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Closing the sustainable development gap: A global study of goal interactions

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Abstract

Meeting one sustainable development goal on human needs, social justice, or environmental limits can make it harder (or easier) to meet others. The extent to which countries succeed in reconciling these goals is context specific but depends largely on how we organize society and on what policy options and strategies we use. We present a model for sustainable development consisting of six indicators and assign thresholds that define a sustainable development space. The distances between the indicator values and their corresponding thresholds constitute the sustainable development gap. We then apply a cluster analysis technique to group 117 countries into six clusters that face similar challenges in closing this gap. Finally, we use illustrative spider web diagrams to assess the performance of these clusters at two points in time. We show that some countries have clearly been better than others at reconciling these goals, and many have reduced their sustainable development gap over time.

KEYWORDS

environmental policy, indicators, just operating space, sustainable development goals, sustainable development space, trade-offs and synergies

1 | INTRODUCTION

The UN report *Our Common Future* (WCED, 1987) included what is now one of the most widely recognized definitions of sustainable development: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This definition contains two key concepts: the "concept of 'needs,' in particular, the essential needs of the world's poor, to which overriding priority should be given" and the "idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs." *Our Common Future* acknowledges that there will be both winners and losers and says: "We do not pretend that the process is easy or straightforward. Painful choices have to be made" (WCED, 1987).

This insight, that pursuing one sustainable development goal may sometimes make it harder to meet other sustainable development goals, was not emphasized in the United Nations 2030 Agenda for Sustainable Development or in the 17 Sustainable Development Goals (SDGs) (UN, 2015a). True, the UN SDGs include "enhance policy coherence for sustainable development" as a separate target,[1] but for example, the idea that environmental limits cannot be crossed and that safeguarding these limits may constrain human behavior (including economic activity) is never referred to in these documents. Nilsson, Griggs, and Visback (2016) offer the following explanation: "International negotiations gloss over tricky trade-offs. Still, balancing interests and priorities is what policymakers do—and the need will surface when the goals are implemented. If countries ignore the overlaps and simply start trying to tick off targets one by one, they risk perverse outcomes."

Recent international efforts to mitigate climate change have, however, begun to consider this insight. The Paris Agreement acknowledges that climate mitigation measures may imply trade-offs (and synergies) with other sustainable development goals and declares an aim "to strengthen the global response to the threat of climate change, in the context of sustainable development" (UNFCCC, 2015). Thus, mitigation measures should recognize the fundamental priority of ending hunger and poverty; ensuring human rights, equity, and justice; and protecting the integrity of all ecosystems. The UN Intergovernmental Panel on Climate Change (IPCC) Special Report, *Global Warming of 1.5°C*, presented the indicative linkages between mitigation options and sustainable development using UN SDGs in a table (IPCC, 2018, Policy summary, p. 20). Just 1 year later, in *Climate Change and Land* (IPCC, 2019), the authors recognized that "Some response options and policies may result in trade-offs, including social impacts, ecosystem functions and services damage, water depletion, or high costs, that cannot be well-managed, even with institutional best practices." Thus, the adoption of the UN 2030 Agenda has highlighted a need for research and policy analysis on interactions across the UN SDGs.

Research on these interactions can help us reduce the negative interactions (trade-offs) and enhance the positive interactions (synergies), thereby helping close the gap between the sustainable development goals and current conditions. The research literature on interlinkages between UN SDGs is large and diverse, and it varies with respect to choice of research methods, sustainable development goals, timespan, and sample studied. Here, we elaborate on a few examples.

First, there is a vast literature using statistical methods to assess the relationship between CO_2 emissions, other environmental costs, and poverty on the one hand, and economic growth, income inequality, and democracy on the other (e.g., Pham-Truffert, Metz, Fischer, Rueff, & Messerli, 2020; Warchold, Pradhan, & Kropp, 2020). One example is the Kuznets Curve (KC) hypothesis, which claims that inequality increases in the early stages of economic growth and then declines after a certain point. Building on this hypothesis, the Environmental Kuznets Curve (EKC) hypothesis claims there is an inverse u-shaped relationship between income and environmental costs; thus, when countries become richer, they become more successful in safeguarding environmental limits. The KC hypothesis, and consequently, the EKC hypothesis, however, are contested. In his book, *Capital in the 21st Century*, Piketty (2013) refuted the KC hypothesis as irrelevant as a universally applicable theory, arguing that inequality rises as a consequence of growth in capitalism because growth is unequally distributed. Yet, in their paper on interactions between UN SDGs, Nilsson et al. (2016, p. 321) stated that "[m]any preconceptions that influence decisions are outdated or wrong, such as the belief that rising inequalities are necessary for economic growth…." Augmented statistical models, where environmental costs are determined not only by income per capita but also by how income is distributed within a country, as well as the form and extent of democracy, give more insights. Yet, the results from such studies are inconclusive (see, e.g., Coondo & Dinda, 2008; Grünewald & Martínez-Zarzoso, 2017; Holtz-Eakin & Selden, 1995). The differences in findings suggest that these relationships depend on context and will vary depending on national income level, institutions, and policies. Thus, when designing national policies, it may be dangerous to rely only on generalized knowledge.

Second, taking context into account, Nilsson et al. (2016) developed a framework for mapping and assessing interactions between the 17 UN SDGs and the 169 associated targets. The framework includes a scale to help categorize the target-level interactions between an "entry goal" and all other goals, ranging from −3 to +3, where a positive (negative) value indicates that pursuing the achievement of an entry goal aids (harms) the fulfillment of another one. The use of this framework can be organized as an iterative process, where researchers, policymakers, and practioners work together across disciplines and sectors, thus enabling a deeper understanding of target interactions. This framework was immediately applied to SDGs on health, energy, and the ocean in a major international research study by the International Council of Science (ICSU, 2017), and insights and experiences were presented in Nilsson et al. (2018). They found that synergies tend to dominate trade-offs with other targets and that interactions depend on key factors such as geographical context, resource endowments, time horizon, and governance. Another example is given in Nerini et al. (2018), who began their analysis with SDG7 (affordable and clean energy) and describe its multiple synergies and trade-offs with other targets, emphasizing that these interactions are highly context specific. There are also a number of studies surveying perceived trade-offs of individual people, policymakers, and bureaucrats (Tremblay, Fortier, Boucher, Riffon, & Villeneuve, 2020; Wong & van der Heijden, 2019).

Third, using integrated assessment models, one may quantify how an integrated approach to policy making and planning could increase positive interactions and reduce negative ones between subsets of SDGs. Such studies often focus on identifying co-benefits between policies directed towards climate mitigation and other energy-related SDGs (Chapman, Howden-Chapman, & Capon, 2016; McCollum et al., 2018; McCollum, Krey, & Riahi, 2011; Rogelj, McCollum, & Riahi, 2013; von Stechow et al., 2015; von Stechow, Minx, Riahi, et al., 2016). Co-benefits could also occur over time. For example, policies directed at phasing out the use of solid-fuel cook stoves (Lacey, Henze, Lee, van Donkelaar, & Martin, 2017) and coal combustion (Rauner et al., 2020) or to transition to plant-based diets (Springmann, Godfray, Rayner, & Scarborough, 2016) could all improve health in the near-term while reducing global warming in the longer term. Finally, potential trade-offs between energy production, climate actions, land degradation, water management, and food production can be managed through coordinated policies (Gao & Bryan, 2017; Zhang et al., 2015). All of these studies focus on the potential co-benefits from more coordinated polices on subsets of SDGs. While these models point at opportunities for achieving more sustainable development, they do not reveal the political feasibility of these choices. Therefore, we need to complement these models with empirical studies examining actual choices.

