2008 ENVIRONMENTAL PERFORMANCE INDEX

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Disclaimers
This 2008 Environmental Performance Index (EPI) tracks national environmental results on a quantitative basis, measuring proximity to an established set of policy targets using the best data available. Data constraints and limitations in methodology make this a work in progress. Further refinements will be undertaken over the next few years. Comments, suggestions, feedback, and referrals to better data sources are welcome at: http://epi.yale.edu or epi@yale.edu.

The word "country" is used loosely in this report to refer both to countries and other administrative or economic entities. Similarly the maps presented are for illustrative purposes and do not imply any political preference in cases where territory is under dispute.

EXECUTIVE SUMMARY

Fueled by advances in information technology, data-driven decisionmaking has transformed every corner of society, from business to biology. In the policy domain, quantitative performance metrics have reshaped decisionmaking processes in many arenas, including economics, health care, and education. The 2008 Environmental Performance Index (EPI) brings a similar data-driven, fact-based empirical approach to environmental protection and global sustainability.

Policymakers in the environmental field have also begun to recognize the importance of incorporating analytically rigorous foundations into their decisionmaking. However, while policymakers are calling for increased intellectual rigor in environmental planning, large data gaps and a lack of time-series data still hamper efforts to track many environmental issues, spot emerging problems, assess policy options, and gauge effectiveness. The EPI seeks to being to fill these gaps and, more broadly, to draw attention to the value of accurate data and sound analysis as the basis for environmental policymaking.

The EPI focuses on two overarching environmental objectives:
- reducing environmental stresses to human health;
- promoting ecosystem vitality and sound natural resource management;.

These broad goals also reflect the policy priorities of environmental authorities around the world and the international community's intent in adopting Goal 7 of the Millennium Development Goals (MDGs), to "ensure environmental sustainability." The two overarching objectives are gauged using 25 performance indicators tracked in six well-established policy categories, which are then combined to create a final score.

The 2008 EPI deploys a proximity-to-target methodology, which quantitatively tracks national performance on a core set of environmental policy goals for which every government can be – and should be – held accountable. By identifying specific targets and measuring the distance between the target and current national achievement, the EPI provides both an empirical foundation for policy analysis and a context for evaluating performance. Issue-by-issue and aggregate rankings facilitate cross-country comparisons both globally and within relevant peer groups such as geography or economy.

It must be emphasized that the EPI's real value lies not in the numerical rankings, but rather in careful analysis of the underlying data and performance metrics. The results are displayed in numerous ways: by issue, policy category, peer group, and country. This format facilitates identification of leaders and laggards, highlights best policy practices for each issue, and identifies priorities for action for each country. More generally, the EPI provides a powerful tool for steering environmental investments, refining policy choices, optimizing the impact of limited financial resources, and understanding the determinants of policy results.

Policy Conclusions

- Environmental decisionmaking can and should be made more data-driven and rigorous. A more fact-based and empirical approach to policymaking promises systematically better results.

- Notwithstanding data gaps and methodological limitations, the EPI demonstrates that environmental results can be tracked quantitatively, facilitating more refined policy analysis.

- To address these gaps, policymakers should invest in collecting additional data and tracking a core set of indicators over time. They must also set clear policy targets and incorporate indicators and reporting into policy formation, and shift toward more analytically rigorous environmental protection efforts at the global, regional, national, state/provincial, local, and corporate scales.

- Environmental challenges come in several forms which vary with wealth and development. Some issues arise as a function of economic activity and its resource and pollution impacts, such that developed and industrializing countries face the most severe harms. Other threats derive from poverty or a lack of basic environmental amenities, such as access to safe drinking water and basic sanitation. The issues affect primarily developing nations.

- Wealth correlates highly with EPI scores and particularly with environmental health results. But at every level of development, some countries achieve results that exceed their income-group peers. Statistical analysis suggests that in many cases good governance contributes to better environmental outcomes.

- The EPI uses the best available global datasets on environmental performance, but the overall data quality and availability is alarmingly poor. The absence of broadly-collected and methodologically-consistent indicators for even basic concerns such as water quality – and the complete lack of time-series data for most countries – hampers efforts to shift pollution control and natural resource management onto more empirical foundations.

The 2008 EPI represents a "work in progress" intended not only to inform, but also to stimulate debate on defining the appropriate metrics and methodologies for evaluating environmental performance. As existing conceptual, methodological, and data challenges are overcome, better metrics will emerge – and a more refined EPI will be possible.

CHAPTER 1: THE NEED FOR ENVIRONMENTAL PERFORMANCE INDICATORS

Environmental policymaking is difficult to do under the best of circumstances. Decisionmakers must address a wide range of pollution control and natural resource management challenges in the face of incomplete or conflicting data, causal complexity, divergent values and preferences, and myriad uncertainties. Without sufficient facts and careful analysis, each step of the process becomes more difficult—problems are harder to see, trends may not be understood, policy goals become more difficult to set, regulatory efforts may be misdirected, investments in environmental protection may be wasted, and optimum environmental performance will not be achieved. Shifting environmental policymaking onto firmer analytic foundations, based on carefully constructed data and indicators, therefore emerges as a matter of considerable urgency.

The commitment to empirical data is just a first step. Identifying an appropriate set of metrics is equally important. Some past performance measurement initiatives have been too broad to be of great value.[1] In covering sustainable development or sustainability in a "triple bottom line" fashion that combined environmental, social, and economic factors, as well as underlying endowments, accumulated harms, current policy efforts, and the prospect for changing future trajectories, these efforts lost coherence and therefore their policy relevance.

Other efforts have been too narrow to cover the full spectrum of environmental challenges. In addressing only a subset of issues that policymakers and members of the scientific community identify as fundamental to meeting society's environmental challenges.[2] These indices have limited value.

