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RESEARCH ARTICLE

The contradiction of the sustainable development goals: Growth versus ecology on a finite planet

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Abstract

There are two sides to the Sustainable Development Goals (SDGs), which appear at risk of contradiction. One calls for humanity to achieve "harmony with nature" and to protect the planet from degradation, with specific targets laid out in Goals 6, 12, 13, 14, and 15. The other calls for continued global economic growth equivalent to 3% per year, as outlined in Goal 8, as a method for achieving human development objectives. The SDGs assume that efficiency improvements will suffice to reconcile the tension between growth and ecological sustainability. This paper draws on empirical data to test whether this assumption is valid, paying particular attention to two key ecological indicators: resource use and CO2 emissions. The results show that global growth of 3% per year renders it empirically infeasible to achieve (a) any reductions in aggregate global resource use and (b) reductions in CO2 emissions rapid enough to stay within the carbon budget for 2°C. In other words, Goal 8 violates the sustainability objectives of the SDGs. The paper proposes specific changes to SDG targets in order to resolve this issue, such as removing the requirement of *aggregate global* growth and introducing quantified objectives for resource use per capita with substantial reductions in high-income nations. Scaling down resource use is also the most feasible way to achieve the climate target, as it reduces energy demand. The paper presents alternative pathways for realizing human development objectives that rely on reducing inequality—both within nations and between them—rather than aggregate growth.

KEYWORDS

climate change, decoupling, growth, human development, inequality, resource use, sustainable development

1 | INTRODUCTION

The Sustainable Development Goals (SDGs) were adopted by the United Nations General Assembly in September 2015. With 17 broad goals and 169 specific targets, the SDGs have been celebrated for advancing a more comprehensive and holistic vision than that of their predecessors, the Millennium Development Goals (MDGs). The SDGs represent a clear shift in development theory from seeing poverty and underdevelopment as separate from environmental concerns, to recognizing that the two are intimately bound together: that human flourishing cannot be achieved and sustained on a planet in ecological crisis. But despite these advances, questions remain about whether the SDGs manage to attain internal coherence.

There are two sides to the SDGs, which appear at risk of contradiction. One calls for humanity to achieve "harmony with nature," to protect the planet from degradation, and to take urgent action on climate change, with specific targets laid out in Goals 6, 12, 13, 14, and 15 (described below). The other calls for continued global economic growth at existing levels or higher through 2030, as outlined in Goal 8, on the assumption that growth is necessary for human development and the eradication of poverty and hunger (as in Goals 1, 2, 3, and 4; described below). A number of studies have commented on the tension between the sustainability and growth objectives of the SDGs. Gupta and Vegelin (2016) noticed that the SDGs embody "trade-offs in favour of economic growth over social well-being and ecological viability." Pongiglione (2015) suggests that such contradictions should be resolved by prioritizing human development goals that are compatible with and indeed even facilitate sustainability objectives. Hajer et al. (2015) call for the SDGs to start with a firm commitment to respecting planetary boundaries and seek to achieve human development within those limits, following the "safe and justice operating space" model.

This paper adds to the literature by assessing the tension between the growth and sustainability objectives in quantified terms, to determine whether it is in fact feasible to pursue them both. Can we achieve the growth demanded by Goal 8 while at the same time feasibly upholding the SDGs' commitments to sustainability? The paper focuses on two key ecological indicators: resource use and greenhouse gas emissions. With respect to resource use, the SDGs assume that we can decouple GDP from resource use such that the global economy can continue to grow while environmental impact declines to sustainable levels. With respect to greenhouse gas emissions, the SDGs assume that the global economy can continue to grow while emissions decline fast enough to stay within the carbon budget for 2°C warming over pre-industrial levels, as per the Paris Agreement. I test these assumptions against extant empirical evidence to determine whether they are robust enough to form the basis of international policy.

The results indicate that the growth Goal—as presently formulated —is not compatible with the sustainability objectives of the SDGs, given existing data and empirical models. The paper concludes by proposing specific changes to the SDGs in order to resolve this contradiction while presenting alternative pathways for realizing human development objectives that rely on equity—both within nations and between them—rather than aggregate growth.

2 | THE TWO SIDES OF THE SDGS

The preamble to the SDGs recognizes that "Natural resource depletion and adverse impacts of environmental degradation, including desertification, drought, land degradation, freshwater scarcity, and loss of biodiversity, add to and exacerbate the list of challenges which humanity faces." To address this crisis, the text affirms that "economic, social, and technological progress" must occur "in harmony with nature." It envisages "a world in which … consumption and production patterns and use of all natural resources—from air to land, from rivers, lakes and aquifers to oceans and seas—*are sustainable* … One in which humanity lives *in harmony with nature* and in which wildlife and other living species are protected." It affirms that "planet Earth and its ecosystems are our common home," and promises to "ensure the lasting protection of the planet and its natural resources." It sets out "*to protect the planet from degradation*," and "to *conserve and sustainably use* oceans and seas, freshwater resources, as well as forests, mountains, and drylands and to protect biodiversity, ecosystems, and wildlife … tackle water scarcity and water pollution, to strengthen cooperation on desertification, dust storms, land degradation, and drought." [emphases added].

Five of the 17 goals deal directly with sustainability. Goal 6: "Ensure availability and sustainable management of water and sanitation for all." Goal 12: "Ensure sustainable consumption and production patterns," with Target 12.2 being particularly important: "By 2030, achieve sustainable management and efficient use of natural resources." Goal 13: "Take urgent action to combat climate change and its impacts." Goal 14: "Conserve and sustainably use the oceans, seas, and marine resources for sustainable development." Goal 15: "Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and biodiversity loss." I refer to these collectively as the "sustainability objectives" of the SDGs.