We need a variety of approaches for systematic identification and characterization of interactions of sustainable development goals. Moreover, to better design policies, politics, and institutions, we need a better understanding of why some countries are better than others in reconciling these goals. This paper provides a national-level

TABLE 1 From sustainable development imperatives to indicators and thresholds

(I) Imperatives	Satisfying human needs	Ensuring social justice	Respecting environmental limits
(II) Theories	Theories on needs	Theories on justice	Planetary boundaries
(III) Themes	Eradicating extreme poverty	Ensuring rich participation	Mitigating climate change
	Enhancing human capabilities	Ensuring fair distribution	Safeguarding biosphere integrity
(IV) Indicators	Percentage living below 1.9 USD/day	VDEM participatory democracy index	GHG emissions in tonnes per capita (CO_2 equivalent)
	Human development indicator	Gini coefficient for distribution of income	Ecological footprint in Gha per person
(V) Thresholds	<1%	≥0.5	≤3.6
	≥0.7	≤0.4	≤1.7

approach for assessing sustainable development gaps and linking these gaps to the challenge of reconciling sustainable development goals. We briefly introduce a normative model of sustainable development consisting of six nation-level indicators with assigned thresholds that together define a space within which sustainable development can be achieved. We then apply a cluster technique to country data to show how different groups of countries face different challenges in meeting the thresholds in our normative model, thereby entering into the sustainable development space. Meeting one threshold may make it easier to meet another (i.e., a synergy mechanism) or harder (i.e., a trade-off mechanism). We identify clusters and countries that have managed these mechanisms in a good way over time, thereby improving their ability to meet all goals simultaneously. A discussion of potential synergy and trade-off mechanisms is facilitated by our use of illustrative spider-web diagrams.

Our study complements recent studies on interactions between subsets of the 17 UN SDGs and the associated 169 targets using qualitative or modeling approaches. By reducing the number of sustainable development goals to six, we are able to identify suitable indicators and find data for a sufficient number of countries and periods to enable us to do a statistical analysis, in contrast to models that aim to find indicators for all 17 UN SDGs (e.g., Schmidt-Traub, Kroll, Teksoz, Durand-Delacre, & Sachs, 2017). At the same time, the six goals chosen are closely related to the 17 UN SDGs and the definition of sustainable development presented in *Our Common Future*, allowing an exploration of the interlinkages between key aspects of the sustainable development concept.

For the purpose of this paper, a model consisting of thresholds that define a sustainable development space is considered to be of more use (e.g., O'Neill, Fanning, Lamb, & Steinberger, 2018; Raworth, 2017; Rockström et al., 2009; Spangenberg, 2002; Steffen et al., 2015) than presenting sustainable development using one composite index (e.g., Hickel, 2020; Sachs et al., 2020). To restrict attention to situations where action is urgently required, we define the concept a "sustainable development gap" to describe situations where these thresholds are transgressed. Using this concept, we can make comparisons across countries and over time.

Finally, by choosing a statistical cluster technique, we are able to more systematically examine the interactions between all six aspects than had we chosen to use a panel data or linear regression estimation approach. As mentioned above, a vast number of statistical studies have estimated the causal relations between a selected goal (e.g., CO_2 emissions) and explanatory variables closely related to sustainable development (e.g., income, equality, and democracy). However, these studies have seldom been designed to capture the complexity of all goal interactions.

2 | METHOD

2.1 | The normative model

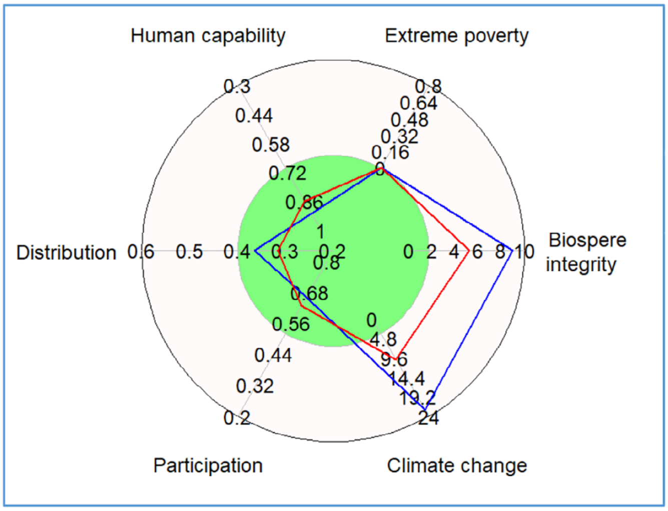
We base our empirical analysis on a normative model of sustainable development that links theory to measurement in five steps (Table 1). With some modifications, we use the normative model developed over time in Holden & Linnerud (2007), Holden et al. (2014, 2017a,b), Linnerud & Holden (2016) and Linnerud et al. (2019).

We start by acknowledging that sustainable development is an ethical statement and derive three moral imperatives for action using *Our Common Future* as a reference: satisfy human needs, ensure social justice, and respect environmental limits.

Next, we derive two themes for each imperative based on scientific knowledge. The capability approach developed by Amartya Sen (2009) and the two principles of justice defined by Rawls (1999) in *A Theory of Justice* directed our choice of themes for the first two imperatives. Climate and biosphere integrity are the two core boundaries in the third imperative. They are derived from the planetary boundary approach (Rockström et al., 2009; Steffen et al., 2015) and have the potential "to drive the Earth system into a new state should they be substantially and persistently transgressed" (Steffen et al., 2015, p. 1). The global biosphere consists of multiple ecosystems of different scales, and its integrity is maintained if it manages to maintain essential system functions.

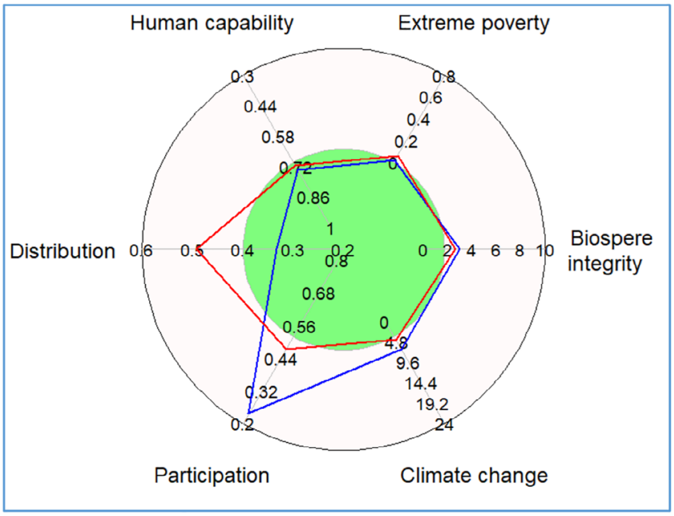
Finally, we select indicators that reflect the themes and their theoretical foundations and for which high-quality data are widely available. We then set thresholds that must be respected to avoid unacceptable, irreversible, and/or uncertain consequences. The six thresholds form a sustainable development space within which it is safe to operate and are defined as follows.

Eradicating extreme poverty: We require that strictly less than 1% of a nation's population should live below the International Poverty Line (IPL), defined as USD1.90 per day per person, given in 2011 purchasing power parity (World Bank, 2017).