Our focus is on environmental sustainability and the current policy performance of individual nations. We have collected data on a broad-gauge list of core pollution and natural resource management challenges as identified by policy and scientific experts. While there is no "correct" answer to the proper scope of an environmental index, we believe our set of 25 indicators offers a comprehensive yet focused perspective on society's environmental challenges. The EPI builds on a set of environmental indicators that can be addressed by current policymakers around the globe. Thus, building on the methodology established in the *Pilot 2006 Environmental Performance Index* (EPI), in

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[1];See, for example, Esty, D.C., M. Levy, T. Srebotnjak and A. de Sherbinin. 2005. The 2005 Environmental Sustainability Index: Benchmarking National Environmental Stewardship. New Haven: Yale Center for Environmental Law and Policy.; Prescott-Allen, R. 2001. The Wellbeing of Nations. A Country-by-Country Index of Quality of Life and the Environment. Island Press. Available at: www.iucn.org

[2] See, for example, South Pacific Applied Geoscience Commission (SOPAC) and United Nations Environment Programme. Environmental Vulnerability Index. Suva, Fiji: SOPAC. Available at: http://www.vulnerabilityindex.net/EVI_2005.htm

addition to feedback from government and policy experts around the world, and the advice of dozens of scientific experts, the 2008 EPI centers on current national environmental performance. It tracks actual results (almost exclusively output measures) related to a core set of environmental issues that governments around the world have prioritized. In addition to providing policymakers with decisionmaking guidance, the EPI advances environmental protection by providing a way to gauge the seriousness of environmental threats, the direction of pollution and natural resource trends on the national, regional and international level, as well as the efficacy of current policy choices.

Metrics and solid analytic underpinnings are critical not only for good environmental policymaking but also for sustainable development. Driven in part by the 2000 Millennium Declaration and the Millennium Development Goals (MDGs), major global efforts are underway in the areas of education, health, and poverty reduction. While environmental sustainability was recognized in MDG Goal 7, environmental programs have not kept pace with the other goals.

As a result, promising areas of connection between the environment and other policy areas are going unrealized. This difficulty in moving forward with environmental improvements has been traced, in part, to an inability to identify the most pressing environmental problems, quantify the burdens imposed, measure policy progress, and assure funders in both the private and public sectors of the worth of their investments. These limitations mean that pollution control and natural resource management issues have been systematically under-funded and lag behind other global challenges.

By choosing a proximity-to-target approach, the EPI seeks to meet the needs of governments to track on-the-ground environmental results. It offers a way to assess the effectiveness of environmental policies against relevant performance goals. It is specifically designed to help policymakers:

- spot current problems and identify priority environmental issues;
- track pollution control and natural resource management trends;
- highlight where current policies are producing good results;
- reveal where ineffective efforts can be halted and funding redeployed;
- provide a baseline for cross-country and cross-sectoral performance comparisons;
- facilitate benchmarking and help to identify leaders and laggards on an issue-by-issue basis; and
- spotlight best practices and successful policy models.

The EPI provides a path toward a world in which environmental targets are set explicitly, progress toward these goals is measured quantitatively, and policy evaluation is undertaken rigorously. As better data become available, particularly time-series data, future versions of the EPI will be able to track not only proximity to policy targets but also provide a "rate of progress" guide. Moreover, as the underlying datasets include additional nations, the future, "universal" EPI will permit global-scale data aggregations that will allow planetary-scale conclusions to be drawn about the world community's trajectory towards environmental sustainability.

More broadly, the EPI team hopes to inspire rigorous and transparent data collection across the world, facilitating movement toward a more empirical mode of environmental protection grounded on solid facts and careful analysis. With the billions of dollars now being spent by governments, corporations, and foundations on pollution and natural resource issues, it is alarming that there is no globally complete and methodologically consistent set of environmental performance indicators. By being forthright about the limitations of both this Environmental Performance Index and the data that underpins it, the Yale Center for Environmental Law and Policy and the Center for International Earth Science Information Network hope to spur action in this regard.

CHAPTER 2: THE EPI FRAMEWORK

The 2008 EPI offers a composite index of current national environmental protection efforts. Recognizing that on-the-ground conditions are the ultimate gauge of environmental performance, the EPI focuses on measurable outcomes that can be linked to policy targets and tracked over time.

The EPI builds on measures relevant to two core objectives:
1. reducing environmental stresses to human health (the Environmental Health objective); and
2. protecting ecosystems and natural resources (the Ecosystem Vitality objective).

The quantitative metrics underlying the 2008 EPI encompass 25 indicators were chosen through a broad-based review of the environmental science literature, in-depth consultation with a group of Scientific Advisors in each policy category, the consensus emerging from the dialogue surrounding the Millennium Development Goals, and expert judgment. Each indicator builds on a foundation either in environmental health or ecological science.

Some of these metrics track the underlying concept closely. Others are "proxy" variables that imperfectly reflect the theoretical focus. The EPI builds on the best available global data. The 25 indicators each represent core elements of the environmental policy challenge.

Due to a lack of data, limited country coverage, methodological inconsistencies, or otherwise poor-quality metrics, a number of relevant issues that are considered to be policy relevant and scientifically important are not reflected in the EPI. These gaps include:

- toxic exposures;
- several dimensions of ambient air quality;
- waste management (including both household and toxic waste);
- nuclear safety;
- pesticide safety and chemical exposure;
- wetlands loss;
- health of freshwater ecosystems;
- agricultural soil quality and erosion;
- heavy metal exposure; and
- several aspects of greenhouse gas emissions.

For each indicator, a relevant long-term public health or ecosystem sustainability goal is identified. These targets are drawn from 1) treaties or other internationally agreed upon goals; 2) standards set by international organizations; 3) leading national regulatory requirements; or the 4) prevailing scientific consensus. The indicators serve as a gauge of

long-term environmental policy success. For each country and each indicator, a proximity-to-target value is calculated based on the distance from a country's current results to the policy target.

