNEP) have explored whether aggressive policy measures and gains in technological efficiency can drive absolute decoupling in the decades to 2050; all of them conclude that *relative* decoupling can be achieved, but they find no evidence that *absolute* decoupling will happen – even under highly optimistic assumptions.[30] Models that incorporate the 'rebound effect' yield particularly discouraging results.[31]

These studies look at material footprint trends at a global level, but the same general conclusion holds for rich nations. While one well-known model (Hatfield-Dodds et al.) suggests absolute decoupling may be possible (in Australia), it assumes a rate of efficiency improvement that lacks empirical basis and is in any case out of scope.[32] Moreover, Ward et al. demonstrate that the result holds only in the short term. As efficiency improvements reach physical limits, the scale effect of growth drives total resource use up. Ward et al. conclude that this implies a 'robust rebuttal to the claim of absolute decoupling': 'decoupling of GDP growth from resource use, whether relative or absolute, is at best only temporary. Permanent decoupling (absolute or relative) is impossible for essential, non-substitutable resources because the efficiency gains are ultimately governed by physical limits. Growth in GDP ultimately cannot plausibly be decoupled from growth in material and energy use, demonstrating categorically that GDP growth cannot be sustained indefinitely'.[33]

Similar concerns apply to CO_2 emissions. It is possible to achieve absolute decoupling of GDP from CO_2 emissions; the question is whether it can be achieved at a rate rapid enough to respect the carbon budget for 2C. Anderson and Bows have modelled the emissions reductions necessary for achieving a 50% chance of staying under 2C (assuming the principle of common but differentiated responsibility, whereby high-income nations need to lead on emissions reductions). They conclude that high-income nations (Annex 1 nations) need to reduce emissions by 10% per year, beginning in 2015.[34] At existing rates of economic growth in Annex 1 nations (i.e. 1.86% per year, the average from 2010–2014), decoupling must occur at a rate of 13.18% per year.[35] This is seven times faster than existing rates of decoupling in Annex 1 nations (viz., 1.9% per year from 1970 to 2013).[36] It also exceeds the decoupling rate implied by the average G20 Nationally Determined Contributions under the Paris Agreement (viz., 3% per year) by a factor of more than four.

It is theoretically possible to achieve the emissions reductions required for 2C by relying on negative emissions technologies. Most IPCC pathways for 2C rely on BECCS (bioenergy with carbon capture and storage) in particular. However, an emerging consensus among climate scientists rejects the use of BECCS in climate models on the grounds that it is a speculative technology and there is no evidence that it can be scaled fast enough and to the extent required; moreover, it would require such expansive land use that it would make it impossible to meet minimum food requirements for the world's population (violating the nutrition threshold) and would significantly exacerbate biodiversity loss, which is one of the key biophysical boundaries.[37] Thus, relying on BECCS for negative emissions is not acceptable as part of a strategy for achieving a good life for all within planetary boundaries.

In sum, there is no empirical evidence to support the notion that rich nations can make sufficiently dramatic reductions in resource use and emissions while at the same time pursuing economic growth. The reason for this is that the scale effect of growth eats the gains that can be feasibly achieved through decoupling. In light of this, achieving a good life for all within planetary boundaries will require that rich nations begin to gradually downscale their aggregate economic activity, embarking on a trajectory of planned de-growth. One approach would be to gradually reduce the size of the population (in an equitable, progressive and non-coercive way), so that GDP per capita can be maintained even while total economic activity shrinks. But if we assume that the population grows according to existing projections and stabilises at 9–11 billion, this will require de-growth in both absolute and per capita terms. Scholars argue that de-growth can be achieved without any loss to social indicators, and could further enhance human well-being if done equitably.[38] This can be accomplished by downscaling socially unnecessary and ecologically destructive industries, while covering any employment shortfalls by shortening the working week, by distributing existing income and resources more fairly through progressive taxation and reallocation into social spending (i.e. on healthcare, education, etc) and/or by improving wages.

It is clear, however, that any prolonged, planned reduction of aggregate economic activity is not compatible with capitalism, which fundamentally depends on ever-increasing growth of production and consumption. De-growth strategies will therefore require evolving beyond the strictures of capitalism toward a post-growth system.