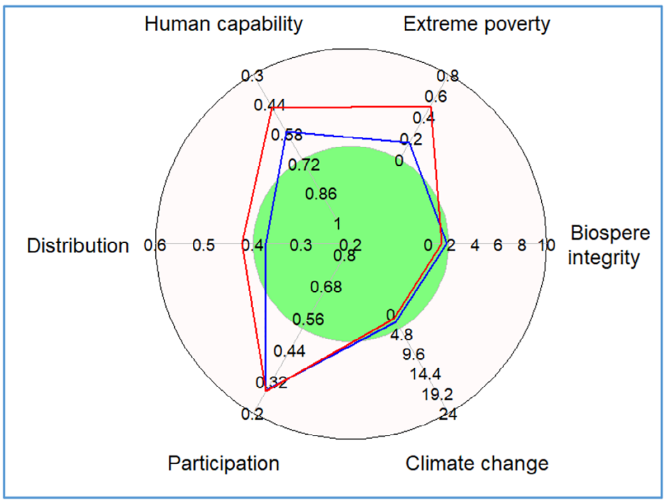
Cluster I (blue): AUS, CAN, USA

Cluster II (red): AUT, BEL, CYP, CZE, DEU, DNK, ESP, EST, FIN, FRA, GBR, GRC, HRV, HUN, IRL, KOR, LTU, LVA, MNG, MUS, NLD, NOR, POL, PRT, ROU, SVK, SVN, SWE, URY.



Cluster III (blue): ALB, ARM, BGR, BIH, BLR, CHN, DZA, EGY, FJI, IRN, IRQ, JOR, KAZ, KGZ, LBN, LKA, MDA, MKD, RUS, THA, TUN, TUR, UKR.

Cluster IV (red): ARG, BOL, BRA, CHL, COL, CRI, DOM, ECU, GTM, HND, MEX, NIC, PAN, PER, PRY, SLV, ZAF.



Cluster V (blue): BGD, BTN, COM, DJI, GEO, GHA, HTI, IDN, IND, LAO, MMR, MRT, NPL, PAK, PHL, SLB, STP, TJK, VNM, VUT, YEM, ZWE.

Cluster VI (red): BDI, BEN, BFA, CIV, CMR, COG, COD, ETH, GIN, GNB, LBR, LSO, MDG, MWI, NER, RWA, SEN, SLE, TCD, TGO, TZA, UGA, ZMB.

FIGURE 1 Cluster analysis for 2010–2015. The six axes represent the six key sustainability themes. The green area is the sustainable development space. The mean indicator values for each cluster are shown as red and blue lines. We refer to countries using the UN's three-letter country codes. See Table 1 for the indicators and Table A1 in the Appendix A for cluster data. *Data sources*: Extreme poverty (World DataBank, 2016); human capability (UNDP, 2016); distribution (World DataBank, 2016); participation (Coppedge et al., 2016); climate change (EDGAR, 2018); biosphere integrity (Global Footprint Network, 2018) [Colour figure can be viewed at wileyonlinelibrary.com]

Enhancing human capabilities: We use the Human Development Index (HDI) comprising measures of life expectancy, education, and income per person. It can take values between zero and one, and we set a threshold of HDI > 0.7 or "high human development" (UNDP, 2016).

Ensuring rich participation: We use the participatory democracy index of the Varieties of Democracy Project (VDEM PI) (Coppedge et al., 2011, 2016).[2] It tests whether citizens have an active role in political processes and can take values from zero to one. We require a VDEM PI > 0.5.

Ensuring fair distribution: We use the Gini coefficient to measure income distribution within a country. It can take values from zero to one, where zero expresses the situation where everybody has the same income. We require a Gini < 0.40, which is the alert line used by the UN (United Nations Habitat, 2012).

Mitigating climate change: We use greenhouse gas (GHG) emissions measured in tonnes CO_2 equivalent (tCO_2eq) per capita. The per capita threshold of 3.6 tCO_2eq is derived from the 2030 GHG emission budget and is consistent with the 2°C target when applying the precautionary principle (UNEP, 2015).[3]

Safeguarding biosphere integrity: We use the Ecological Footprint as a proxy indicator for biosphere integrity. It measures, in global hectares (gha) per person, the ecological assets that a country requires to produce the natural resources it consumes and to absorb its waste (Mancini et al., 2016; Wackernagel et al., 1999).[4] These national Ecological Footprints are then compared to how much land and sea area is available per capita globally (i.e., 1.7 gha per person for 2014) (Global Footprint Network, 2018).

Before we proceed, a comment on the challenge of selecting suitable indicators and thresholds is warranted. Take, for example, our choice of the indicator for biosphere integrity. There is no publicly available indicator that captures the complexity of biosphere integrity and where a corresponding threshold can be set to reflect a country's responsibility. The world-renowned biologist Wilson claims (Wilson, 2016, p. 20), "To measure the biosphere and its rate of diminution, the best unit to use by far is the species," and the crucial factor is "the amount of sustainable habitat left to them" (pp. 185–186).

Although statistics on protected areas are available, these areas are unevenly distributed across countries, and allocating the responsibility for their protection per country is not a straightforward process. A nation's Ecological Footprint is related to land use, and we can allocate responsibility for keeping it below a threshold because the concept is derived from consumption. If, for example, Germany imports industrial products from China, the products' environmental impacts will be reflected in Germany's Ecological Footprint and China's GHG emissions. Thus, our two indicators for respecting environmental limits complement each other, but both indicators and thresholds should be replaced as new and better indicators become available to reflect development in key factors and new scientific insights.

2.2 | The sustainable development gap

The normative model for sustainable development consists of six indicators and the six associated assigned thresholds that define a sustainable development space. The advantage of using this model for assessing global progress towards a sustainable development is threefold: (a) By focusing on only six themes and selecting indicators that are widely published at the national level over time, we are able to perform statistical analyses on publicly available data. (b) By choosing themes that cover the main dimensions of the sustainable development concept as defined in *Our Common Future*, as well as of the 17 UN SDGs, we are able to identify the main challenges in reconciling sustainable development goals. Composite indicators of