At the same time, the SDGs call for a significant increase in the size of the global economy. This is clearest in Goal 8. Target 8.1 reads: "Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7% gross domestic product growth per annum in the least developed countries," as measured by "annual growth rate of real GDP per capita." Target 8.2 adds: "Achieve higher levels of economic productivity," as measured by "annual growth rate of real GDP per employed person." Target 9.2 indicates that this growth should be primarily industrial: "Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product in line with national circumstances, and double its share in least developed countries."

We can quantify Target 8.1. In the years between the end of the financial crisis in 2010 and the publication of the SDGs in 2015, world GDP per capita grew at an average of 1.85% per year.[1] Following the language of Target 8.1, let us assume that the SDGs aim to sustain this rate of growth from 2015 to 2030. At this rate, global GDP per capita would increase 32% by 2030. To get a sense for what the size of the global economy would be in 2030 at this rate, we have to account for population growth. According to the United Nations, global population is projected to grow from 7.2 billion in 2015 to 8.5 billion in 2030,[2] at an average rate of 1.11% per year over the period. To sustain *per capita* growth of 1.85%, then, the GDP needs to grow at 2.96% per year. At this rate, the global economy would expand 55% by 2030.

Yet Target 8.1 goes beyond simply maintaining the present rate of global GDP growth. In least developed countries (LDCs), the goal is to *increase* annual GDP growth and maintain it at a minimum of 7% per year. This represents an additional 1.73% annual growth in LDCs on top of their 2010–2014 average. If we add this additional LDC growth

[1]The timeframe here is the 4 years from the end of 2010 to the end of 2014. All GDP-related figures are derived from World Bank data, in constant 2010 US$.

[2]United Nations, "UN projects world population," 2015.

requirement to the 2.96% baseline global growth required by Target 8.1, this translates into aggregate global GDP growth of 3% per year. In what follows, I will use this figure as the specific expression of Target 8.1.

There is no rationale given for why the SDGs promote increasing industrial growth (Esquivel, 2016). The document does not specify whether it is an end in itself, or a means to an end. The assumption seems to be—although this is never articulated—that industrial growth is necessary for achieving human development. The SDGs are committed to ending poverty (Goal 1), ending hunger (Goal 2), ensuring health and promoting well-being (Goal 3), and improving access to education (Goal 4). Szirmai (2015) suggests that Goals 8 and 9 were included as a reaction to the criticism that the MDGs lack a theoretical foundation for how to achieve the development goals (the assumed link between growth and human development is employment: Target 8.5 implies that growth should create more jobs). But this move has not helped matters much, and indeed introduces another problem. In their review of the SDGs, the International Council for Science and International Social Science Council (2015) finds that the SDGs lack theoretical grounding and suffer from internal contradictions between development and sustainability, although they do not specify the latter.

Let us leave aside for now the question of whether GDP growth is in fact necessary for human development—that is, whether it is a meaningful and efficient way of reducing poverty and hunger and of improving human well-being. I will return to this in the concluding discussion. The more immediate matter is a straightforward empirical question: whether it is possible to achieve 3% annual global GDP growth through 2030, as Goal 8 demands, while at the same time upholding the SDGs' commitment to the sustainability objectives, specifically (a) achieving sustainable use of natural resources and (b) reducing greenhouse gas emissions rapidly enough to keep us within the carbon budget for 2°C. I will examine these in turn.

3 | IS GOAL 8 COMPATIBLE WITH SUSTAINABLE RESOURCE USE?

Goals 6, 12, 14, and 15 all have to do with resource use in various dimensions, but here, I will focus on the all-encompassing objective represented in Target 12.2: "By 2030, achieve sustainable management and efficient use of natural resources," as measured by "material footprint, material footprint per capita, and material footprint per GDP."

Material footprint is a measure of resource use that covers all of the resources consumed by a nation (metals, fossil fuels, biomass, and construction materials), including the upstream resources involved in producing and shipping imported goods (Gutowski, Cooper, & Sahni, 2017; Wiedmann et al., 2015). Although material footprint is not a direct indicator of ecological pressure, a robust proxy (Krausmann et al., 2009, p. 2703). Van der Voet, van Oers, and Nikolic (2004) find that there is a high degree of correlation (0.73) between material throughput and ecological impacts. In this sense, material footprint is an important indicator of pressure on marine ecosystems (Goal 14) and terrestrial ecosystems (Goal 15).

Material footprint per GDP is an indicator of resource efficiency. Higher resource efficiency means more GDP extracted per unit of material resources. Target 8.4 states: "Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead." The SDGs rely on this objective to reconcile the tension between economic growth and ecological sustainability.

The SDGs offer no quantified target for resource efficiency, and do not specify what a sustainable level of material footprint might be.[3] The supplementary material to Goal 12 clarifies that achieving sustainability requires "reducing resource use," but without indicating by how much. The scholarship on this question is still limited, but a clear consensus is emerging. Dittrich, Giljum, Lutter, and Polzin (2012) initially proposed 50 billion tons per year as a planetary boundary for material footprint, with a per capita limit of 8 tons per year by 2030. The figure of 50 billion tons has also been adopted by Hoekstra and Wiedmann (2014) in a high-profile study, as well as by the UN Environment Programme's International Resource Panel (2014), which recommends a per capita target of 6–8 tons per year by 2050. Bringezu (2015) offers further justification for 50 billion tons and suggests a per capita target of 3–6 tons by 2050. Bringezu proposed a quantified potential sustainability corridor for the SDGs, but it was not included in the final draft of the goals.