Implications for the development agenda

When it comes to achieving a good life for all within planetary boundaries, poor nations are the 'easy' part. It is rich nations that present the real challenge. For poor nations, achieving a good life for all within planetary boundaries requires improving the development model to make it more efficient at converting resources into well-being. In some cases, this can be accomplished largely through redistribution of existing domestic resources; in others, it requires moderate increases in resource use, up to the level of planetary boundaries. For rich nations, it requires reductions of resource use that are so significant as to require the adoption of de-growth strategies, and therefore a shift toward post-capitalist economic models. This requires a fundamental reorientation of development theory, from focusing primarily on the deficiencies of poor countries to focusing on the excesses of rich countries.

Much of the existing literature on the safe and just space framework sidesteps this conclusion. For example, Raworth does note the crucial role of national-level redistribution (advocating for stronger minimum wages and the introduction of maximum wages, land-value taxes, resource taxes, more egalitarian distribution of finance, a shift to cooperative models of business, etc), and highlights various strategies for recycling and regeneration that businesses and governments can use.[39] However, on the question of growth she is 'agnostic' and argues for the need to design 'an economy that promotes human prosperity whether GDP is going up, down, or holding steady'.[40] At most, she promotes an 'S Curve' for growth. Just as plants and animals grow to the point of maturity and then remain at an equilibrium, so too nations should seek to achieve 'arrival' at an adequate level of economic development, with GDP reaching a steady, zero-growth level.[41] But she sidesteps the question of how much GDP is actually sufficient for a good life for all, and sidesteps the question of whether de-growth will be necessary for countries that dramatically overshoot planetary boundaries. Indeed, the S Curve implies that rich nations can safely continue their *existing* levels of economic activity so long as they do not grow any further. In an era of dangerous ecological overshoot, and given the absence of empirical evidence for sufficient absolute decoupling of GDP from environmental impact, this is not a defensible position.

Like Raworth, O'Neill et al. identify key strategies that nations can use to reduce their biophysical footprints: switching to renewable energy, producing products with longer lifetimes, reducing unnecessary waste, shifting from animal to crop products, investing in new technologies and moving beyond GDP to embrace new measures of progress. Unlike Raworth, however, they indicate that 'It could also involve the pursuit of "degrowth" in wealthy nations, and the shift towards alternative economic models such as a steady-state economy'.[42] Yet it would seem that the O'Neill data requires a stronger conclusion here. Achieving a good life for all within planetary boundaries will require overshoot nations to reduce their biophysical footprints by at least 40–50% on average from current levels (assuming poor nations can achieve social thresholds within planetary boundaries). Extant empirical evidence indicates that this is highly unlikely to be possible without de-growth strategies.

This has radical implications for our approach to international development. The Sustainable Development Goals, for instance, will need to be rethought. At present they include a demand for exponential global GDP growth. Target 8.1 reads: 'Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries', as measured by 'annual growth rate of real GDP per capita'. The assumption is that global growth will facilitate the achievement of key social goals, such as on poverty, hunger and education. But achieving the aggregate rate of growth required by Goal 8 will violate the sustainability goals (i.e. Goal 12.2: 'By 2030, achieve sustainable management and efficient use of natural resources'; Goal 13: 'Take urgent action to combat climate change and its impacts'). In other words, the SDGs, as presently written, are internally contradictory.

In order for the SDGs to succeed, they will need to allow for growth in poor nations (for the sake of defined social goals, with high levels of efficiency in converting resources into well-being, and with heavy pro-poor bias), while calling for rich nations to reduce their biophysical footprints down to sustainable levels, with specific targets. As noted above, one way to achieve this would be through redistributing global GDP from rich nations to poor nations, either by making the rules of the global economy fairer, or through direct transfers of income. But the only way to ensure that planetary boundaries are not violated on a global level would be to impose caps on resource use and pollution for every biophysical process identified in the planetary boundary framework, so that we never extract more than the Earth can safely regenerate, and never pollute more than it can absorb. The 'budgets' for each biophysical process could then be distributed equitably among nations, on the basis of 'common but differentiated responsibility' (as in UNFCCC Article 3.1), taking account of development needs and historical responsibility for overshoot.

Acknowledgments

I would like to thank Dan O'Neill for his comments on an earlier draft and for insights he shared through conversations and correspondence. Thanks also to the anonymous reviewers, whose comments significantly improved the argument. Any shortcomings are my own.