In calculating EPI scores, we average around isolated data gaps. But countries with more than a few missing data values (preventing any of our category scores from being calculated) are dropped from the Index. Our data matrix covers 149 countries for which an EPI can be calculated across the 25 indicators. Data gaps mean that another 90 or so countries that cannot be ranked in the 2008 EPI.

Using the 25 indicators, scores are calculated at three levels of aggregation. See Figure 1.

First, building on two to four underlying indicators (each representing a data set), we calculate scores for each of the six core policy categories – Environmental Health, Air Quality, Water Resources, Biodiversity and Habitat, Productive Natural Resources, and Climate Change. In some cases, subcategories are also tracked. The weight given to each indicator varies as shown in Table 1. This level of aggregation permits countries to track their relative performance within these well-established policy areas – or at the disaggregated indicator level.

Second, the Environmental Health subcategories and the Ecosystem Vitality categories are aggregated with weights allocated as shown in Figure 1.

Finally, the overall Environmental Performance Index is calculated, based on the arithmetic mean of the two broad objective scores. The logic for the weightings each subcategories and indicators is discussed below.

Indicator Selection and Targets

Indicators were sought to cover the full spectrum of issues underlying each of the major policy categories identified. To ensure the use of the best suited metrics, the following indicator selection criteria were applied:

Relevance: The indicator clearly tracks the environmental issue of concern in a way that is relevant to countries under a wide range of circumstances.

Performance orientation: The indicator tracks ambient conditions or on-the-ground results (or is a "best available data" proxy for such outcome measures).

Transparency: The indicator provides a clear baseline measurement, has the ability to track changes over time, and is transparent with regard to data sources and methods.

Data quality: The data used by the indicator should meet basic quality requirements and represent the best measure available.

Data Gaps and Country Data Coverage

The 2008 EPI builds on the best environmental data available, but remains seriously constrained by a lack of both quality and quantity in data sources. About 90 countries cannot be included in the EPI because data are not available in one of the six policy categories. Many critical issues also lack reliable measures. The 2008 EPI covers 149 of a possible 238 countries.

Due to a lack of data, limited country coverage, methodological inconsistencies, or otherwise poor-quality metrics, a number of relevant issues that are considered to be policy relevant and scientifically important are not reflected in the EPI. These gaps include:

- toxic exposures;
- several dimensions of ambient air quality;
- waste management (including both household and toxic waste);
- nuclear safety;
- pesticide safety and chemical exposure;
- wetlands loss;
- health of freshwater ecosystems;
- agricultural soil quality and erosion;
- heavy metal exposure; and
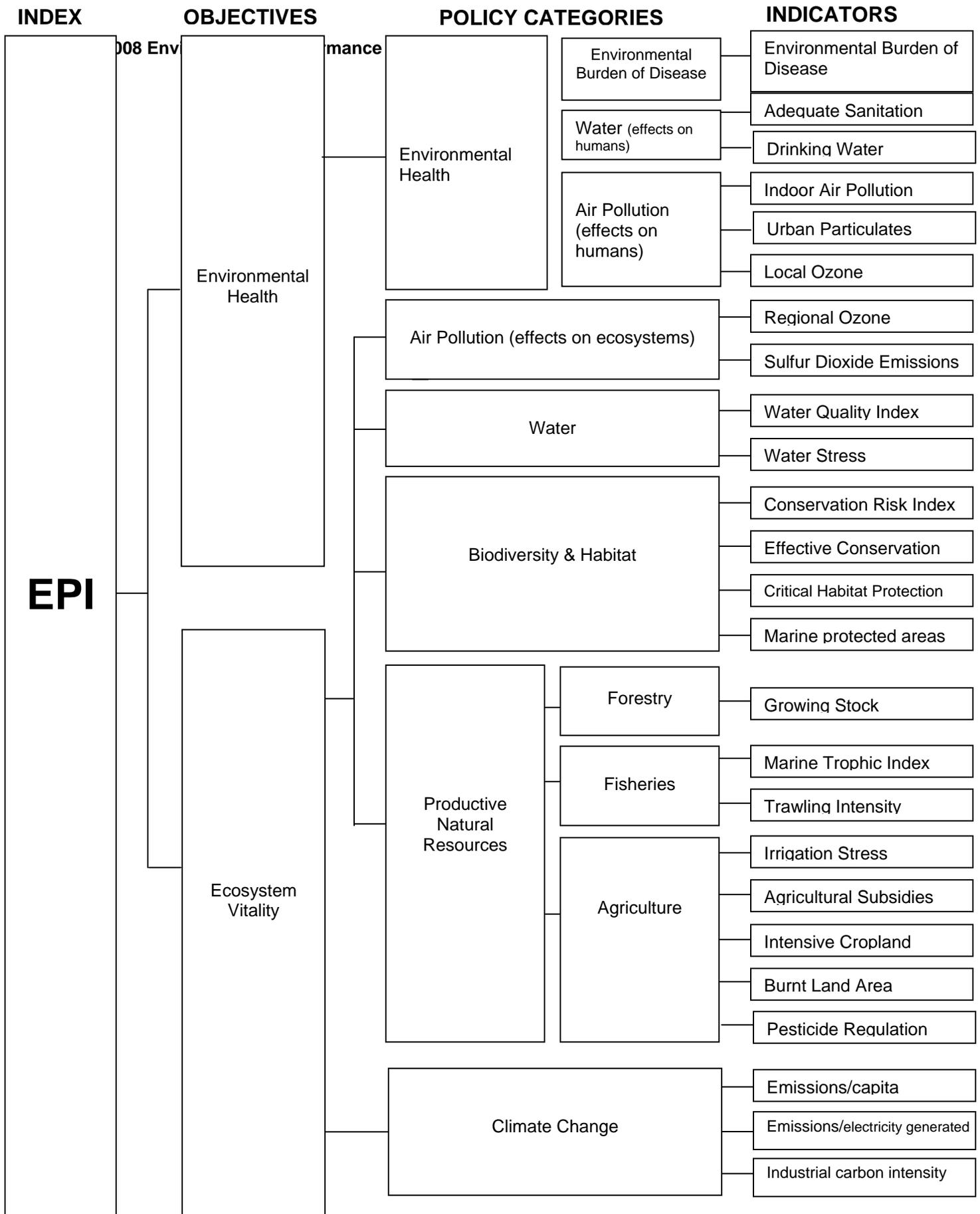- several aspects of greenhouse gas emissions.