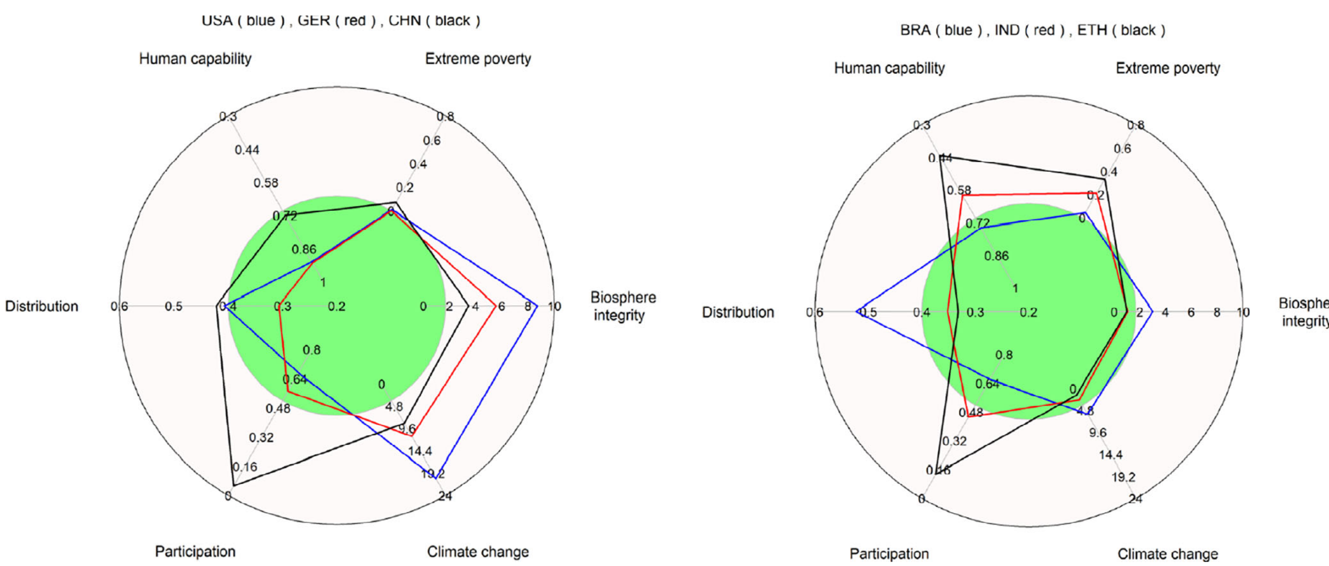


FIGURE 2 Mean indicator values for 2010–2015 for the largest country, in terms of population, in each of the six clusters. The six axes represent the six key sustainability themes. The green area is the sustainable development space. We refer to countries using the UN's three-letter country codes. See Table 1 for the indicators, and Table A1 in the Appendix A for cluster data [Colour figure can be viewed at wileyonlinelibrary.com]

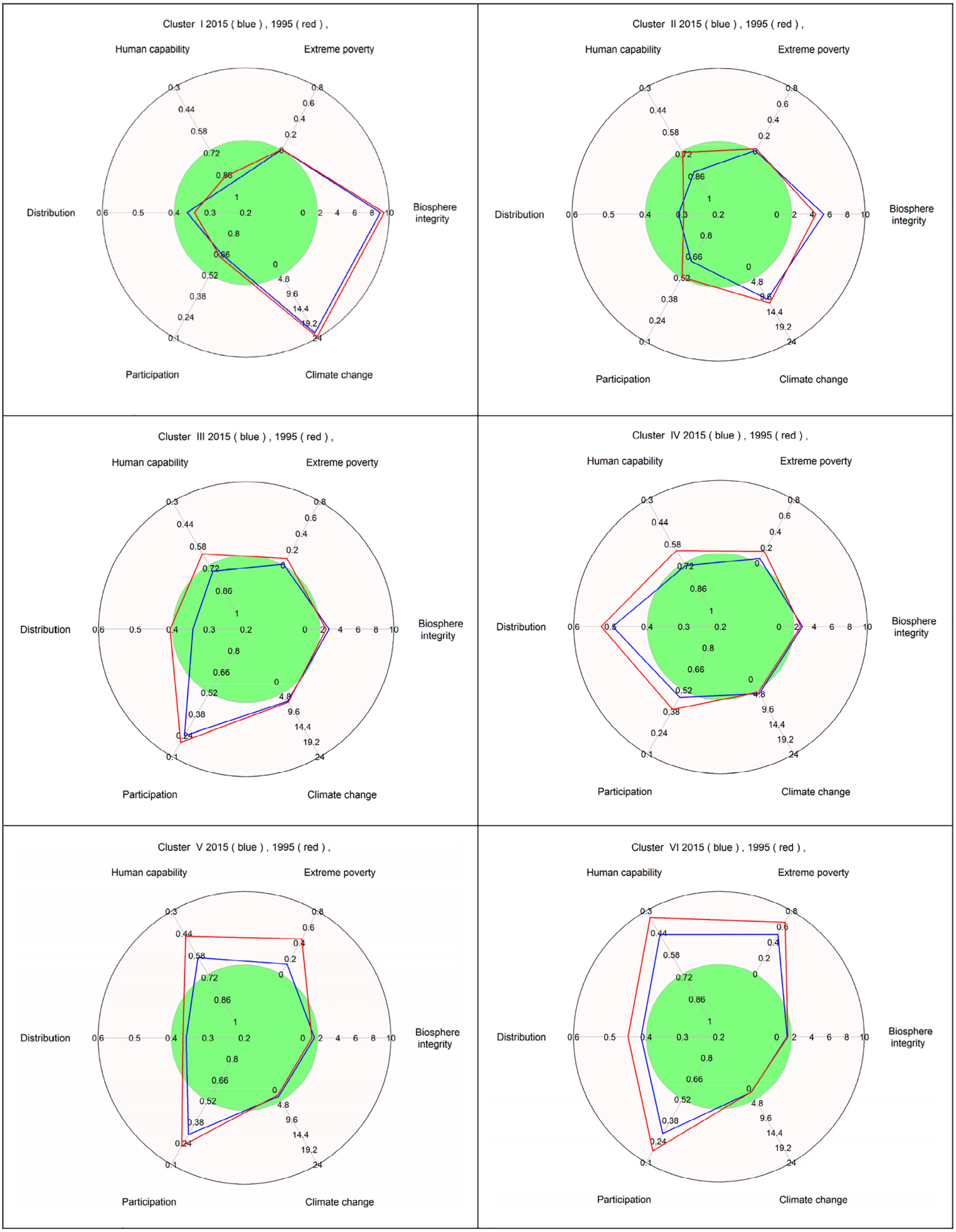


FIGURE 3 Mean indicator values for 2010–2015 (blue line) and 1990–1995 (red line) for each cluster. Only countries with data items in both periods are included (55 of the 117 countries in Figure 1). The six axes represent the six key sustainability themes. The green area is the sustainable development space. We refer to countries using the UN three-letter country codes. See Table 1 for the indicators and Table A2 in the Appendix A for comparable cluster data for the two periods. *Data sources*: Extreme poverty (World DataBank, 2016); human capability (UNDP, 2016); distribution (World DataBank, 2016); participation (Coppedge et al., 2016); climate change (EDGAR, 2018); biosphere integrity (Global Footprint Network, 2018) [Colour figure can be viewed at wileyonlinelibrary.com]

sustainable development conceal this challenge. (c) By setting thresholds that should not be transgressed and treating each of these thresholds as equally important, we direct the focus towards challenges in entering the sustainable development space.

In our analysis, we focus on closing the sustainable development gap. A gap occurs when at least one threshold is transgressed, and it can be measured as the difference between an indicator value and its corresponding threshold. Thus, if a threshold has already been met, a further improvement in the relevant indicator value will not contribute to closing the sustainable development gap.

Our use of this concept is inspired by the related "sustainability gap" defined by Ekins, Simon, Deutsch, Folke, and De Groot (2003) and applied by them to the environmental aspects of sustainable development (e.g., Fischer et al., 2007). According to Ekins et al. (2003), the gap should be set in physical terms and comprise the difference between the current level and the environmentally sustainable level of the indicator in question. Similarly, we do not sum up a nation's "gaps" to one number. Rather, we treat them individually using the relevant unit for each indicator. Although the term sustainability gap has also been used to capture social aspects of sustainable development (e.g., Hák, Janoušková, Moldan, & Dahl, 2018), we choose to distinguish our concept from that of Ekins et al. (2003) by referring to it as "the sustainable development gap."

2.3 | Cluster analysis and data

Countries face different challenges in closing the sustainable development gap. We use cluster analysis to categorize countries into groups that deal with similar challenges (Hartigan, 1985; Hartigan & Wong, 1979). In particular, countries in one cluster have performances on the six indicators that are more similar than countries in another cluster. That is, the cluster analysis groups countries so that indicator-value variances within the clusters are less than the indicator-value variances across the clusters.