Regardless of the target we might choose, the objective of reducing material footprint by any amount requires a dramatic reversal of present trends. Material footprint has been rising on a steady trajectory over the past century of recorded data (Giljum, Dittrich, Lieber, & Lutter, 2014; Krausmann et al., 2009), and reached 87 billion tons in 2015.[4] On a per capita basis, the majority of this overshoot is due to consumption in high-income nations (~27 tons per person per year). As for material footprint per GDP, there was a period of relative decoupling from 1980 to 2002: material footprint grew by 1.78% per year, which was slower than the rate of global GDP growth (2.9% per year).[5] Using the formula (Δ Efficiency = Δ Output/Δ Input), this represents relative decoupling of 1.11% per year. But during the period 2002 to 2013, the relationship changed. Material footprint growth accelerated to 3.85% per year, outstripping the growth rate of GDP (2.93% per year).[6] In other words, the material efficiency of the world economy has been worsening in the 21st century, not improving.

This represents a problem for the SDGs. If the resource efficiency trends of the 21st century continue, the call in Target 8.1 for 3% annual global GDP growth will drive material footprint up from

[3]Nor does the 10-year framework of programs on sustainable consumption and production, to which the SDGs refer (in Targets 8.4 and 12.1).

[4]According to the 2018 imprint of materialflow.net.

[5]These figures come from the 2015 imprint of materialflows.net.

[6]These figures come from the 2015 imprint of materialflows.net.

87 billion tons in 2015 to 167 billion tons in 2030, overshooting the sustainability threshold by a factor of three. If we achieve the resource efficiency trends of 1980 to 2002, 3% annual GDP growth will drive material footprint to 119 billion tons per year by 2030, which overshoots the sustainability threshold by a factor of two. Both of these scenarios violate Goal 12. The only way to achieve the GDP growth target while at the same time reducing material footprint is to achieve *absolute* decoupling, in other words, decoupling at a rate that exceeds the rate of GDP growth. Given that Target 8.1 requires GDP growth of 3%, this would require sustained decoupling at a rate of at least 3.01% per year—simply to reduce material footprint by any amount at all.

If we take 50 billion tons as the target for sustainability, material footprint must be reduced by 43% from 2015 levels. To do this by 2030 requires reducing annual resource use by 3.63% per year from 2015 to 2030.[7] If global GDP grows by 3% per year during this period, this requires decoupling at 6.88% per year. In other words, one might argue that we can keep the growth objectives of Target 8.1 as long as we achieve absolute decoupling at a rate of 3.01% per year (in order to reduce material footprint) or 6.88% per year (in order to reduce material footprint to 50 billion tons). The difficulty is that this would require efficiency improvements at a rate three to six times faster than has ever been achieved in history. Indeed, although relative decoupling has occurred in multiple countries and on a global scale in the past (Bringezu, Schultz, Steger, & Baudisch, 2004), there are no examples of nations achieving sustained absolute decoupling and there has never been absolute decoupling at a global scale (Pulselli et al., 2015). The question becomes: Is decoupling at a rate of 3.01% to 6.88% per year feasible?

There are three major empirical studies that explore this question on a global scale. In the first, Dittrich et al. (2012) run a best-case scenario with what they consider to be highly optimistic assumptions, under conditions of continued economic growth. The scenario assumes that all countries follow best practice in efficient resource use, and that reducing the consumption of one material will not lead to more consumption of another material. Under this scenario, material footprint stabilizes at 93 billion tons by 2050. This represents relative decoupling over the period, with some improvement over the 1980–2002 efficiency trend described above. But there is no reduction in material footprint, and it far outstrips the sustainability threshold of 50 billion tons. Thus Goal 12 is violated.

In a second study, Schandl et al. (2016) explore the potential for policy measures to improve resource use outcomes, once again under conditions of continued economic growth (3% per year). The "high efficiency" scenario, with a carbon price rising to $236 per ton, plus a doubling in the material efficiency of the economy due to technological innovations (improving from a rate of 1.5% per year to 4.5%), shows that global material footprint still grows steadily, reaching 95 billion tons in 2050.

It is important to note that Schandl et al. (2016) provide no evidence that their assumed rate of efficiency improvement is possible to sustain. But even so, they conclude: "Our research shows that while some relative decoupling can be achieved in some scenarios, none would lead to an absolute reduction in … materials footprint." As with Dittrich et al. (2012), this result achieves no reduction in material footprint and is far from achieving sustainable levels, thus violating Goal 12.

Finally, the International Resource Panel of the UN Environment Program (2017a, pp. 42–45) models a high efficiency scenario with strong policy measures: a global carbon price rising to $573 per ton, a resource extraction tax, and rapid improvements in resource efficiency (for full details of the model see UNEP, 2017b, p. 287, ff). The result shows that with a modest rate of 1.75% GDP growth, global material footprint rises to 132 billion tons in 2050. Although some relative decoupling is achieved, there is no reduction in material footprint. Indeed, material footprint ends up being significantly higher in 2050 than either Dittrich et al. (2012) or Schandl et al. (2016) predict, because the model incorporates the "rebound effect": As resource efficiency improves, the cost of resources goes down, thus increasing demand and cancelling out some of the gains (UNEP, 2017b, p. 106, ff.; see Herring & Sorrell, 2009).

In other words, existing empirical evidence suggests that absolute decoupling of GDP from material footprint is not feasible on a global scale in the context of continued economic growth, even under the best possible conditions. This presents a problem for the SDGs, as the only way to reconcile Goal 8 with Goal 12 is to achieve absolute decoupling.

There is one well-known study that suggests absolute decoupling is possible on a national scale, however. Hatfield-Dodds et al. (2015) explore scenarios for Australia from 2015 to 2050, assuming high levels of policy-driven efficiency gains and an overall 70% improvement in resource efficiency. The result shows that material footprint falls while GDP continues to rise at 2.41% per year. There are three reasons to be cautious when applying this result to the SDGs, however. First, the study is focused on one of the richest nations in the world, which has unique capacity for resource efficiency improvements, and thus cannot be extrapolated worldwide. Second, the rate of efficiency gains that Hatfield-Dodds et al. assume has been criticized as baseless and unrealistic (Alexander, Rutherford, & Floyd, 2018). Indeed, the Australian Bureau of Agricultural Economics (ABARE, 2008) reports that efficiency is likely to improve by only one-eighth of the rate that Hatfield-Dodds et al. assume. Third, even if we could extrapolate this result worldwide, it would not be enough to reduce resource use to sustainable levels. The result implies decoupling at an average rate of about 4% per year. If the world could achieve this rate from 2015, an economic growth rate of 3% per year would leave us with resource use of 74 billion tons per year by 2030. This represents a reduction in material footprint, but it still overshoots the sustainability threshold by 48%.