Figure 1: Construction of the EPI

Table 1: Weights, Sources, and Targets of EPI Objectives, Categories, Subcategories, and Indicators

Index	Objectives	Policy Categories	Subcategories	Indicators	Data Source	Target
EPI	**Environmental Health** 50%			**Environmental burden of disease (DALYs)** 25%	WHO	0 DALYs
			Water (effects on humans) 12.5%	**Adequate sanitation** 6.25%	WHO-UNICEF Joint Monitoring Program	100%
				Drinking water 6.25%	WHO-UNICEF Joint Monitoring Program	100%
			Air Pollution (effects on humans) 12.5%	**Urban particulates** 5%	World Bank, WHO	20 ug/m^3
				Indoor air pollution 5%	WHO	0%
				Health ozone 2.5%	MOZART II model	0 exceedance above 85 pbb
	Ecosystem Vitality 50%	**Air Pollution (effects on ecosystems)** 2.5%		**Ecosystem ozone** 1.25%	MOZART II model	0 exceedance above 3000 AOT40. AOT40 is cumulative exceedance above 40 ppb during daylight summer hours
				Sulfur dioxide emissions 1.25%	EDGAR/Netherlands	0 tons SO_2 / populated land
		Water (effects on ecosystems) 7.5%		**Water quality** 1.25%	UNEP GEMS/Water	100 score
				Water stress 1.25%	UNH Water Systems Analysis	0% territory under water stress
		Biodiversity & Habitat 7.5%		**Conservation risk index** 1.25%	The Nature Conservancy	0.5 ratio
				Effective conservation	The Nature Conservancy	10%
				Critical habitat protection*	Alliance for Zero Extinction, TNC	100%
				Marine Protected Areas*	Sea Around Us Project, Fisheries Centre, UBC	10%
		Productive Natural Resources 7.5%	**Forestry*** 2.5%	**Growing stock change**	FAO	ratio of at least 1
			Fisheries* 2.5%	**Marine Trophic Index**	UBC, Sea Around Us Project	no decline
				Trawling intensity	UBC, Sea Around Us Project	0%

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Ecosystem Vitality 50%	**Productive Natural Resources** 7.5%	**Agriculture*** 2.5%	**Irrigation Stress***	CIESIN calculation based on global irrigation map by Johann Wolfgang Goethe University and Food and Agriculture Organization of the UN, and water stressed area map by University of New Hampshire Water Systems Analysis Group	0%
			Agricultural Subsidies	World Bank, World Development Report	0
			Intensive cropland	CIESIN calculation based on global cropland grid from Ramankutty et al. (forthcoming)	0%
			Burned Land Area	Joint Research Centre's Global Burnt Areas 2000-2007 (L3JRC) CIESIN Global Rural-Urban Mapping Project (GRUMP) land area and country grids.	0%
			Pesticide Regulation	UNEP-Chemicals	9 banned POP chemicals and full participation in Rotterdam and Stockholm Conventions
	Climate Change 25%		**Emissions per capita**	IEA, CDIAC, Houghton	2.24 Mt CO_2 eq. (Estimated value associated with 50% reduction in global GHG emissions by 2050, against 1990 levels)
			Emissions per electricity generation	IEA	0 g CO_2 per kWh
			Industrial carbon intensity	IEA, WDI	.85 tons of CO_2 per $1000 (USD, 2005, PPP) of industrial GDP (Estimated value associated with 50% reduction in global GHG emissions by 2050, against 1990 levels)

*Averaged around if missing data or not applicable to country

Table 1: EPI Indicators, Targets, and Indicator Weightings

Objectives	Policy Categories	Sub-Categories	Indicators	Data Source	Target	Weight in EPI
Environmental Health		Env. Burden of Disease	Environmental burden of disease	WHO	0 Disabled Adjusted Life Years	.25
		Water (human effects)	Adequate sanitation	WHO-UNICEF Joint Monitoring Program	100%	.0625
			Drinking water	WHO-UNICEF Joint Monitoring Program	100%	.0625
		Air Pollution (human effects)	Urban particulates	World Bank, WHO	20 ug/m^3	.05
			Indoor air pollution	WHO	0%	.05
			Local ozone	MOZART II model	85 pbb	.025
Ecosystem Vitality and Natural Resource Management	Air Pollution (ecosystem effects)		Regional ozone	MOZART II model	3000 ppb.h	.0125
			Sulfur dioxide emissions	EDGAR/Netherlands	0 tons SO_2 / populated land	.0125
	Water (ecosystem effects)		Water quality	UNEP GEMS/Water	100 score	.0375
			Water stress	UNH Water Systems Analysis	0% territory under water stress	.0375
	Biodiversity & Habitat		Conservation risk index	The Nature Conservancy	0.5 ratio	.01875
			Effective conservation	The Nature Conservancy	10%	.01875
			Critical habitat protection	Alliance for Zero Extinction, TNC	100$%	.01875
			Marine protected areas	UBC, Sea Around Us Project	10%	.01875
	Productive Natural Resources	Forestry	Deforestation	FAO	0	.0125
			Change in growing stock	FAO	No decline	.0125
		Fisheries	Marine Trophic Index	UBC, Sea Around Us Project	No decline	.0125
			Trawling intensity	UBC, Sea Around Us Project	0%	.0125
		Agriculture	Irrigation stress	CIESIN	0%	.00625
			Agricultural subsidies	World Bank, World Development Report	0	.00625
			Intensive cropland	CIESIN	0%	.00625
			Pesticide regulation	UNEP-Chemicals	22 points	.00625
Climate Change			Emissions per capita	IEA, CDIAC, Houghton	2.24 Mt CO_2 eq.	.08333
			Emissions per electricity generation	IEA	0 g CO_2 per kWh	.08333
			Industrial carbon intensity	IEA	.85tons CO_2/$1000 of industrial GDP	.08333

Targets

The EPI builds on a set of carefully chosen policy targets. Measuring success against these targets provides useful information about country-specific conditions and policy results, as well as areas in need of increased attention and resources. A proximity-to-target measure helps to clarify comparative rankings, demonstrate which countries are leading or lagging in each area, and whether (as a global aggregate) the world is on a sustainable trajectory.