More technically, all indicator values have been converted to Z values by subtracting the mean value and dividing by the standard deviation for each indicator. This procedure transforms all indicator values to a unit-free distribution because they measure the distance from the mean in standard deviations. The cluster analysis was performed by using the PROC FASTCLUS procedure in SAS. This algorithm uses least-squared-based Euclidean distances for selecting clusters. The means of observations assigned to a cluster is the cluster center for each iteration of the algorithm (the algorithm is called k-means). We predefine the number of clusters to six, which results in a grouping of countries that explains 53% of the variation in the indicator values. A higher number of clusters always gives a higher explanatory power or R^2. For example, by increasing the number of clusters from 6 to 10, our cluster analysis would explain 64% of the variation in our data, but the analysis would not be very meaningful because each cluster includes only a few countries.

Our presentation of data for clusters that perform similarly with respect to a set of sustainable development indicators differs from the way data are presented in the UN SDG report (UN, 2019a, p. 59). In the UN report, data are presented for different geographic regions; in earlier progress reports on the Millennium Development Goals, data were presented for countries in "developed" and "developing" regions. We believe our clustering technique is better suited to address challenges shared by a set of countries and to design policies that are tailored to these challenges.

We present the results in spider web diagrams that clearly illustrate the sustainable development gap between the indicator values and the corresponding thresholds defining the sustainable development space (i.e., the green circles in Figures 1–3). Thus, by comparing clusters, we can identify clusters that are better than others at reconciling the sustainable development goals. Moreover, by comparing data for different periods, we can determine whether a cluster has improved or impaired its ability to reconcile these goals over time. The analysis, however, is valid only for the periods we study, and challenges in closing the sustainable development gap will vary over time in response to demographic, economic, political, and environmental changes.

We use national data for the six indicators for the periods 1990–1995 and 2010–2015. Because there were missing observations, we calculate unweighted averages for each indicator. For the most recent period, we have data for 117 countries. This accounts for 87% of the global population in 2015. We are not able to calculate all six indicator values for these 117 countries for the period 1990–1995.[5] In particular, we often lack data for the Gini coefficient and the poverty indicator; for these indicators, we must be careful when interpreting changes over time within each cluster.

In Section 3, we present the six clusters as groups of countries that similarly score from high (Cluster I) to low (Cluster VI) achievement on the HDI indicator because the HDI indicator is statistically most decisive in determining which countries are grouped together. The cluster analysis uses country data for 2010–2015. To enable comparisons over time, we use the same groups of countries when we present country data for 1990–1995. We would have liked to make comparisons with earlier periods, but a lack of data prevented us from doing so.

3 | RESULTS AND DISCUSSION

3.1 | Spider web diagrams

The clusters are presented in Figures 1–3, and a summary of the indicator values for 2010–2015 is given in Table A1 in the Appendix A.

An assessment of 117 countries in the period 2010–2015 shows that no country met all six thresholds, some countries met four or even five[6] thresholds, and a few met none.[7] Overall, countries have been most successful in meeting thresholds for the following three themes: enhancing human capabilities, ensuring fair distributions, and mitigating climate change.

To close the sustainable development gap, however, we should not count the number of thresholds met, but instead focus on the challenges involved in meeting the remaining thresholds. Although most rich countries meet the thresholds related to needs and justice, their consumption results in substantial transgression of environmental limits. Not surprisingly, there seems to be an inverse relationship between a country's ability to meet the thresholds of human needs and its ability to safeguard environmental limits.

To assess the achievements in the clusters, we use spider web diagrams shown in Figures 1–3. These diagrams show the differences between the six indicator values and the relevant threshold values. The directions of the axes are chosen so that the thresholds form a sustainable development space. Figures 1–3 should be interpreted as follows:

- When one or more indicators are outside the sustainable development area (i.e., the green circle), a sustainable development gap exists.
- For these indicators, the sustainable development gap is equal to the set of differences between the indicator values and their thresholds.
- A cluster/country is more sustainable than another if by comparing these sets of differences you find that at least one is smaller while the others are not greater.
- Similarly, a cluster/country has become more sustainable over time if at least one of these differences has become smaller while the others have not increased.

For some situations, we argue that it is not possible to rank the achievements unambiguously across clusters/countries or across time. Yet, if a cluster/country performs better on indicators within the green circle without performing worse on indicators outside the green circle, the interlinkages between sustainable development goals have improved. It indicates that it may be feasible to close the sustainable development gap.

In the next subsections, we focus on what countries/clusters have managed to reduce the sustainable development gap. That is, we identify clusters or countries that, based on our indicators, seem to be better than others in reconciling sustainable development goals or that have improved their ability to do so over time. These clusters and countries may serve as role models on how sustainable development gaps can be closed.

3.2 | Differences across clusters

We choose to compare three pairs of clusters, where each pair has relatively similar values on the HDI indicator (Figure 1). This enables us to discuss how sustainable development goals are reconciled in societies with comparable income, education, and health levels.

3.2.1 | Advanced economies transgressing environmental limits

Most countries in the first pair of clusters have a "very high human development" according to the UN definition (HDI ≥ 0.8).[8] Cluster I consists of Australia, Canada, and the United States. Cluster II includes most countries in the European Union, Mauritius, Norway, Japan, Switzerland, South Korea, the United Kingdom, and Uruguay.

These countries are rich, democratic, and egalitarian but have substantially transgressed environmental limits. Obviously, achieving a sustainable development for these countries means reducing the impact of their economic activity on the environment. The clusters differ, however, with respect to the magnitude of the environmental challenges, and based on the criteria in the above section, Cluster II has a smaller sustainable development gap than Cluster I. The GHG emissions vary from 6 to 8 tCO_2eq per person for many countries in Cluster II[9] to 20–27 tCO_2eq per person in Australia, Canada, and the United States. Similarly, Ecological Footprints vary from 3 to 5 gha per person for many countries in Cluster II[10] to 8–10 gha per person in Cluster I.

Admittedly, conditions such as domestic resources, climate, and topography may explain part of the differences across countries, but comparisons of individual countries in these two clusters provide a staggering insight. Australia and Sweden are among the world's top 15 in human development, but Australia has 3.5 times the GHG emission per person compared to Sweden and 1.4 times the Ecological Footprint.[11] Comparing the large economies of Germany, Japan, and the United States provides a similar insight. All of the countries rank in the world's top 20 in human development, but one (the United States) has twice the GHG emissions per person and 1.5–2.0 the Ecological Footprint of the others.[12]

These comparisons show that it is clearly possible to achieve the same high standard of living at a considerably lower cost to the environment. They also indicate that the interlinkages between efforts to achieve different sustainable development goals are not fixed and can be weakened or enhanced to close a country's sustainable development gap.

3.2.2 | Emerging economies struggling with social justice

Most countries in the second pair of clusters have a "high human development" according to the UN definition (0.7 ≥ HDI ≥0.8). Cluster III includes 23 countries from all continents except North and South America. More than half of the countries come from Asia, including China, Iran, Russia, Thailand, and Turkey. Other populous countries in this cluster are Algeria, Egypt, and Ukraine. Cluster IV consists of countries from South America, such as Argentina, Brazil, Colombia, and Mexico, and South Africa.