Moreover, the Hatfield-Dodds et al. (2015) results apply only to the short term. Ward et al. (2016) have demonstrated that the same model extrapolated into the longer term shows that material footprint begins to rise again after 2050, approaching the rate of GDP growth.

[7]Assuming that resource use in 2015 was the same as in 2013—a conservative assumption.

The reason is that resource efficiency improvements eventually approach physical limits, after which growth drives resource use back up. Ward et al. conclude that this implies a "robust rebuttal to the claim of absolute decoupling." "We conclude that 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. It is therefore misleading to develop growth-oriented policy around the expectation that decoupling is possible."

In other words, although it may be feasible for rich nations to achieve absolute decoupling within the period of the SDGs, existing empirical evidence suggests that it is not feasible to sustain this trajectory in the longer term (i.e., to 2050). On a global scale, the evidence indicates that absolute decoupling is not feasible within any timeframe.

4 | IS GOAL 8 COMPATIBLE WITH THE 2°C CARBON BUDGET?

Goal 13, the goal on climate change, includes a qualifier: "Acknowledging that the United Nations Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change." The UNFCCC's Paris Agreement, which entered into force in November 2016, commits the world to keeping global warming to no more than 2°C above preindustrial levels—and this is what the SDGs therefore pledge to uphold. However, the emissions reductions that the Paris Agreement commits to thus far are not adequate to achieve this goal. Business-as-usual is set to lead to 4.2°C of warming (2.5°C to 5.5°C) by 2100. With the Nationally Determined Contributions and Intended Nationally Determined Contributions in place, global warming is projected to reach 3.3°C (1.9°C to 4.4°C)—an improvement over the reference scenario but still far exceeding the 2°C threshold.[8] Both scenarios violate Goal 13.

In order fulfil Goal 13 and keep within the carbon budget for 2°C, the world will have to make much more aggressive reductions in CO2 emissions, at a rate of 4% per year.[9] Theoretically, this can be accomplished with a total shift to renewable energy (see Jacobson & Delucchi, 2011). The question is, can this be done rapidly enough against a backdrop of economic growth? If the global economy grows by 3% per year, as per Goal 8, then achieving emissions reductions of 4% per year requires decoupling (or decarbonization) of 7.29% per year. For reference, World Bank data shows that global carbon efficiency (CO2 per 2010 $US GDP) improved at a rate of 1.28% per year from 1960 to 2000. In order to stay under 2°C, then, decarbonization needs to occur six times faster than historical rates. And it is important to note that the rate of decarbonization has not improved in the 21st century; World Bank data shows that from 2000 to 2014 there was zero improvement in global carbon efficiency.

The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) includes 116 mitigation scenarios that are consistent with Representative Concentration Pathway 2.6 (RCP2.6), which offers the best chances of staying below 2°C. As all of these scenarios stabilize global temperatures while global GDP continues to rise (GDP growth is a prior assumption in all existing IPCC scenarios), it would appear that they successfully reconcile SDGs 8 and 13. But most of these scenarios do not accomplish this solely by decarbonizing economic activity; rather, they accept that continued economic growth will drive emissions up to the point of overshooting the carbon budget, and assume that "negative emissions technologies" will draw excess CO2 back out of the atmosphere later in the century. One hundred one of the 116 mitigation scenarios rely on negative emissions, specifically a technology known as bioenergy with carbon capture and storage (BECCS), although others are included as well (for a review see Minx et al., 2018).[10] BECCS requires growing large tree plantations to sequester CO2 from the atmosphere, harvesting the biomass and burning it for energy, while capturing the CO2 emissions from the power stations and storing the waste underground.

BECCS is highly controversial among climate scientists. First, it has never been proven to be economically viable at scale (Peters, 2017). Second, the biofuel plantations assumed in the AR5 scenarios would require land two to three times the size of India, which would undermine food production and drive biodiversity loss, water depletion and chemical loading (Smith et al., 2016; Heck, Gerten, Lucht, & Popp, 2018). Third, the necessary CO2 storage capacity may not exist (De Coninck & Benson, 2014; Global CCS Institute, 2015). Anderson and Peters (2016) conclude that "BECCS thus remains a highly speculative technology" and that relying on it is therefore "an unjust and high stakes gamble"; if it is unsuccessful, "society will be locked into a high-temperature pathway." This conclusion is shared by a growing number of scientists (e.g., Fuss et al., 2014; Vaughan & Gough, 2016; Larkin, Kuriakose, Sharmina, & Anderson, 2017; Van Vuuren et al., 2018), and by the European Academies Science Advisory Council (2018).

Given these concerns, it is not clear that we can adjudicate the compatibility of SDGs 8 and 13 using scenarios that rely heavily on BECCS. Moreover, evidence from Smith et al. (2016) and Heck et al. (2018) suggests that the development of bioenergy plantations expansive enough to achieve Goal 13 would likely violate Goal 2 on ending hunger (by removing land from food production), Goal 6 on sustainable water management (due to irrigation requirements), Goal 14 on oceans (due to runoff of agricultural chemicals), and Goal 15 on terrestrial ecosystems (due to expansive monoculture development).

If we exclude BECCS as a dominant assumption, the tension between Goals 8 and 13 becomes more apparent. Only six of the

[8] "Climate scoreboard," climate interactive.