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Notes

1. Rockström et al., "Planetary Boundaries"; Steffen et al., "Planetary Boundaries."
2. Raworth, "A Safe and Just Space"; Raworth, *Doughnut Economics*.
3. O'Neill et al., "A Good Life for All."
4. Per capita equivalents are applied equally across countries. O'Neill et al. do not account for whether some countries require more resource use than others for reasons beyond their control; for instance, Arctic nations may require more energy to heat their homes than tropical nations.
5. O'Neill et al., "A Good Life for All," 88.
6. Ibid., 90.
7. Ibid., 90.
8. Leeds University, "A Good Life for All."
9. O'Neill et al., "A Good Life for All," 92.
10. Leeds University, "A Good Life for All."
11. In mathematical terms, the normalised data are given by $y_{norm} = (y - y_{min}) \div (y^* - y_{min})$, where y is the social indicator, y^* is the social threshold and y_{min} is the lowest value for the social indicator.
12. For instance, changing the lowest actually-existing value for one of the social indicators would change its weighting in the average.

13. Franzoni and Sanchez-Ancochea, *Quest for Universal Social Policy.*
14. The Moldova result is dubious; there are some concerns about the validity of the biophysical data for Moldova, as it is a very small country and information on trade across its borders is difficult to verify.
15. O'Neill et al., "A Good Life for All," 91.
16. O'Neill et al., "Supplementary Materials," Table 3.
17. Hoy and Sumner, "Gasoline, Guns and Giveaways."
18. Higher levels of inequality tend to increase ecological degradation. For instance, Holland et al., "Cross-National Analysis", find that countries with higher levels of inequality have higher levels of biodiversity loss. It is reasonable to expect that removing subsidies for fossil fuels and reallocating surplus military spending would probably reduce CO_2 emissions. Redistributing income downward might have a similar effect, given that CO_2 emissions are disproportionately high among the richest 10% of each nation; Chancel and Piketty, *Carbon and Inequality.*
19. Hickel, "True Extent of Global Poverty and Hunger."
20. NDTV, "Poverty in India"; Prashad, "Making Poverty History."
21. Cimadamore et al., *Poverty and Millennium Development Goals*.
22. Wagstaff, "Child Health on a Dollar a Day."
23. Lahoti and Reddy, "$1.90 per Day."
24. New Economics Foundation, "How Poor is Poor?"
25. Edward, "The Ethical Poverty Line."
26. López-Calva and Ortiz-Juarez, "A Vulnerability Approach"; Sumner et al., "Prospects of the Poor."
27. Kenny, "Why Ending Extreme Poverty"; Pritchett, "Who is Not Poor?"
28. Raworth, *Doughnut Economics.*
29. Hickel, *The Divide*, 253–278.
30. Dittrich et al., *Green Economies*; Schandl et al., "Decoupling Global Environmental Pressure"; UNEP, "Resource Efficiency."
31. UNEP, "Resource Efficiency," 106 ff.
32. Alexander et al., "A Critique of Decoupling."
33. Ward et al., "Is Decoupling Possible?"
34. Anderson and Bows, "Beyond 'Dangerous' Climate Change."
35. Using the equation: Rate of necessary decoupling = GDP growth rate / (1 – Rate of necessary emissions reductions).
36. Decoupling slowed from an average of 2.3% per year in the first half of the period to an average of 1.6% in the second half, according to World Bank, *World Development Report 1999/*2000, Databank, CO_2 emissions (kg per 2010 US$GDP).
37. For concern about the viability of BECCS, see: Anderson and Peters, "The Trouble with Negative Emissions"; Larkin et al., "What if Negative Emissions Technologies Fail?"; Fuss et al., "Betting on Negative Emissions." For concern about the ecological consequences of implementing BECCS, see: Smith et al., "Biophysical and Economic Limits"; Heck et al., "Biomass-Based Negative Emissions."
38. Alier, "Socially Sustainable Economic De-growth"; Jackson, *Prosperity without Growth*; Kallis, "In Defense of Degrowth."
39. Raworth, *Doughnut Economics.*
40. Ibid., 245.
41. Ibid., 251.
42. O'Neill et al., "A Good Life for All," 92.

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