Whenever possible our targets are based on international treaties and agreements. For issues with no international agreements, we looked next to environmental and public health standards developed by international organizations and national governments, the scientific literature, and finally, expert opinion from around the world. Only a few of the indicators have explicit consensus targets established at a global scale. This suggests that there is also a need for the international and national policy communities to be clearer about the long-term goals of environmental policies set at all levels. International agreements are often based on compromises, however, and targets derived from them do not necessarily reflect environmental performance required for full sustainability.

Calculating the EPI

To make the 25 indicators comparable, each metric was converted to a proximity-to-target-measure with a range of 0 to 100. Prior to this step, we examined the distribution of each indicator and transformed some indicators logarithmically to keep extreme values from skewing the aggregations. However, where there was reason to believe that the extreme values were "outliers" rather than the result of a skewed distribution, they were adjusted to make them equal to the value of the 5th percentile, a recognized statistical technique called winsorization.

A second decision concerned the treatment of countries that exceeded the long-term performance or sustainability target. To avoid rewarding "over-performance," no indicator values above the long-term target were used. In the few cases where a country did better than the target, the value was reset so that it was equal to the target. Once those two adjustments were made, a simple arithmetic transformation was undertaken: the observed values were placed onto a zero to 100 scale where 100 corresponds to the target and zero to the worst observed value.

Data Aggregation and Weighting

Aggregation is an area of inescapable methodological controversy. While the field of composite index construction has become a well-recognized subset of statistical analysis, there is no clear consensus on how best to construct composite indices. Various aggregation methods exist, and the choice of an appropriate method depends on the purpose of the composite indicator as well as the nature of the subject being measured.

To help identify appropriate groupings and weights for each indicator, we carried out a principal component analysis (PCA). Most categories did not have clear referents in the PCA results. Absent a PCA-derived basis for weighting the indicators, equal weights were used with some refinements determined by the EPI team with expert guidance.

The Environmental Health and Ecosystem Vitality subcategories each represent 50% of the total EPI score. This equal division of the EPI into issues related to (1) humans and (2) nature is not a matter of science but rather policy judgment. But this even weighting of the two overarching objectives of environmental policy reflects a broad-based institution – and this choice (used in the 2006 Pilot EPI) has not been generally criticized. Indeed, for every "deep ecologist" who favors more weight being placed on Ecosystem Vitality, there is a "humans first" environmental policymaker who prefers that the tilt go the other way.

Within the Environmental Health subcategory, the Environmental Burden of Disease (DALY) indicator is weighted 50% and accordingly contributes 25% of the overall EPI score, because it is widely regarded to be the most comprehensive and carefully-defined available measure of environmental health burdens. The effects of Water and Air Pollution on human health comprise the remainder of the Environmental Health subcategory and are each allocated a quarter of the total score for Environmental Health, reflecting a widespread policy consensus.

The two water-related indicators (Adequate Sanitation and Drinking Water) are equally weighted. Urban Particulates and Indoor Air Pollution receive equal weights, and double the weight given to the effects of ground-level Local Ozone on human health. Urban Particulates and Indoor Air are widely acknowledged by the United Nations Environment Programme (UNEP), World Health Organization (WHO), and United Nations Children's Fund (UNICEF) as excellent indicators of the burden of air pollution on human health. There is, however, a growing literature that suggests a link between ozone exposure and human health. Our human-exposure-related ozone metric builds on ozone exposure modeled by Denise Mauzerall and her colleagues on the global chemical transport Model of Ozone and Related Tracers, version 2 (MOZART-2). Because this indicator is experimental, we give it half the weight of those with known reliability.

Within the Ecosystem Vitality subcategory, the Climate Change indicator carries 50% of the subcategory's weight. The Air Pollution indicator is weighted to 2.5% of the subcategory total, due to the statistical variance of the datasets and the understanding that policymakers find water issues more fundamental than air pollution to ecosystem vitality. The remaining indicators: Water, Biodiversity, and Productive Natural Resources, are each evenly weighted to cover the remaining 22.5% of the subcategory.

CHAPTER 3: RESULTS AND ANALYSIS

The 2008 EPI provides policymakers and environmental experts an empirically grounded basis for comparing the environmental performance of nearly 150 countries worldwide. While general trends exist, such as a correlation between wealth and strong environmental health performance, some countries perform beyond income-based expectations. The results highlight policy leaders and laggards. They also provide a basis for identifying environmental "best practices."

The top five ranked countries in the 2008 EPI, in order of best performance, are Switzerland, Sweden, Norway, Finland, and Costa Rica. As expected, developed countries with significant financial resources for environmental management make up a large portion of top performers. But Costa Rica, a middle-income country, outperforms many developed countries as well as its neighbors. The bottom five countries in the 2008 EPI in order of performance are Niger, Angola, Sierra Leone, Mauritania, and Mali, are all located in Sub-Saharan Africa and lack resources for even basic environmental investments.

Overall there were many more high performing countries in the Environmental Health arena than in Ecosystem Vitality. Sixty-six countries had scores of 90 or above in Environmental Health, whereas only 2 scored above 90 in Ecosystem Vitality. The number of high performers in Environmental Health reflects government attention to basic human needs, such as drinking water and sanitation. Unlike Ecosystem Vitality, Environmental Health is highly correlated with wealth, indicating that many of the low-performing countries have not made the requisite investment in baseline environmental amenities.