[9] PWC, "Is Paris possible? The Low Carbon Economy Index 2017"

[10] Another nine scenarios include some BECCS but not to the point of achieving negative emissions.

116 scenarios for 2°C in AR5 exclude BECCS. These assume "optimal full technology" in all other areas, plus mass afforestation, and with high mitigation costs. While these are theoretically possible pathways, there is no empirical evidence that they are feasible.

Results of empirical studies that do exist are not promising. Raftery, Zimmer, Frierson, Startz, and Liu (2017) project that decarbonization is likely to reach 1.9% per year on a global scale going forward. Schandl et al. (2016) show that with a carbon price rising to $236 per ton plus a doubling in the material efficiency of the economy (albeit without evidence that this is feasible), we can achieve decarbonization of 3% per year. Before the IPCC began including BECCS in its scenarios, they projected that the world could achieve as much as 3.3% decarbonization per year in a best-case scenario (IPCC, 2000). The C-ROADS model (developed by Climate Interactive and MIT Sloan) suggests that high subsidies for renewables and nuclear power, plus high taxes on oil, gas, and coal could drive global decarbonization at an average rate of 4% per year.

None of these scenarios get us to 7.29% per year, which is the rate of decarbonization required to keep emissions within the 2°C carbon budget while at the same time growing the global economy in line with SDG 8. In other words, empirical models show that the pursuit of SDG 8 will entail violating Goal 13, as the scale effect of growth diminishes gains achieved through decarbonization. Studies published in the past year confirm this conclusion. The International Renewable Energy Association (IRENA, 2018) modelled a rapid shift to solar and wind energy with installation rates up to 4.6 times faster than the present, plus improvements in energy intensity of the global economy at double the historical rate. Van Vuuren et al. (2018) modelled a decline of global population to 6.9 billion by 2100; 80% reduction of meat consumption by 2050; and a rapid shift to the most efficient cars, airplanes, and production facilities for cement and steel, in addition to a carbon tax and other aggressive mitigation strategies. Both studies found that even with these highly optimistic assumptions in place, the pressures of continued GDP growth drive emissions to exceed the carbon budgets for 1.5°C and 2°C. Indeed, Holz, Siegel, Johnston, Jones, and Sterman (2018) find that without widespread use of negative emissions technologies, the required rate of decarbonization for meeting the Paris Agreement is "well outside what is currently deemed achievable, based on historical evidence and standard modelling."

Although the SDGs focus on *global* emissions reductions, it is important to observe the principle of "common but differentiated responsibility," whereby high-income nations (referred to in the climate agreements as Annex-1 nations) will need to make more aggressive reductions than poor nations, given their greater historical responsibility for emissions and their greater capacity for managing the costs of transition to a zero-carbon future. The principle of common but differentiated responsibility is also embodied in the SDGs. Anderson and Bows (2011) have modeled the emissions reductions necessary for achieving a 50% chance of staying under 2°C (more relaxed than the two-thirds chance that the UNFCC calls for), in the absence of BECCS. They assume that non-Annex 1 nations defer peak emissions until 2025, and thereafter are able to mitigate at 7% per year (an ambitious assumption). They then calculate the remaining carbon budget and use the result to determine the necessary mitigation pathway for Annex 1 nations. They conclude that Annex 1 nations need to reduce emissions by 8–10% per year, beginning in 2015. Updating this model for 2019, Anderson estimates that Annex 1 nations need to reduce emissions by 12% per year.[11]

Anderson and Bows note that emissions reductions greater than 3–4% per year are thought to be incompatible with a growing economy. They draw this from Stern (2006), the UK's Committee on Climate Change (2008), and Hof, den Elzen, and van Vuuren (2009). Anderson and Bows conclude, therefore, that the Annex 1 mitigation rates required for staying under 2°C are incompatible with economic growth. According to this literature, then, SDG 8 is incompatible with Goal 13.

We can also approach this question by looking at decarbonization rates in Annex 1 nations. If GDP growth in Annex 1 nations continues at 1.86% per year (the average from 2010 to 2014), as per Target 8.1, then for Annex 1 nations to cut emissions by 12% per year requires decarbonization to occur at a rate of 15.8% per year. For perspective, this is eight times faster than the historic rate of decarbonization in Annex 1 nations (viz., 1.9% per year from 1970 to 2013), and it is important to bear in mind that the rate of decoupling has generally slowed over this period, moving from an average of 2.3% in the first half of the period to an average of 1.6% in the second half (note that these are territorial emissions, not consumption-based emissions; using the latter would show even less progress).[12] 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 five. From this perspective too, the pursuit of Goal 8 entails violating Goal 13.

There is one empirical model, by Grubler et al. (2018), that feasibly accomplishes emissions reductions consistent with 1.5°C, without relying on negative emissions technologies. It does this by reducing material throughput (mostly in high-income nations), which cuts global energy demand by 40% and therefore makes a rapid transition to clean energy possible. Although the Grubler et al. scenario projects continued GDP growth at just over 2% per year, this is an exogenous assumption that is insensitive to changes in material throughput. In other words, the scenario does not account for how reductions in production and consumption might impact GDP. Although the model provides a feasible pathway for achieving Goal 13—indeed the only feasible pathway yet published—that pathway is likely to be incompatible with the GDP growth requirement of Goal 8 (given the coupling between material throughput and GDP), and is incompatible with the industrial output objectives of Goal 9. I will return to the Grubler et al. scenario below.

5 | IMPLICATIONS

In light of the empirical evidence presented above, we can conclude that there are strong indications that Goal 8 (to sustain aggregate

[11] 12% is the figure that Anderson used in various public lectures in 2018. In personal correspondence (2019) he confirmed a range of 10-15% per year.

[12] According to the World Bank, Databank, CO2 emissions (kilograms per 2010 US$ GDP).

GDP growth at 3% per year) is incompatible with the sustainability objectives on resource use and climate change. I will discuss these conclusions in turn.