This pair of clusters manages to achieve a better balance between the imperatives satisfying human needs and respecting environmental limits. Six countries in Cluster III (Albania, Armenia, Fiji, Jordan, Sri Lanka, and Tunisia) and five countries in Cluster IV (Colombia, Costa Rica, Ecuador, Dominican Republic, and Peru) have high human development (i.e., HDI ≥0.7) while keeping their GHG emissions below the 3.6 tCO_2eq per person threshold. In fact, comparing this pair of clusters with the first pair, it seems that increasing human development from "high" to "very high" results in substantial environmental costs.

However, this pair of clusters struggles with the third imperative—ensuring social justice. Cluster III does not meet our threshold for participation (i.e., scores low on the V-dem indicator), and Cluster IV does not meet our threshold for distribution (i.e., scores high on the Gini coefficient). Because we consider meeting each of the six thresholds as equally important, we cannot rank one of these clusters as more sustainable than the other. The patterns revealed in Figure 1 do, however, point to two interesting research questions.

First, does a more egalitarian distribution of income within a country make it easier to eradicate extreme poverty? We find that Cluster III performs better than Cluster IV with respect to both extreme poverty (1.5% vs. 5.8%) and the Gini coefficient (0.33 vs. 0.49). In fact, 10 countries in Cluster III[13] manage to keep the fraction of people living in extreme poverty close to 0% while simultaneously keeping the Gini coefficient below the threshold of 0.40. At the same time, however, there are examples of poverty declining in countries that have increasing inequality (i.e., rising Gini coefficients). In the two last decades, China (Cluster III) and South Africa (Cluster IV) have experienced income growth and reduced the rate of extreme poverty while also increasing income inequality as measured by the Gini coefficient.

Second, does a more egalitarian distribution of income within a country make it harder to mitigate climate change? We find that Cluster IV countries are on average better at mitigating climate change than countries in Cluster III (4.4 vs. 6.6 tCO_2eq per person). Although the pattern in our diagram may be mainly or partly explained by differences in energy resource endowments,[14] statistical studies controlling for such aspects suggest that income distribution has played an instrumental role in mitigating climate change. However, research assessing the historical relation between income distribution and GHG emissions are inconclusive. Some studies conclude that a more equal distribution of income would increase emissions, all else equal, while others conclude it depends on the income level of the country (see, e.g., Coondo & Dinda, 2008; Grünewald & Martínez-Zarzoso, 2017; Holtz-Eakin & Selden, 1995).

3.2.3 | Less developed countries improving their lot

The last pair of clusters struggle with low human capabilities, extreme poverty, and poor participation, but they meet environmental limits. Cluster V accounts for more than a third of the global population and includes densely populated countries in Asia such as Bangladesh, India, Indonesia, the Philippines, and Vietnam, but also a few countries from other continents such as Georgia, Ghana, and Zimbabwe. Cluster VI consists of the poorest nations in the world and includes only African countries such as Ethiopia, Tanzania, and Uganda.

An examination of the spider web diagram reveals an interesting pattern; the blue line (Cluster V) is (more or less) within the red (Cluster VI). Focusing on thresholds that are not met (i.e., indicator values outside the sustainable development space), Cluster V performs better or equally well as Cluster VI. Thus, we can conclude that the sustainable development gap is smaller for Cluster V than for Cluster VI. Focusing on thresholds that are met (i.e., indicator values inside the sustainable development space), we find that the better performances on the societal indicators are accompanied by poorer performances on the environmental indicators. Thus, it is clearly possible to reduce the sustainable development gap for Cluster VI without transgressing the environmental thresholds in our model.

Most countries in Cluster V are in the "medium human development" category according to the UN definition (0.55 ≥ HDI ≥ 0.7). Because the income is equally distributed, some of the least developed countries in this cluster (HDI < 0.55) manage to keep the percentage of people living below the poverty line below 10% (Pakistan, Myanmar, and Mauritania). Unfortunately, this cluster scores very low on the V-dem indicator, and the lack of rich participation is arguably the most important challenge for this cluster.

For countries in Cluster VI, there are many societal challenges to be solved. Compared to Cluster V, inequality reinforces the problem of extreme poverty. For example, although Congo, Madagascar, Tanzania, and Zimbabwe all have an HDI close to or above 0.55, the share of extreme poverty ranges from 37% to 78%.

Although environmental problems are currently not a major issue in these clusters, it is important that economic growth be promoted in a way that ensures a low level of pressure on natural resources.

3.2.4 | Selected countries

We end our cross-sectional comparison with a presentation of the largest, in terms of population, country in each cluster (Figure 2). The figure clearly illustrates that human development comes at a cost for the environment. Nevertheless, it also shows that Germany is clearly better than the US, and India is clearly better than Ethiopia, in reconciling sustainable development goals and closing the sustainable development gap. Thus, although there are negative interactions between our efforts at improving human welfare and our efforts at respecting environmental limits, some countries seem to deal with these interactions in better ways. To explore this question further, we examine changes in indicator values within each cluster over time in the next section.

3.3 | Differences across time

In the years following the publication of *Our Common Future* (WCED, 1987), have countries become better or worse at reconciling the six sustainable development goals? To answer this question, we examine changes in the indicator values for each cluster over time (Figure 3). Ideally, we would hope to find a reduction in the sustainability gap for each cluster. As noted in Section 3.1, a gap will be reduced if at least some of the indicator values outside the sustainable development space in 1990–1995 are better in 2010–2015 and none is worse. A strengthening in a cluster's ability to reconcile sustainability goals is also important; that is, if all average indicator values for 2010–2015 (the blue lines in Figure 3) are within or equal to average indicator values for 1990–1995 (the red lines). Although, this second objective does not necessarily imply a reduction in the sustainability gap, it shows that such reductions are feasible.

Our data provide evidence of an increased ability over time to reconcile the per capita thresholds. Moreover, they provide evidence that some clusters and some countries have even been able to reduce their sustainable development gap during the last decades.

The advanced economies (Clusters I and II) have improved their ability to reconcile development and environmental goals. That is, these clusters have on average managed to improve their lot without increasing per person environmental impacts. Some countries have managed to reduce their sustainable development gap by reducing both their per person GHG emissions and Ecological Footprint. Examples of such countries are the United States, Canada, Germany, Denmark, Spain, France, the United Kingdom, Greece, Hungary, Ireland, and Romania. Recent numbers from the International Agency of Energy (IEA, 2019) show that global CO_2 emissions in advanced economies decreased by 3.2% in 2019, mainly due to changes in the power sector, including increased use of renewable sources, fuel switching from coal to natural gas, and greater nuclear power output. Thus, changes in the economy's content may reduce its environmental costs per capita, even when the economy is growing.

The emerging economies (Clusters III and IV) have improved their scores on societal goals, while not performing significantly worse on per person environmental goals. In fact, Cluster IV countries closed the sustainable development gap between 1990–1995 and 2010–2015; that is, none of the (average) indicator values that were outside the green circle 1990–1995 has moved in the wrong direction, and many have improved significantly. Focusing on individual countries in Cluster III, many have unambiguously closed their sustainable development gap, including Algeria, China, Egypt, Iran, Iraq, Kyrgyzstan, Madagascar, Sri Lanka, Tunisia, and Ukraine.[15] Unfortunately, for this cluster, there has been a 14% increase in the consumption-driven Ecological Footprint. Thus, ensuring that our consumption puts less pressure on natural resources is still a considerable challenge.