Because so many countries had high Environmental Health scores, especially among the top countries, a low performance in Ecosystem Vitality had the ability to reduce a country's rank substantially. Countries such as Australia, Belgium, and the United States, which have Environmental Health scores at above 98, perform well below many members of their peer groups in the EPI because of their substantially lower Ecosystem Vitality scores.

Performance in Ecosystem Vitality is more normally distributed than the performance in Environmental Health. In part, this reflects the fact that Ecosystem Vitality is a composite of many different indicators, which tends to spread those scores.

Countries that scored well in ecosystem vitality often did so for very different reasons. Of the two countries with scores above 90, Switzerland's performance can be primarily attributed to good environmental management whereas Laos's high score arises from a lack of development and limited stress on the land, air, and water.

Countries falling in the middle of the rankings vary considerably. Some low-ranked countries, such as Kuwait, at 111th position, have an Environmental Health scores above

90. This result suggests they have on-going struggles with one or more of the ecosystem vitality policy categories. Likewise, Laos, despite its top ecosystem vitality score, ranks at 101 in the EPI because of a very low environmental health score. The United States, though very high in the Environmental Health score, ranked at 107th in the Ecosystem Vitality category, below countries like Sudan and Myanmar, which have significant non-environmental challenges and limited resources for environmental protection. Poor performance in the areas of air emissions and climate change reduced the United States' score significantly. China and India, containing about one third of the world's population, received similar low Ecosystem Vitality scores. Both countries were ranked in the bottom third of the index. However China scored higher in the overall EPI because of its improved Environmental Health score.

EPI Results by peer group

The overall EPI results offer a useful snapshot of environmental performance. But breaking down the results into peer groups offers an even more valuable perspective because it allows for comparisons between countries. The peer group analysis gives policymakers a way to understand the context of their policy choices and guidance on what is possible in the way of policy results given their circumstances. The policies and programs of the peer group leaders present an important guide to best practices and the most efficient approaches to improving environmental health and ecosystem vitality with similar challenges and opportunities.

OECD countries occupy four of the top five ranks in the 2008 EPI. Most of the OECD countries are in the top quarter of the Index, and all are in the top half. These relatively wealthy countries all have quite good Environmental Health results. But their scores on the various metrics of Ecosystem Vitality vary widely. Some of these nations, notably the Scandinavians, have distinct geographic advantages, including large land areas and low population densities. But their success is also a function of concerted policy effort and deep commitment to environmental values across their public and business communities.

None of the Least Developed Countries (LDC) were in the top half of the EPI, and the bottom 14 countries in the EPI are found in this group. With little access to financial resources for immediate needs like nutrition and disease, many of these countries are struggling to make even baseline efforts on environmental health. Their lack of development translates into limited pollution stress and thus contributes to relatively strong scores on air emissions, climate change, and biodiversity.

High population density countries are spread throughout the EPI. Germany, for example, sits in the 13th position while Burundi ranks 132nd. High populations density generates special challenges, but the high-ranked performers in this category demonstrate that population density is not an insurmountable barrier to good environmental quality. Many of the lower ranked countries in this grouping face challenges, but can look to their higher ranking peers for guidance on how to develop in an environmentally sustainable manner.

Other peer groups, like the African Union, the Alliance of Small Island States, the Desert Countries, and the Newly Independent States contain are spread across the EPI. Each of these peer groups is largely populated by developing countries that struggle with a wide variety of challenges, including a lack of natural resources like water and arable land, as well as the burden of poverty. Overall, these peer groups show much more diversity than do groupings like the OECD and the LDCs. This result implies that countries in the midst of economic transitions vary widely in how well they fold environmental protection into their development strategies.

COMPARISON OF PILOT 2006 EPI TO THE 2008 EPI

Both the Pilot 2006 EPI and the 2008 EPI are outcome-oriented performance indices. Like the 2006 Pilot EPI, the 2008 EPI is an attempt to assess current environmental conditions to provide policymakers with information they can use now in forming and assessing policy responses to environmental challenges. Both indices use a proximity-to-target approach to assess countries' performance on accepted targets for environmental sustainability where governments can have an immediate effect on efforts to improve environmental conditions.

While following the same general principles of construction and interpretation, i.e., a multi-tier aggregation of proximity-to-target indicators, the 2008 EPI differs from the pilot index in several structural and substantive areas. Structurally, the 2008 EPI's Environmental Health and Productive Natural Resources categories are further broken down into sub-categories to reflect the thematic similarities between the underlying indicators and allow for a more appropriate weighting scheme. Overall, the number of indicators has increased to 24 compared to 16 in Pilot 2006 EPI. The 2008 EPI now presents a more thorough inclusion of data that provide information on a wider variety of environmental indicators.

Furthermore, the 2008 EPI does not use the hybrid weighting of the Pilot 2006 EPI, which combines statistically derived weights from Principal Component Analysis with weights reflecting the combined judgment of experts and policymakers. The reasons for this methodological change do not mean we are abandoning the application of rigorous statistical principles in the index's design but the need for a nuanced and balanced compromise between what the data are telling us on the one hand and what is sensible from a policy perspective on the other[3].

A third methodological change compared to the Pilot 2006 EPI is the very limited and controlled use of missing data imputation to fill data gaps. Since one of our guiding principles is to offer a globally relevant and applicable performance assessment tool, data coverage is of paramount importance. Unfortunately, the inclusion of more advanced indicators in the 2008 EPI often comes at the expense of geographical coverage. For this reason, we have used a suite of imputation methods, including regression and correlation analysis, to increase country coverage in these indicators: Sanitation, Drinking Water, Indoor Air Pollution, Water Quality Index, CO_2 Emissions per Electricity Generated, and Industrial Carbon Intensity. Since these imputed values may reflect the true but unknown values to varying degrees of accuracy, we have clearly marked them in the data tables.