5.1 | Resource use

Existing empirical evidence suggests that even with aggressive policy measures and optimistic assumptions about efficiency improvements, it is not feasible to achieve any reductions in global material footprint in the context of existing rates of GDP growth (as per Goal 8). The high efficiency scenario in the UNEP (2017a, 2017b) model implies that decoupling of GDP from material footprint can be achieved at a rate of 1% per year on a global scale over the period 2015 to 2050.[13] The Schandl et al. (2016) model implies that decoupling can be achieved at a maximum rate of 2.5% per year over the period 2010 to 2050, although—unlike the UNEP model—this model uses some unjustified assumptions and does not account for the rebound effect.[14]

To reduce global material footprint to 50 billion tons per year requires that resource use falls 3.63% per year from 2015 to 2030. In an economy growing at 3% per year, this requires decoupling of 6.88% per year.[15] This outstrips the UNEP projection by a factor of six, and the Schandl et al. projection by a factor of three. In light of this, we can conclude that Goal 8 violates Goal 12. Indeed, the optimistic decoupling rate projected by Schandl et al.'s high efficiency scenario is not adequate to achieve reductions in material footprint of 3.63% per year even in a zero-growth scenario. The only way to achieve such reductions would be to scale down aggregate global economic activity (i.e., as presently measured by GDP). Reducing material footprint by 3.63% per year requires reducing economic activity by 1.22% per year (if we use Schandle et al.'s assumptions) or 2.67% per year (if we use the UNEP assumptions).

Although 50 billion tons is a consensus figure in the literature, it does not appear as a target in the SDGs, and some might argue that material footprint need not be so low in order to be sustainable. Goal 12 does however require achieving at least *some* reduction in resource use from present levels. In the context of global 3% GDP growth, any level of reduction requires decoupling of at least 3.01% per year. As this exceeds the rates of decoupling projected by UNEP and Schandl et al. (2016), we can conclude that Goal 8 violates Goal 12 even under these "easier" parameters. Achieving any reductions in global material footprint would require capping the maximum rate of global GDP growth at 2.5% per year (under the Schandl et al. assumptions) or at 1% per year (under the UNEP assumptions)—both of which are significantly lower than Goal 8 calls for.

[13]GDP grows by 1.75% per year, whereas resource use grows by 1.27% per year.

[14]GDP grows by 3% per year, whereas resource use grows by 0.45% per year.

[15]Setting the target date at 2050 instead of 2030 would allow for a slower rate of decoupling.

5.2 | Climate change

In order to stay within the carbon budget for 2°C, global emissions need to be cut by 4% per year—assuming no widespread use of BECCS. In the context of an economy growing at 3% per year, this requires decoupling of 7.29% per year. This is six times faster than historical rates, more than double what the Schandl et al. (2016) model and IPCC (2000) model project (3% per year and 3.3% per year, respectively), and significantly faster than what the C-ROADS model projects (4% per year), all under best-case scenario policy settings. In light of this data, we can conclude that Goal 8 violates Goal 13. If we use the Schandl et al. assumptions, reducing emissions by 4% per year requires reducing global economic activity by 1.12% per year. If we use the C-ROADS assumptions, it requires maintaining global GDP at present levels (in other words, it is possible to decarbonize fast enough to stay under 2°C, but only in a zero-growth economy).

These models are restricted to relatively conventional approaches, such as taxes and efficiency improvements. Alternative approaches—including a planned transition to wind and solar power, reductions in global population and meat consumption, and so forth (i.e., IRENA, 2018; Van Vuuren et al., 2018)—may allow for some continued global economic growth, but significantly lower than the rate required by Goal 8. Schroder and Storm (2018) find that, if we are to reduce emissions in line with the 2°C target, global economic growth can be no more than 0.45% per year over the coming decades.

Yet even while low levels of aggregate economic growth may be acceptable on a global level, the implications for Annex 1 nations are starker. The maximum feasible rate of decarbonization suggested by the models above is 4%, using conventional approaches. Even if Annex 1 nations are able to double this rate using the alternative approaches suggested above (a highly optimistic assumption), they would still fall significantly short of the 12% rate of annual emissions reductions that they need to achieve. These results suggest that the only feasible pathway for Annex 1 nations to achieve their obligations under the Paris agreement is to scale down economic activity.

The objective of "scaling down" economic activity is known in the ecological economics literature as "degrowth." The goal is not to reduce GDP, but rather to reduce material throughput and energy demand (with the understanding that this may result in a reduction of GDP as currently measured). Schneider et al. (2010, p. 511) define degrowth as "an equitable downscaling of economic production and consumption that increases human well-being and enhances ecological conditions." There is an extensive literature on how high-income countries can maintain and even improve their levels of human development while slowing their economic activity (e.g., Alier, 2009; Jackson, 2009; Kallis, 2011; Kallis, 2018; Victor, 2008), for example by redistributing existing income, investing in social services, shortening the working week, and improving wages.

Both the Van Vuuren et al. (2018) and Grubler et al. (2018) scenarios cited above represent a degrowth approach, showing the Paris target can be brought within reach (and, in the case of Grubler, achieved) by reducing material throughput and energy demand, with positive synergies for the social and environmental objectives of the SDGs.

The Grubler et al. scenario was included in the IPCC Special Report on 1.5°C (2018) as an alternative to relying on speculative negative emissions technologies. Similar scenarios (i.e., D'Allessandro, Dittmer, Distefano, & Cieplinski, 2018; Victor, 2019) demonstrate that degrowth can be used to accomplish environmental objectives while at the same time improving social indicators. These scenarios suggest that the SDGs can be achieved without the growth objective of Goal 8.