Finally, the less developed countries (Clusters V and VI) have reduced their sustainable development gaps clearly and unambiguously. For each cluster, all average indicator values outside the sustainable development space have moved in the right direction. Focusing on individual countries, where we have data for all indicators, we find that all have reduced their sustainable development gap. Although both clusters still face great challenges entering the sustainable development space (i.e., the green circle), they have made substantial progress during the last decades.

4 | CONCLUSION

The *Sustainable Development Goals Report 2019* gives the status for each of the 17 UN SDGs for 2030 (UN, 2019a). There are many favorable trends for human development; extreme poverty has been cut from 36% in 1990 to 9% in 2018, child mortality has been cut in half since 2000, immunization programs have saved millions of lives, and most people in developing countries now have access to electricity. Moreover, countries have taken concrete actions to safeguard environmental limits. For example, marine protected areas have doubled since 2010 and 186 countries have ratified the Paris Agreement on climate change.

Urgent action is needed in many areas, however: 736 million people live in extreme poverty; 750 million still remain illiterate; 3 billion lack clean cooking fuels and technology; in many countries, an increasing share of income goes to the top 1%; the global Ecological Footprint is rapidly growing, outpacing population and economic growth rates; the global mean temperature is 1°C higher than pre-industrial baseline; and biodiversity loss is accelerating (UN, 2019a).

We have solutions to these problems. Nevertheless, to make these solutions politically feasible, policymakers must direct their attention towards areas that can help enhance policy coherence for sustainable development. In May 2019, UN Secretary-General António Guterres highlighted eight areas that can drive progress across all 17 SDGs (UN, 2019b): leaving no one behind; mobilizing adequate and well-directed financing; building resilience; strengthening relevant institutions; accelerating the implementation of SDGs locally; investing in better use of data; harnessing science, technology, and innovation; and strengthening international cooperation.

To work systematically on these areas at the national and international levels, we need to understand the linkages between the SDGs. As emphasized by Nerini et al. (2018, p. 2), "By understanding the complex links between the SDGs and their constituent Targets, researchers can better support policymakers to think systematically about interactions between the different SDGs; including how actions to achieve each Goal affect each other within and between sectors."

The methodological approach we have developed in this paper can inform the design of these policy areas in three ways.

First, by using only six themes to describe sustainable development, we are able to identify indicators where high-quality data are widely available and make comparisons across countries and over time. The themes reflect the idea of sustainable development first presented in *Our Common Future* and capture the essence of the 17 UN SDGs to guide world development until 2030.

Second, by directing our focus to only those indicator thresholds that are transgressed—that is, the sustainable development gap—we are able to distinguish between situations where action is urgently required and situations were sustainable development improvements are welcome. That is, our main attention is on how to enter the sustainable development space.

Third, by using a cluster analysis to group countries, we draw attention to groups of countries facing similar challenges in entering this space. Thus, it is easier to suggest remedies that are tailored to meet their needs. The resulting clusters are not necessarily by geographic area or level of development, the two sorting mechanisms used in the UN SDG reports (UN, 2019a).

Our main findings, using global country-level datasets for the periods 1990–1995 and 2010–2015, are as follows:

1. Comparing countries that face similar challenges in closing the sustainable development gap, we find that some are better than others. For example, our study of the 2010–2015 dataset shows that Germany has clearly been better than the United States, and India has clearly been better than Ethiopia, in reconciling sustainable development goals.
2. Studying the development of sustainable development indicators over time, we find that all clusters have managed to perform better on some indicators, while not performing worse on others. In particular, four Clusters (III, IV, V, and VI) have managed to close their sustainable development gaps. That is, they were closer to meeting all six thresholds in 2010–2015, as compared to 1990–1995. For example, Cluster VI, consisting of only African countries, has clearly improved on some indicators without increasing the per person pressure on the environment or transgressing the environmental thresholds.

The gaps are being closed far too slowly, however, particularly for the two environmental themes. Completely closing the gaps—and thus achieving sustainable development—would require an absolute decoupling of human well-being from environmental degradation (Sachs et al., 2020). Unfortunately, several studies question the viability of this type of decoupling. In fact, there is no evidence supporting that we are now, or ever have been, near the necessary level of decoupling (Haberl et al., 2020; Vadén et al., 2020). This lack of evidence suggests two possible strategies for closing the gaps. The first is to accelerate decoupling to a scale not previously experienced in history. Such an acceleration would require deep decarbonization and dematerialization in all sectors (Sachs, Schmidt-Traub, et al., 2019). The second strategy would be some sort of degrowth in specific sectors of the economy (Lamb & Steinberger, 2017; Millward-Hopkins et al., 2020). We believe that both strategies are challenging and that the preferred one ultimately depends on social and political will.

The benefit of our approach is to draw attention to the performance on selected headline indicators, and the interactions between these in achieving sustainable development. Our approach also, however, has some weaknesses. First, to draw attention to a country's responsibility in achieving global sustainable development, we focus on per capita achievements. By doing so, we under-communicate the environmental problems stemming from the global growth in population. For example, although a country's per capita Ecological Footprint may not have increased significantly from 1990–1995 to 2010–2015, its national Ecological Footprint may have increased because of its population growth.

Second, our six headline indicators are meant to draw attention to areas that need urgent action, but they do not capture all aspects of any given theme in our normative model. For instance, to describe the complexity of safeguarding biosphere integrity, we obviously need more information than what is covered by the consumption-based Ecological Footprint. Therefore, when we design practical policies, we need a wider set of indicators and more qualitative information.

Third, a country's good performance on a single indicator may not be the result of any political effort. For example, while many countries in Africa meet the environmental indicator thresholds, this is mainly the result of low human development. The economic growth needed to lift these countries out of poverty must be based on environmentally friendly technologies, such as infrastructure that is based on renewable energy as well as greater access to electricity. Admittedly, this requires that we not only focus on situations where thresholds have already been transgressed, but also on developments towards such situations.

Fourth, the choice of imperatives, theories, themes, and indicators in our model reflect some degree of subjectivity and arbitrariness. Nevertheless, we firmly believe that the model rests on theories fundamental to the understanding of sustainable development and also covers the main domains presented in the UN 2030 Agenda for sustainable development. Still, the suggested thresholds must not be interpreted as exact numbers, but rather as intervals that encompass uncertainty, and we have not performed an analysis of uncertainty in this article. Finally, thresholds should be replaced as new and better data becomes available or to reflect new scientific insights.

To end on an optimistic note, our analysis has shown that many countries have improved their ability to enhance synergies and reduce trade-offs between sustainable development goals over time, and that some countries are now better than others are at reconciling these goals. Countries worth examining more thoroughly are (in alphabetic order) Albania, Algeria, Armenia, Belarus, Bosnia and Herzegovina, Colombia, Costa Rica, Croatia, Cyprus, Dominican Republic, Ecuador, Fiji, France, Greece, Hungary, Iran, Ireland, Japan, Jordan, Kazakhstan, Latvia, Lebanon, Lithuania, Mauritania, Mauritius, Myanmar, Pakistan, Peru, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Sri Lanka, Spain, Sweden, Thailand, Tunisia, Ukraine, and Uruguay. These countries may serve as role models, and learning from their experience can guide future sustainable development policies.

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ENDNOTES

[1] The 17 UN SDGs are divided into 169 targets with corresponding indicators that cross the five domains of people, planet, prosperity, peace, and partnerships (5Ps). Target 17.14 is "Enhance policy coherence for sustainable development." The indicator for this target is the number of countries with mechanisms in place to enhance policy coherence of sustainable development (Retrieved 2020, January 30 https://sustainabledevelopment.un.org/sdg17).