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[3] Although PCA weights reflect the importance, expressed as fractions of variation in the data that can be explained, of an indicator relative to others with respect to the principal component(s), these weights are not always representative of the policy attention given to an environmental issue. In addition, since the PCA weights depend on the data, their reliability depends on the quality of the data and, furthermore, subsequent releases of the index would with high likelihood result in different weights, which does not generally coincide with changes in policy attention.

Substantively, the 2008 EPI demonstrates our commitment to identifying the best available and developing the best possible environmental performance indicators that are currently available at the global level. We believe that the new 2008 EPI is a continued improvement and makes a significant contribution to environmental performance assessment.

Specifically, the 2008 EPI has improved upon the 2006 EPI in the environmental health area through the use of Disability Adjusted Life Years (DALY's), which more fully capture the effect of environmental conditions on human health and productivity than the child mortality indicator in the Pilot EPI. This year's EPI also more fully captures the effects of air pollution on both human health and the environment, adding indicators for sulfur dioxide pollution and separating the health and ecological effects of ground-level ozone according to scientific evidence and large-scale tempo-spatial modeling results. We have further strengthened the water indicators, primarily by advancing the measurement of water quality with information on pH, dissolved oxygen, conductivity, and total phosphorus in addition to the 2006 EPI's inclusion of data on nitrogen.

Perhaps one of the biggest changes in the 2008 EPI is the weight placed on the new Climate Change category, which absorbs the 2006 EPI's Sustainable Energy category, and the additional data included in its calculation: Emissions Per Capita, CO_2 Emissions Per Electricity generated, and Industrial Carbon Intensity. Because of the greater recognition of climate change as one of the most pressing environmental challenges, the 2008 EPI weights climate change much more heavily in the ecosystem vitality objective. As a result, countries with otherwise advanced environmental regulatory and enforcement systems such as the United States and Australia, dropped in this year's EPI in part because of this expanded category.

Biodiversity, Agriculture, and Fisheries were all improved with new and more sophisticated indicators in this year's EPI. The Agriculture category includes measures assessing intensive cropland coverage, pesticide regulations, irrigation stress, and burned land area in addition to the agricultural subsidy data included in the 2006 EPI. The subsidies data have also been improved in their consistency and extent by tapping into an expanded data source. The Fisheries category assesses Trawling intensity and the Marine Trophic Index compared to the overfishing indicator used in the 2006 Pilot EPI. Finally, the Biodiversity and Habitat category offers a completely new suite of advanced conservation and threat measures including the Conservation Risk Index and assessments of the Effectiveness of Conservation Efforts, Critical Habitat Protection, and – importantly – Marine Protected Areas.

Despite the progress made in indicator development and data availability, the 2008 EPI continues to highlight the glaring gaps in global environmental data. Several important environmental concerns such as population exposure to pollutants and toxins, trans-national outsourcing and spill-over effects of 'dirty' industries, and the effects of widespread human activities on locally sensitive conditions (e.g., critical loads of sulfur dioxide deposition) still cannot be measured adequately at the global level because of

lack of data, targets, and/or scientific certainty. Although the 2008 EPI contains 149 countries, many countries are not included because of the lack of information about key indicators, despite our efforts to produce meaningful imputations. This makes tracking and monitoring of environmental progress and success of policy and management efforts difficult, and although the 2008 EPI improves upon the 2006 EPI, much work remains to be done in establishing consistent data collection and monitoring of environmental metrics.

Comparison of the Environmental Sustainability Index and the Environmental Performance Index

Between 1999 and 2005 the Yale and Columbia team published four Environmental Sustainability Index reports aimed at gauging countries' overall progress towards 'environmental sustainability'. Since then our focus has shifted to environmental performance, measuring the ability of countries to actively manage and protect their environmental systems and shield their citizens from harmful environmental pollution.

Why this shift in our work? While sustainability research continues at a fast pace across the world, a commonly accepted and measurable definition of environmental sustainability remains elusive. Distinct approaches have emerged and consolidated within different disciplines, and cross-disciplinary exchange has promoted new advances, but the challenges are still formidable. In addition, the immediate value to policymakers was limited by the complexity of the problem, scientific uncertainties about cause-effect relationships, and the intricate and competing linkages between policy actions and the social, economic, and environmental aspects of sustainable development.

In contrast, environmental performance offers a more relevant and easily measured approach to reducing our societal environmental impacts. The possibility of selecting outcome-oriented indicators for which policy drivers can be identified and quantified is an appealing scenario for policymakers, environmental scientists and advocates, and the public alike. This method promotes action, accountability, and broad participation. The EPI's proximity-to-target approach in particular highlights a country's shortcomings and strengths compared to its peers in a transparent and easily visualized manner. These signals can be acted on through policy processes more quickly, more effectively, and with broader consensus than most sustainability metrics. In some cases, the EPI targets can already be viewed as sustainability targets, while other indicators represent the most widely accepted or most stringent agreed-upon policy goals.

Aside from these main conceptual and structural differences, how exactly do the EPI and ESI differ from each other? A summary of the differences is shown in Table A for the 2005 ESI, 2006 Pilot EPI, and 2008 EPI.

In contrast to the relative measurements of the ESI, the EPI is a benchmark index. The sustainability thresholds of many environmental and socio-economic aspects are extremely difficult to determine and, given the dynamics of human and ecological change, might not exist in an absolute sense. The ESI evaluates environmental sustainability

relative to the paths of other countries. The EPI, on the other hand, uses the distance to performance targets as the main criteria, acknowledging that these targets represent imperfect goalposts and can depend on local circumstances.