6 | CONCLUSIONS AND DISCUSSION

The SDGs offer no clear justification for the demand for *global* GDP growth in Goal 8. The assumption seems to be that growth is essential for achieving the human development objectives on poverty, hunger, health, and so on. But this is only justifiable in the case of low-income countries. Past a certain threshold, additional GDP is no longer necessary for achieving these objectives. Costa Rica, for example, has ended extreme poverty and posts high levels of nutrition, life expectancy, education, sanitation, and access to energy (exceeding SDG thresholds) with GDP per capita of only $11,000, less than one fifth that of the United States (O'Neill, Fanning, Lamb, & Steinberger, 2018). It makes little sense to call for growth in nations where GDP is already significantly above this level. In such cases, human development objectives can be achieved by distributing existing GDP more fairly, and by investing in social services (healthcare, education, etc).

The relationship between GDP growth and human development is not always robust, even in low and middle-income countries (see Reddy & Kvangraven, 2015). This applies to a number of key objectives in the SDGs:

Goal 1 sets out to end extreme poverty. The notion that growth contributes to poverty reduction relies largely on the assumption that growth will generate gainful employment for the poor (as in Goal 8). This link is increasingly tenuous, however, given automation and the threat of technological unemployment. The UN Conference on Trade and Development predicts that up to two thirds of jobs in developing countries might be lost to automation, as "the increased use of robots in developed countries risks eroding the traditional labour-cost advantage of developing countries."[16] The production of textiles and small electronics (which accounts for significant employment in the global South) is particularly easy to automate. In light of this, we cannot assume that growth will automatically reduce poverty. It would make more sense to target this objective directly, with policy instruments such as cash transfers, basic income, job guarantees, minimum wage laws, and so forth.

Goal 2 sets out to end hunger. Yet the Food and Agriculture Organization states that "the linkage between economic growth and nutrition has been weak."[17] There are other factors that are more strongly correlated with food security, such as ensuring that small farmers have secure access to land (Moore Lappé et al., 2013). The UN Special Rapporteur on the right to food (De Schutter, 2014) argues that food security requires protecting small farmers from land grabs and displacement; ensuring they have rights to use, save, and exchange seeds; regulating financial speculation on food commodities to prevent price spikes; and reducing corporate control over food systems. Unfortunately, none of these measures are promoted by the SDGs. What is more, it is worth noting that many of these measures are regarded by policymakers as "barriers" to GDP growth, which illustrates that what is good for poor people is not always what is good for growth, and vice versa—a reality that Goal 8 does not account for.

Goal 3, on health, aims to reduce a number of mortality indicators. Although there is a general correlation between GDP and longevity (countries with higher GDP generally have better life expectancy), the relationship is not one-to-one; rather, it follows a saturation curve with sharply diminishing returns (Preston, 2007; Steinberger & Roberts, 2010). When it comes to longevity, there are other important variables at play besides GDP, such as investment in universal healthcare. Costa Rica's healthcare system allows the country to match US life expectancy with only one fifth of the US GDP per capita. Goal 3 also covers "mental health and well-being." Here, the relationship with GDP is particularly tenuous (see Easterlin, 1995; Easterlin, McVey, Switek, Sawangfa, & Zweig, 2010). In the United States, happiness levels have remained unchanged since the early 1970s, despite a doubling of real GDP per capita. According to the Gallup World Poll, many countries (Germany, Austria, Sweden, Netherlands, Australia, Finland, Canada, Denmark, and Costa Rica) have higher levels of well-being than the United States, with less GDP per capita.

It is not just that GDP is not strongly correlated with human development after a point—it is also that GDP growth past a certain threshold often has a negative impact. Alternative metrics of economic progress, such as the genuine progress indicator (GPI), make this effect visible. GPI starts with personal consumption expenditure (also the starting point for GDP) and adjusts using 24 different components, such as income distribution, environmental costs, and pollution, while adding positive components left out of GDP, such as household work. Kubiszewski et al. (2013) find that in most countries GPI grows along with GDP until a particular threshold, after which GDP continues to grow, whereas GPI flattens and in some cases declines. The authors draw on Max-Neef (1995) to interpret this threshold as the point at which the social and environmental costs of GDP growth become significant enough to cancel out consumption-related gains (Deaton, 2008; Inglehart, 1997).

Of course, one might argue that GDP growth is necessary for mobilizing resources to invest in the technological change required to achieve absolute decoupling of GDP from resource use and emissions and shift the world towards sustainability. Large economies tend to be more resource efficient than small economies. The problem with this approach is that the scale effect of growth outstrips the efficiency gains that it produces; in other words, larger economies consume and pollute more in absolute terms, even though they are more efficient. Furthermore, there is no evidence for the assumption that *aggregate* growth is necessary for improving efficiency. If the objective is to achieve specific kinds of technological innovation, it would make more sense to invest in those directly, or incentivize innovation with policy measures (e.g., caps on carbon and resource

[16]UNCTAD, Robots and industrialization in developing countries, 2016.

[17]Food and Agricultural Organization, State of food insecurity in the world, 2012.

use), rather than to grow the whole economy indiscriminately and hope for a specific outcome.

We can conclude, then, that the inclusion of Goal 8 as currently formulated is under-justified. Certainly, there is no reason for Goal 8 to call for continued GDP growth in *every* nation, and no reason to call for continued growth past the point at which it delivers social benefits. Of course, it is reasonable to call for growth in poorer nations, but this would only make sense if coupled with a commitment to pro-poor bias in the distribution of new income, to be accomplished either directly by giving the poor more economic power (through say land reform and higher wages), or indirectly by redistribution (through taxation and social spending, or through some kind of basic income).