[2] See the project's website: https://www.v-dem.net.

[3] We take the lower bound of the range of the global 2030 waypoints (31 $GtCO_2eq$) (IPCC, 2014; Meinshausen et al., 2015) and divide this by a medium-variant global 2030 population projection (8.5 billion people) (UN, 2015b).

[4] See the official Ecological Footprint website for definitions, measurements, and country data (https://www.footprintnetwork.org/our-work/ecological-footprint/).

[5] For the period 2010–2015, we were able to calculate average indicator values for all six indicators for 117 countries. For the period 1990–1995, we were not able to calculate six indicator values for all these countries. Poverty: 63 countries (76% of global population). HDI: 104 countries (86% of global population). VDEM: 117 countries (88% of global population). Gini coefficient: 60 countries (35% of global population). Ecological Footprint: 114 countries (88% of global population). GHG emissions: 117 countries (88% of global population).

[6] Mauritius met all but the Ecological Footprint threshold.

[7] Bolivia, Paraguay, and South Africa met none of the thresholds.

[8] Of the 32 countries in clusters I and II, only three have an HDI value below 0.8: Mongolia (0.72), Mauritius (0.77), and Uruguay (0.79).

[9] Countries in Cluster II that had GHG emissions in the range of 6–8 CO_2eq per person in the period 2010–2015 were Croatia, France, Hungary, Japan, Latvia, Lithuania, Mauritius, Portugal, Romania, Spain, and Sweden.

[10] Countries in Cluster II that had Ecological Footprints in 3–5 gha per person range in the period 2010–2015 were Croatia, Cyprus, Greece, Hungary, Ireland, Japan, Mauritius, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Uruguay.

[11] The average values for the period 2010 to 2015 are as follows. GHG emissions: 7.6 tCO_2eq/capita for Sweden and 26.5 tCO_2eq/capita for Australia. Ecological Footprints: 6.86 gha/capita for Sweden and 9.60 gha/capita for Australia.

[12] The average values for the period 2010–2015 are as follows. GHG emissions: 20.34 tCO_2eq/capita for the US, 11.33 tCO_2eq/capita for Germany, and 10.37 tCO_2eq/capita for Japan. Ecological Footprints: 8.72 gha/capita for the United States, 5.56 gha/capita for Germany, and 4.94 gha/capita for Japan.

[13] The 10 countries with close to 0% extreme poverty are Bosnia and Herzegovina, Belarus, Algeria, Iran, Jordan, Kazakhstan, Lebanon, Russia, Thailand, and Ukraine.

[14] Bosnia and Herzegovina China, Iraq, Kazakhstan, and Russia in Cluster III rank among the world's top 15 per capita producers of oil and/or coal, but Cluster IV includes countries such as South Africa and Colombia who are among the world's top 10 coal producers measured in production per capita. (*sources*, https://en.wikipedia.org/wiki/List_of_countries_by_oil_production and https://www.nationmaster.com/country-info/stats/Energy/Coal/Production/Per-capita).

[15] Some countries in Cluster IV also have unambiguously closed the sustainable development gap: Argentina, Dominican Republic, Guatemala, Honduras, and Nicaragua.

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APPENDIX A

TABLE A1 Average indicator values for each cluster for the period 2010–2015

Themes Indicators	Number of countries	Share of population (%)	Human capabilities HDI	Extreme poverty % below IPL	Rich participation VDEM PI	Distribution Gini coefficient	Biosphere integrity EF	Climate change GHG/capita
Threshold			≥ 0.7	< 1%	≥ 0.5	≤ 0.4	≤ 1.7	≤ 3.6
Cluster I	3	6	0.92	0.5	0.66	0.36	8.97	22.44
Cluster II	29	8	0.86	0.4	0.63	0.32	5.19	10.02
Cluster III	23	32	0.74	1.5	0.24	0.33	2.98	6.55
Cluster IV	17	10	0.71	5.8	0.47	0.49	2.59	4.39
Cluster V	22	36	0.57	15.6	0.28	0.37	1.54	2.01
Cluster VI	23	8	0.46	50.1	0.28	0.42	1.14	1.25
Average (countries)	117	100	0.68	11.1	0.4	0.38	2.99	5.61
Average (population)			0.67	10.8	0.34	0.37	2.81	5.5
% of countries meet thresholds			53	35	29	63	38	54
% of population live in countries that meets threshold			52	17	18	55	44	49

Note: See Table 1 in the main text for a description of the themes, indicators, thresholds, and data sources. See Figure 1 for an overview of the countries included in each cluster. Table A1 is the basis for Figure 1 in the main text and covers 117 countries with a population of 6.37 billion (2015).

TABLE A2 Average indicator values for each cluster for the periods 1990–1995 and 2010–2015

Themes Indicators	Number countries	Human capabilities HDI	Extreme poverty % below IPL	Rich participation VDEM PI	Distribution Gini coefficient	Biosphere integrity EF	Climate change GHG/capita	Countries (UN three-letters country codes)
Threshold		≥0.7	<1%	≥0.5	≤0.4	≤1.7	≤3.6	
2010–2015								
Cluster I	3	0.92	0.5	0.66	0.36	8.97	22.44	AUS, CAN, USA
Cluster II	9	0.83	0.4	0.63	0.31	5.33	10.43	CZE, EST, HUN, LTU, LVA, MNG, POL, SVK, SVN.
Cluster III	12	0.74	1	0.24	0.34	2.72	6.25	BGR, DZA, EGY, IRN, JOR, KGZ, LKA, RUS, THA, TUN, TUR, UKR.
Cluster IV	15	0.72	5.6	0.47	0.49	2.67	4.69	ARG, BOL, BRA, CHL, COL, CRI, DOM, ECU, HND, MEX, NIC, PAN, PRY, SLV, ZAF.
Cluster V	10	0.59	12.9	0.3	0.36	1.33	2.19	BGD, GHA, IDN, IND, LAO, MRT, NPL, PAK, PHL, VNM.
Cluster VI	13	0.45	50	0.29	0.41	1.2	1.27	BDI, BFA, CIV, ETH, GIN, GNB, LSO, MDG, NER, SEN, TZA, UGA, ZMB.
1990–1995								
Cluster I	3	0.86	0.7	0.64	0.34	9.41	23.72	AUS, CAN, USA
Cluster II	9	0.71	2.5	0.52	0.3	4.44	11.73	CZE, EST, HUN, LTU, LVA, MNG, POL, SVK, SVN.
Cluster III	12	0.63	8.3	0.2	0.41	2.39	6.55	BGR, DZA, EGY, IRN, JOR, KGZ, LKA, RUS, THA, TUN, TUR, UKR.
Cluster IV	15	0.62	15.1	0.39	0.53	2.48	4.2	ARG, BOL, BRA, CHL, COL, CRI, DOM, ECU, HND, MEX, NIC, PAN, PRY, SLV, ZAF.
Cluster V	10	0.46	45.1	0.22	0.37	1.03	1.75	BGD, GHA, IDN, IND, LAO, MRT, NPL, PAK, PHL, VNM.
Cluster VI	13	0.34	65.5	0.18	0.45	1.27	1.22	BDI, BFA, CIV, ETH, GIN, GNB, LSO, MDG, NER, SEN, TZA, UGA, ZMB.

Note: Only countries with data for all six indicators in both periods are included, that is, 55 of the 117 countries in Table A1. See Table 1 for a description of themes, indicators, thresholds, and data sources and Figure 3 for lists of the countries included in each cluster.