Although both the EPI and ESI are multi-tier, average-based indices, they significantly differ in the categories of which they are composed. In line with sustainability research, the ESI considers not only environmental systems but also adapts the Pressure-State-Response framework to reflect institutional, social, and economic conditions. The EPI, in contrast, considers only ecological and human health outcomes regardless of the auxiliary factors influencing them. The basic premise of the EPI is therefore normative. Each country is held to the same basic conditions necessary to protect human and environmental health now and in the future. The benchmarks for these conditions are enshrined in the 25 indicator targets. As a result of the EPI's narrowed scope, the categories and indicators tracked are both different and smaller in number.

Data quality and coverage play important roles in both the EPI and ESI. We believe that the value of a sustainability and performance index is diminished if only a handful of countries can be included and compared. Yet, while the ESI makes relatively extensive use of imputation techniques to fill data gaps, the availability of actual 'real' data was given much higher weight in the EPI to reflect the relevance of observed data in the policy process (2008 EPI does impute missing values in selected variables to maintain country coverage). As our knowledge of cause-effect relationships and statistical methods for data imputation continues to increase, however, it is likely that model-based imputations will gain more credibility in the future and in some cases even outperform real observations in accuracy.

Table A: Comparison of ESI and EPI objectives and design

Category	2005 ESI	2006 EPI	2008 EPI
Objective	Gauges the long term environmental trajectory of countries by focusing on "environmental sustainability"	Assesses current environmental conditions	Assesses current environmental conditions
Design	Provides a relative measure of past, current, and likely future environmental, socio-economic, and institutional conditions relevant to environmental sustainability	Provides an absolute measure of performance by assessing countries on a proximity-to-target basis	Provides an absolute measure of performance by assessing countries on a proximity-to-target basis
Design and theoretical framework	Tracks a broad range of factors that affect sustainability using an adaptation of Pressure-State-Response framework	Focuses narrowly on areas within governmental control using a framework of absolute, fixed targets	Focuses narrowly on areas within governmental control using a framework of absolute, fixed targets

Structure	Multi-tier consisting of **5 components:** Environmental systems, Reducing environmental stresses, Reducing human vulnerability, Social and institutional capacity, Global stewardship undergirded by **21 indicators** and **76 variables** (Note: the variables in the ESI can be compared with indicators in the EPI and indicators in the ESI are more reflective of the categories in the EPI)	Multi-tier consisting of **2 objectives:** Environmental health and Ecosystem vitality, **6 categories:** environmental health, air quality, water resources, biodiversity and habitat, productive natural resources, and sustainable energy, and **16 indicators**	Multi-tier consisting of **2 objectives:** Environmental health and Ecosystem vitality, **6 categories:** environmental health, air quality, water resources, biodiversity and habitat, productive natural resources, and climate change, and **25 indicators**
Data quality and coverage	Stringent grading system; flexible data requirements allow for missing data to be imputed	Stringent data quality requirements, no imputation of missing data	Stringent data quality requirements; imputation of missing data in selected indicators
Environmental Health (EPI objective, ESI indicator)	Indicators compare mortality rates of environmentally related diseases using proxy indicators: child mortality, child death from respiratory diseases, and intestinal infectious diseases	Estimates environmentally-related impacts on health through child mortality, indoor air pollution, urban particulates concentration, access to drinking water, and adequate sanitation	Estimates environmental burden of disease directly using WHO-developed disability adjusted life year (DALYs), local ground-level ozone and urban particulate concentrations, indoor air pollution, access to drinking water, adequate sanitation
Air pollution	Measures effects of air pollution as well as levels of air pollution: Coal consumption per capita, anthropogenic NO2, SO2, and VOC emissions per populated land area, and vehicles in use per populated land area	Measures air quality: Percent of households using solid fuels, urban particulates and regional ground-level ozone concentration	Measures atmospheric conditions pertaining to both human and ecological health: Health – Indoor air pollution, urban particulates, local ozone Ecosystems – Regional ozone, sulfur dioxide emissions (as proxy for its ecosystem impacts when deposited)
Water Resources and stress	Measures both water resources and stress: *Quantity* - Freshwater per capita and internal groundwater per capita	Measures both water resources and stress: water consumption and nitrogen loading	Measures water stress through water stress index

	Reducing stress – BOD emissions per freshwater, fertilizer and pesticides consumption per hectare arable land, percentage of country under water stress		
Water Quality	Key water quality indicators: dissolved oxygen, electrical conductivity, phosphorus concentration, suspended solids	Proxy for water quality: nitrogen loading.	Assesses water quality through composite Water Quality Index, which incorporates dissolved oxygen, pH, electrical conductivity, total nitrogen and total phosphorous concentrations
Climate Change / Energy	Tracks emissions per capita and per GDP Eco-efficiency indicator includes a measure of energy efficiency and renewable energy	Links energy to climate change via CO_2 emissions per GDP, percent of renewable energy and energy efficiency	Explicitly assesses contributions to climate change through Emissions per capita, emissions per electricity generated, and industrial carbon intensity
Biodiversity & Habitat	Focuses on species protection: Percentage of threatened birds, mammals, and amphibians in a country, the National Biodiversity Index (measures species richness and abundance), and threatened ecoregions	Focuses on biome and resource protection: Wilderness protection, ecoregion protection, timber harvest rate, and water consumption	Focuses on biome protection, including marine areas, and species conservation through Effective conservation, Conservation Risk Index, and critical habitat protection, indicators
Forests	Proxies for sustainable forest management: Annual change in forest cover and Percentage of total forest area that is certified for sustainable management	Proxy for sustainable forest management: Timber harvest rate	Proxy for sustainable forest management: Change in growing stock
Agriculture	Proxy for sustainable agriculture: Agricultural subsidies	Proxy for sustainable agriculture: Agricultural subsidies	Proxies for sustainable agriculture: Agricultural subsidies, Intensive cropland usage, Pesticide regulations, and Burned land area
Fisheries	Proxy for sustainable fisheries management: Overfishing	Proxy for sustainable fisheries management: Overfishing	Proxy for sustainable fisheries management: Trawling intensity, Marine Trophic Index