The SDGs do have a goal on reducing inequality (Goal 10). Target 10.1 reads: “By 2030, progressively achieve and sustain income growth of the bottom 40% of the population at a rate higher than the national average.” There are a number of problems with this approach, however. First, the language of Target 10.1 is weak: the phrase “by 2030” means that existing patterns of pro-rich distribution can continue—or even worsen—until 2029, so long as pro-poor distribution is achieved in the final year. Second, it focuses on relative rather than absolute distribution of growth, and does not specify a target rate of income growth for the poor. Even if the incomes of the poorest 40% rise faster rate than the national average, this is no guarantee that the income gap will shrink (indeed, it may even worsen), as they are starting from a much lower baseline. Third, it depends entirely on generating *new* income rather than distributing *existing* income more fairly. Given the ecological consequences of growth, it would make more sense to prioritize the latter approach.

More importantly, in order to ensure that the SDGs' sustainability objectives are not violated, any call for GDP growth in poorer nations would have to come along with an acknowledgment that rich nations need to make dramatic reductions to material throughput, which may require post-growth or degrowth strategies.

In light of the above, I propose the following specific changes to the SDGs:

1. Remove Target 8.1 (on GDP growth), or otherwise rewrite so that it (a) calls for GDP growth specifically in low-income nations rather than growth in all nations; (b) specifies that this growth should be pro-poor and directed at clear human development outcomes (poverty reduction, health, education, employment, etc.), beyond which further growth is unnecessary; and (c) clarifies that there is no need for continued growth in high-income nations, in terms of human development.
2. Strengthen Target 12.2 (on sustainable consumption and production) with specific quantified goals for global material footprint (ideally, reduction down to 50 billion tons per year) and material footprint per capita, building on work by Bringezu (2015), Dittrich et al. (2012) and, in particular, the UNEP International Resource Panel (UNEP, 2014).
3. Strengthen Target 8.4 (on resource efficiency) with specific quantified goals for reducing material footprint per GDP, differentiated by country income group, with targets for relative decoupling in poorer nations (see UNCTAD, 2012, pp. 74–75) and absolute decoupling in richer nations.
4. Strengthen Target 10.1 (on inequality) so that (a) reductions of inequality begin with immediate effect, rather than being potentially delayed to 2029; (b) it is focused on closing the *absolute* income gap, with quantified targets; and (c) it emphasizes the importance of prioritizing fairer distribution of existing GDP.

Given the data presented in the preceding sections, it is clear that achieving the sustainability objectives of the SDGs requires that we rethink aggregate global economic growth as a development strategy. The human development objectives of the SDGs can be more safely and feasibly achieved by shifting a portion of global income from richer nations to poorer nations. In other words, reducing *global* income inequality becomes the only reasonable method by which the SDGs can accomplish the human development objectives without violating the sustainability objectives. Meaningful reductions in global inequality can be achieved by changing the rules of the world economy to make it fairer for developing countries (Hickel, 2017), for example by:

1. Implementing a global minimum wage system, for example, pegged at 50% of each nation's median income, allowing poor nations to retain their comparative advantage in wages while at the same time commanding a fairer price for the labour they contribute to international trade (Cope & Kerswell, 2016; Hickel, 2013)
2. Making international trade fairer by rectifying imbalances in bargaining power in the World Trade Organization, phasing out the agricultural subsidy regime in the US and EU, reducing patent licensing fees, and allowing poor nations to use tariffs to protect infant industries (Stiglitz, 2002; UNCTAD, 1999)
3. Cancelling odious or otherwise unpayable external debt in global South nations to allow them to retain a greater proportion of their annual GDP and shift their budgets from interest payments on old loans to social spending and poverty reduction
4. Closing down tax havens and secrecy jurisdictions in order to end illicit financial flows out of global South nations (Kar & Spanjers, 2015; Pogge & Mehta, 2016)
5. Democratizing key institutions of global economic governance such as the World Bank and the IMF, so that global South countries have a fairer voice in macroeconomic policy decisions that affect them (Chang, 2010; Stiglitz, 2002).

An alternative approach would be to tax specific international revenue and resource flows (i.e., a financial transaction tax, a land value tax, a carbon tax, a pollution tax, a global minimum corporate tax, and a resource extraction tax) and use the yields to implement an international basic income. A basic income of $1.25 per day (2005 PPP) for every human would achieve Goal 1 immediately. Indeed, given the threat of technological unemployment, this may prove to be a necessary mechanism for preventing humanitarian crisis if jobs disappear across the South.

Unfortunately, none of these concerns are adequately addressed by the SDGs. Target 8.5 calls for "decent work for all" and "equal pay for work of equal value," and Target 10.4 calls for "wage and social protection policies," but there are no quantified objectives and no mention of global standards. Targets 2a and 10a call for fairer trade rules, but these have been included only as supplementary or subordinate objectives. Target 10.6 calls for "enhanced representation and voice for developing countries in decision making in global international economic and financial institutions," but provides no objectives for shifting voting power. Target 17.1 calls for improving domestic capacity for tax collection, but offers no concrete policy objectives (such as country-by-country reporting, global minimum corporate tax, etc) and says nothing about the tax haven system controlled mostly by rich countries. Target 17.4 calls for debt "restructuring," but says nothing about debt cancellation.

Most importantly, resolving the contradictions of the SDGs requires rethinking the use of GDP as an indicator of progress—a purpose it was never intended to serve (Costanza, Hart, Posner, & Talberth, 2009; Fioramonti, 2013; Kuznets, 1934; Stiglitz, Sen, & Fitoussi, 2010). During the SDG negotiations, some parties called for GDP to be replaced with a more balanced indicator, but this demand was not meaningfully incorporated into the final document. Target 17.19 reads: "By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product and support statistical capacity-building in developing countries." The term "complement" here means that GDP is to remain the dominant indicator of progress, whereas the phrase "by 2030" effectively shelves the problem until 2029. If we are to find real pathways towards ecological sustainability, the United Nations will need to revisit this question with urgency. Target 17.9 will need to be strengthened to call for GDP to be phased out as a primary measure of progress by 2030 and replaced by indicators designed to incentivize the pursuit of human well-being within planetary boundaries (O'Neill et al., 2018).

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